Understanding the Selection and Use of Water Related Innovations in Green Buildings

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ABSTRACT

This manuscript provides an understanding of water conservation related innovations in green buildings, both in terms of what is being selected in design phase and how professionals perceive their experiences with these innovations. The innovations examined include toilets, showers, sinks, plumbing, water heating, appliances, alternative water sources, landscaping, performance monitoring, and user education. It contains a literature review of unanticipated consequences associated with these innovations, and creates a framework for categorizing these based on a synthesis of the literature of unanticipated consequences. A review of certification documents from the Leadership in Energy and Environmental Design (LEED) rating system identifies what landscaping, toilet, and shower innovations are most commonly designed for in LEED certified buildings. These data are also used to identify differences in innovation selection across climate regimes. An internet survey of green building professionals provides a picture of satisfaction with these innovations in practice. It also gives examples of these experiences so that future users can take advantage or take caution as necessary.

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Attribution

The manuscript “Green Building Water Efficiency Strategies: An analysis of LEED NC 2.2 project data” was co-authored by Benjamin Chambers, Annie Pearce, and Marc Edwards. Benjamin Chambers did the main body of design, analysis, and writing. Annie Pearce and Marc Edwards offered extensive advice on how to proceed with the work, as well as edits to the report.

The manuscript “Water Systems in Green Buildings: Innovation Selection and Climate” was co-authored by Benjamin Chambers, Annie Pearce, Marc Edwards, and Randel Dymond. Benjamin Chambers did the main body of design, analysis, and writing. Annie Pearce gave extensive advice on how to proceed with the work, as well as edits to the report. Marc Edwards and Randel Dymond gave some suggestions for analysis as well as edits.

The manuscript “Green Building Water Systems: User Satisfaction and Experiences” was co-authored by Benjamin Chambers, Annie Pearce, Marc Edwards, and Randel Dymond. Benjamin Chambers did the main body of design, analysis, and writing. Marc Edwards and Annie Pearce contributed to development of the survey, as well as direction on analysis and presentation of results, and edits. Randel Dymond provided edits for the paper.

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Chapter 1: Introduction

Water is indisputably important to humanity. Needs and usage habits are unfortunately in conflict with the limited resources available on Earth. Access to clean water is a problem worldwide. Over a billion people lack access to safe drinking water (United Nations 2006). Part of the problem is the lack of adequate wastewater treatment, and part is usage patterns. Water is used by every person, and every industry. For most people, personal interactions with and use of water occur through building systems.

Public and domestic users have a major impact on a crumbling water infrastructure in the United States. In the United States, these sectors together account for about 11% of freshwater consumption (Barber, 2009). The American Society of Civil Engineers (ASCE) publishes an infrastructure report card, which in 2013 assigned the grade of D to both drinking water and wastewater infrastructure (ASCE, 2013). The ASCE estimates a cost of over $600 billion over the twenty years after the report card to bring the systems up to where they need to be. The building design and construction industry can reduce the load on this infrastructure, and the environmental and economic impacts of water use by using techniques and features that reduce needs and waste production.

Water efficient features are used in many buildings today to save money and reduce environmental impacts. They are most commonly found in 'green' buildings. The most common rating system in the US is the US Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED), which has certified almost 30,000 buildings (USGBC, 2013). This is only a small number compared to the over five million commercial and industrial buildings in the US (US Department of Energy, 2006).

The adoption of any innovation in a system can have unanticipated consequences, which can impact the system in a feedback loop. An unanticipated consequence is any effect or outcome of a purposeful action that is not foreseen as a possibility. These may be positive or negative, and can potentially affect any or all stakeholders. This idea is captured in many common concepts, such as Murphy's Law, serendipity, and the butterfly effect. It is important to understand the unanticipated consequences of an innovation, because a systems look at diffusion of innovations theory makes it clear that the consequences of adoption affect not only future adoption, but the whole social system (Ash et al., 2007; Rogers, 2003).

If it is in humanity's interest to adopt green water innovations, it is very important to understand what is being adopted, and the unanticipated consequences of these innovations. Otherwise, people might learn to mistrust these innovations, and adoption could slow or fail. It is important to determine what water innovations are being adopted in green buildings, where and how these innovations are being selected, what unanticipated consequences are being experienced as a result of this adoption, and how the people responsible for selecting and maintaining these innovations perceive them.

This manuscript seeks to answer these questions. Chapter 2 provides a literature review of unanticipated consequences associated with water innovations in green buildings that creates a framework for categorizing these consequences. Chapter 3 is a report published by the US Green Building Council describing the results of an investigation into innovations selected by designers in order to achieve LEED green building certification. Chapter 4 is a paper prepared for publication that correlates those innovations from the first report with climate zones to see if water conservation designers are taking climate into consideration. Chapter 5 is a paper prepared for publication that describes the results of an internet survey given to green building professionals about their experiences with water conservation innovations to identify common problems.

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Chapter 2: Literature Review

In green buildings, many types of water related technologies and strategies are applied to a variety of problems, and can affect all stakeholders in the system. The adoption of any innovation, especially in a complex socio-technical system such as a building, creates the potential for unexpected effects. These effects could run the gamut from social to technical, and affect any combination of the many stakeholders involved in building systems. These effects can also be caused by social or technical factors, or actions of any of the stakeholders. In the context of this paper, green water systems will include any system, technology, appliance, or social technique that involves the use of water in a building and which is intended to make the building as a system more sustainable. Key stakeholders considered in this paper are those entities directly affected by building design and performance: owners, users, operations and maintenance personnel, external suppliers (e.g. utilities), and project actualization parties (e.g. construction firms).

In order to understand and examine the unanticipated consequences of green water systems, some theory must be discussed. This background section will explain classification of consequences in diffusion of innovations theory, as well as the classification of causes of unanticipated consequences.

Classification of Consequences of Innovation

In order to better understand the consequences of innovations, Rogers developed a basic taxonomy for classification of the effects of innovations (Rogers, 2003). In his model, there are three dimensions: desirability, directness, and anticipation. These dimensions are applied to qualify effects on a social unit basis. A consequence could be desirable for the adopting party, but undesirable for another stakeholder set in the system, so each would have a separate classification for the effect.

- Desirability - describes functional effects of the innovation for individuals or social systems. Desirable consequences are positive, functional effects. Undesirable consequences are negative, dysfunctional effects created by the innovation.
- Directness - describes the order of the effect. Direct consequences are first order effects, occurring in immediate response to the innovation. Indirect consequences are second order or above, changes to individual or social systems resulting from the direct effects of the innovation.
- Anticipation - describes intent and expectation. An anticipated consequence is recognized and expected, and often intended, by the actors or other members of the social system adopting the innovation. An unanticipated consequence is any change due to an innovation that was neither intended nor expected by the members of the social system.

Causes of Failure to Anticipate Consequences

There are a variety of reasons that the consequences of innovation are unanticipated. Because human systems are complex, unanticipated consequences tend to occur with any purposive action. Robert Merton built a career on the theory of unanticipated consequences. Part of this theory is a taxonomy of causes for a consequence to be unexpected. The categories of cause are ignorance, error, immediate interest, basic values, and self-defeating prophecy (Merton, 1936). Multiple causes may apply to a consequence.

- Ignorance - when actors have an incomplete picture of the system. They are unable to properly analyze the situation and anticipate the consequence in question.
- Error - when the actor makes a mistake in their analysis of the situation. This may mean incorrect projections, or improper application of methods or technologies to the situation in question.
- Immediate Interest (also Immediacy) - when actors need a solution right away, and do not have time to consider potential outcomes of an innovation.
- Basic Values - when values or morals fundamental to an actor's worldview mean that they deem an action is necessary, and do not bother or think of considering further consequences of the action.
- Self-defeating Prophecy - when predictions of problems cause stakeholders in the system to take actions to avoid them, creating the unanticipated outcome of the predictions not coming true.

Defining Unanticipated Consequences for a Building Water System Context

To apply unanticipated consequence theory to building water systems, a model of consequence dimensions must be developed for this context. A thematic hierarchical network model of consequence dimensions has been developed for better analysis and classification of unintended consequences in health care information technology systems (Ash et al., 2007). The researcher adapted this for water technologies in buildings (Table 1), and added relevant examples for clarification of the concept. It should be noted that while the hierarchy contains both anticipated and unanticipated consequences for completeness and clarity, this review focuses only on unanticipated consequences.

The hierarchy of dimensions developed by Ash et al. further defines Rogers' dimensions for classification of consequences, and is applicable to building systems with only slight modification. Desirable anticipated consequences can be called goals, as they are the reason for the innovation. Undesirable anticipated consequences can be called tradeoffs, as they can be considered a concession made to meet the goal. On the other side, unanticipated desirable consequences can be thought of as serendipity. Ash et al. term unanticipated undesirable consequences as "unintended consequences," but in unanticipated consequence articles online, this term is often used interchangeably with "unanticipated consequences" and when used that way does not imply desirability or undesirability. Instead, for this paper, undesirable unanticipated consequences will be called faults, selected because the word implies a problem, hidden beneath the surface. The final breakdown is into direct and indirect consequences, with direct (first order) effects being termed process or measure effects, and indirect (higher order) effects being termed outcomes. This process term is not as easily applied to building water systems, so this paper will use Rogers' terminology of direct and indirect effects. Thus, this paper will classify unanticipated consequences as direct or indirect serendipity or faults.

Evaluation of Unanticipated Consequences in the Literature

The literature was searched for examples of unanticipated consequences for each type of water innovation previously identified. The consequences were then examined to classify their types and causes. The consequences were organized by innovation type. It should be noted that many consequences exist, but only those that were not anticipated by adopters are included in this review.

Gap Analysis for Research Needs

The results of this literature review were arranged for comparison of innovation type, consequence type, and cause of failure to anticipate (Table 1). This was used to identify areas missing from the literature. The review turned up surprisingly few unanticipated consequences, despite being expanded to a thorough search of about 700 case studies published online. Given the complex social and technical nature of building systems, and the wide variety of water related innovations, more unanticipated consequences should be expected. It is possible that few unanticipated consequences exist, but it is more likely that most have yet to be found. This review uncovered no general assessments of unanticipated consequences for any of the innovation types in question, which may partially explain this. The lack of discussion of consequences in case studies implies a need for research into how to increase documentation and sharing of such consequences by building stakeholders.

The review found no standard taxonomy of 'green' water related innovations in building systems. This could improve the ability of researchers to conduct thorough searches and compare work. Therefore, it is suggested that future research be done to develop this taxonomy.

This literature review found very few unanticipated consequences related to most of the water innovation types considered. The types with no associated unanticipated consequences were plumbing, appliances, and performance monitoring. Only one unanticipated consequence each was found for outlet fixtures, alternative water sources, and user education types. The highest number of consequences identified was four, for the water heating type. This suggests that future research should be done into all of these water systems to identify other unanticipated consequences.

Unanticipated consequences in the literature demonstrate a bias towards faults. Only one consequence identified could be classified as serendipitous. The consequences were more or less evenly distributed between direct and indirect relation to adoption. This suggests that particular attention be given to positive outcomes in future research on identifying unanticipated consequences.

The causes of adopters to fail to anticipate consequences were heavily skewed towards ignorance. None of the unanticipated consequences identified were related to immediate interest or self-defeating prophecy, and only one could be linked to basic values. Future research should be conducted on the effects of immediacy on water innovation choices. Basic values of key stakeholders related to water use in the built environment should be examined in order to identify and understand their effects on anticipation of consequences. Likewise, predictions of failures of water related systems should be collected and analyzed with some consideration of exposure, to identify the role of prophecy in unanticipated consequences in these systems.

Table 1: Summary of Unanticipated Consequences in the Literature

Innovation Type	Unanticipated Consequence	Types				Causes				
		Serendipity	Fault	Direct	Indirect	Ignorance	Error	Immediacy	Basic Values	Prophecy
Toilets and Urinals	Smell from waterless urinals installed without consideration of maintenance requirements (Guevarra, 2010)		x		x	x				
	Corrosion of copper pipes where waterless urinals are installed (Guevarra, 2010; Shapiro, 2010)		x	x		x				
Showers and Faucets	Low flow showerheads require users to take longer showers, increasing water usage (Walker 2009)		x		x		x			
Plumbing	(None identified)									
Water Heating	Legionella growth from reduced water heater tank temperatures (Bagh et al., 2004; Codony et al. 2002; Mathys et al., 2008)		x	x		x			x	
	Legionella growth from hot water recirculation systems (Brazeau 2012; Moore et al. 2006)		x	x		x				
	Higher energy intensity of hot water systems due to the addition of hot water recirculators (Brazeau, 2012)		x	x			x			
	Abandonment of solar water heaters due to incompatibility with adopting organization's maintenance practices (Pearce, 2011)		x		x	x				
Appliances	(None identified)									
Alternative Water Sources	Abandonment of rainwater and greywater harvesting systems due to incompatibility with adopting organization's maintenance practices (Pearce, 2011)		x		x	x				
Landscaping	(None identified)									
Performance Monitoring	(None identified)									
User Education	Increased tolerance of problems with buildings that are 'green' (Leaman and Bordass, 2007)	x			x	x				
Whole System	Increased bacterial growth in water distribution system caused by reduced flow rates with water conserving innovations (Pearce, 2011)		x	x		x				
	Reduced water consumption drives utility to raise rates (Porter, 2012)		x		x	x				

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Chapter 3: Green Building Water Efficiency Strategies: An analysis of LEED NC 2.2 project data

Green Building Water Efficiency Strategies:
An analysis of LEED NC 2.2 project data

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Abstract

This report describes some aspects of project compliance paths for projects earning water efficiency credits under LEED for New Construction v2.2. A stratified random sample was taken of all non-confidential certified projects earning these credits under this version of the rating system, and compliance forms for Water Efficiency credits 1, 2, and 3 were analyzed. Usage rates for water efficient landscaping, non-potable water sources, on-site wastewater treatment, and selection of plumbing fixtures and tap fittings were calculated. It was found that for WEc1: Water Efficient Landscaping, projects most often avoid permanent irrigation altogether. Rainwater was the most common non-potable water source for those that selected that compliance path. Wastewater reduction was selected over on-site treatment, and high efficiency toilets and non-water urinals were most often used to meet the high reduction necessary to earn the WEc2: Innovative Wastewater credit. Dual flush and high efficiency urinals were most often selected for lower (20+% or 30+%) water use reduction needs for WEc3: Water Use Reduction.

Introduction

Water use in the built environment is a very important aspect of human civilization. Public supply and domestic use accounts for about 12% of all fresh water withdrawals in the US (Barber, 2009). The energy alone used to run the drinking water and wastewater plants in the US costs about $4 billion each year (Energy Star., 2012). Societally, this water use affects municipal water supply and treatment facility loads. Economically, it affects utility bills and municipal spending. Environmentally, it affects fresh water sources both in terms of volume extracted and pollution added. Because of these impacts, it is beneficial to reduce building water usage rates. There are many different facets of this issue, and many ways of addressing it in buildings, including water efficient fixtures and fittings such as toilets and sinks, collection of non-potable water sources such as rain, and treatment and reuse of wastewater.

The Energy Policy Act of 1992 (EPAct) took a step towards reducing the impacts of building water use by imposing flow restrictions on bathroom fixtures. Since then, many technological advances have been made which can further reduce water impacts while delivering the same level of service expected by building occupants. As a leader in the movement to create built environments that meet the needs of people and life on Earth without sacrificing the long term viability of either, the U.S. Green Building Council has sought to promote these technologies by including their use in the Leadership in Energy and Environmental Design (LEED) rating system for built environments.

In order to achieve certification, applicants must earn credits for inclusion of features in their building that achieve the goals of the rating system. LEED devotes an entire category of credits to efficient water use, covering several aspects of water efficiency. This report aims to describe how projects achieved credits for this category in LEED for New Construction v2.2 through an analysis of compliance paths and choices. Factors investigated include water efficient landscaping, non-potable water sources, on-site wastewater treatment, and flush fixture and tap fitting selection.

Methodology

Sample

The research team began with the public LEED project directory from the USGBC website, and a list of all non-confidential projects earning Water Efficiency (WE) 1, 2, and 3 credits under LEED NC v2.2. Non-US and confidential projects were not included in the sample. Owner types were obtained from the public database and statistics were generated to describe their distribution. A stratified random sample was then taken of the WE credit-earning projects based on owner type. The result was a sample of 448 projects earning at least one of WE credits 1, 2, and 3. Credits 1 and 3 were earned much more frequently than credit 2 (Figure 1).

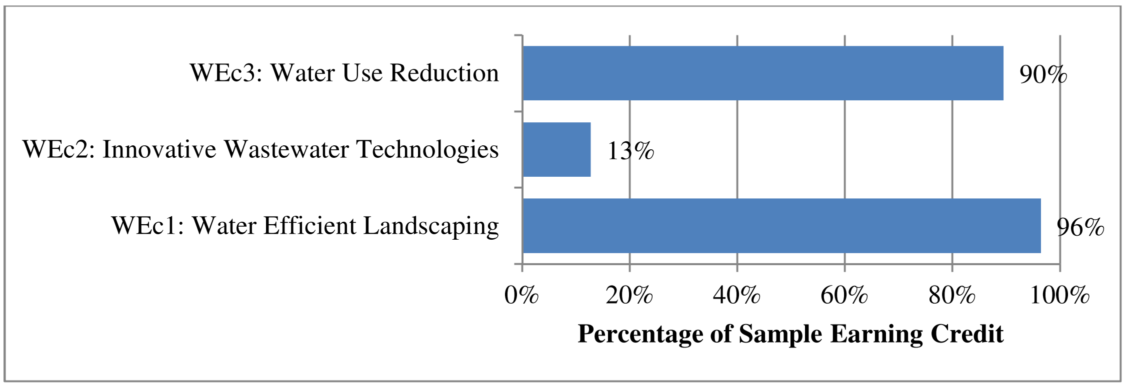

Figure 1: Counts of projects earning WEc 1, 2, and 3 in sample

For data validity, credit earning and owner type mentions were analyzed. The percentages of projects earning each credit are approximately equal in the population and the sample. Project teams specified one or more owner types as part of project documentation, and this selection was the basis for owner type classification (Figure 2). This stratified random sampling meant that the percentages of projects mentioning each owner type were equal in the population and the sample.

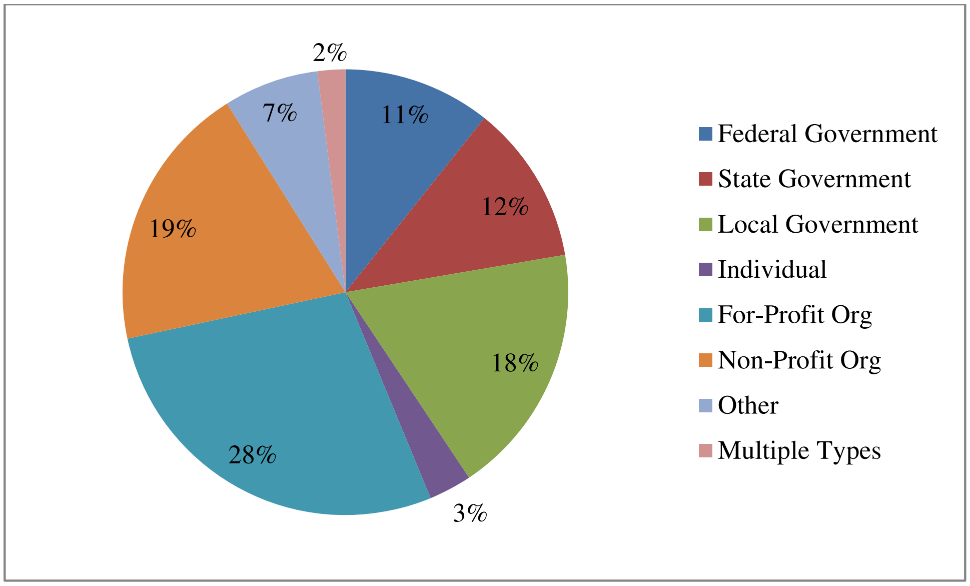

Figure 2: Percentages of projects mentioning each owner type

Measures

The data used in this study were drawn from LEED credit submittal forms and from the USGBC list of non-confidential certified projects. LEED credit submittal forms accept input in three different ways: radio buttons, check boxes, and text input fields. Each was treated and displayed differently.

Radio buttons allow a user to select only one of several options. These are presented in this report as pie charts, with data as percentages of projects earning that credit making each selection. This type is used for compliance paths for WEc1 and WEc2.

Check boxes allow a user to select more than one option. Because they are not mutually exclusive, these results are presented as bar charts, with data as percentages of projects with the ability to make a choice selecting each option. This type is used for non-potable water sources in WEc1.

Text field form entry is used to describe and specify flush fixtures and tap fittings in WEc2 and WEc3. Text fields allow manual entry of a description. These are by nature not standardized. The research team generated a list of all unique values, and assigned a standardized value to each. These standardized values are normalized and presented in this report in bar charts, with data as percentages of projects using the flush class of fixtures that used that particular type of fixture, or percentages of tap fittings using a particular flow rate. Projects typically use more than one type of fixture and fitting. For instance, a building might have different types of urinals in different bathrooms. Tap fittings and flush fixtures were categorized by classes and types, as many different brands and flow rates were mentioned. The water closet class included dual flush, high efficiency, compressed air, and composting toilet types. High efficiency toilets are defined as water closets that use a maximum of 1.28 gallons per flush (GPF), which is 20% less water than the current U.S. maximum of 1.6 GPF. Urinal class fixtures were placed in one of two major types: High efficiency and non-water. High efficiency urinals are those that use no more than 0.5 GPF, half of the current U.S. maximum of 1 GPF. Non-water urinals have no flush.

Tap fittings include sinks and showers. These are categorized by type and flow rate. Flow comparisons for water use reduction towards credit compliance are based on EPAct standards.

Results

WEc1: Water Efficient Landscaping

This credit covered landscaping water use. 401 out of 448 projects (89.5%) in the sample earned this credit. There were four paths to compliance (Figure 3), by some combination of reduced irrigation and non-potable water sources, or by removing permanent irrigation altogether. The most commonly selected option was no permanent irrigation. Reduced irrigation consumption is part of options 1 and 3, and between them the technique almost rivaled the lack of permanent irrigation in popularity.

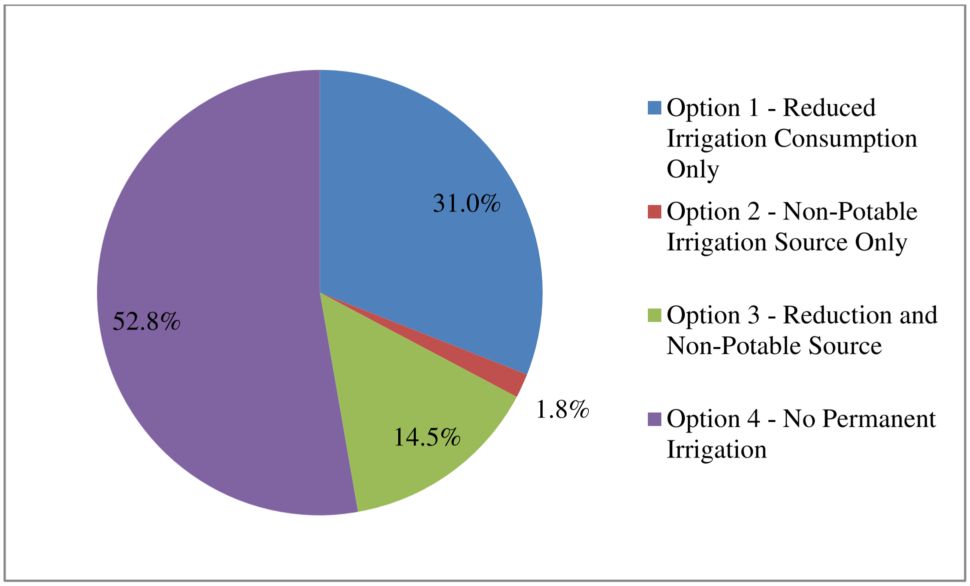

Figure 3: WEc1 Compliance path for sample

For those projects selecting option 2 or 3, at least one non-potable water source was listed. Of the 401 projects earning WEc1 in the sample, 65 made this choice. The categories on the forms were rainwater, greywater, wastewater, and publicly supplied non-potable water (reclaimed municipal wastewater that has been treated, but not up to drinking standards), also known as purple pipe. Some projects used more than one source. Rainwater was the most popular choice, followed by public sources (Figure 4).

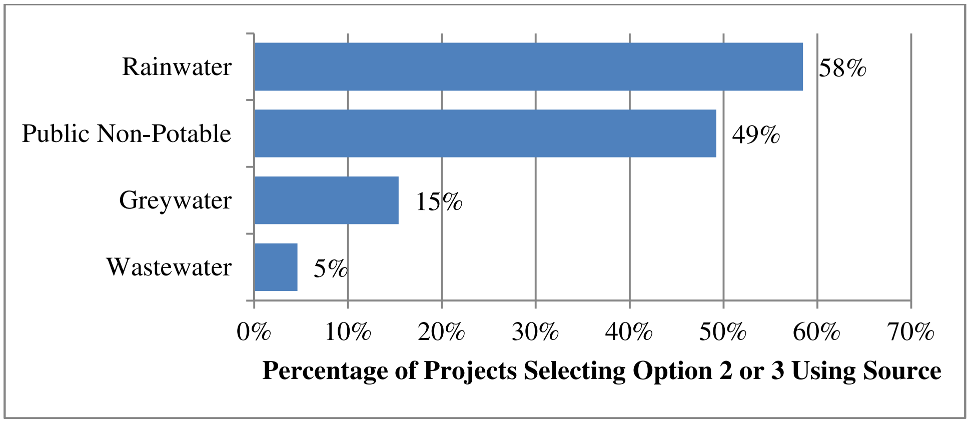

Figure 4: WEc1 Non-potable water source for projects selecting option 2 or 3

WEc2: Innovative Wastewater Technologies

This credit addresses generation and treatment of wastewater, and can be achieved either through on-site wastewater treatment or a sewage conveyance water savings of at least 50%, both of which reduce the demand placed on public wastewater treatment facilities by a project. This 50% reduction can be achieved with the use of efficient water closets and urinals. Of the 57 (12.7%) projects in the sample that achieved this credit, most projects selected reduced sewage conveyance based on water savings calculation for their compliance path (Figure 5).

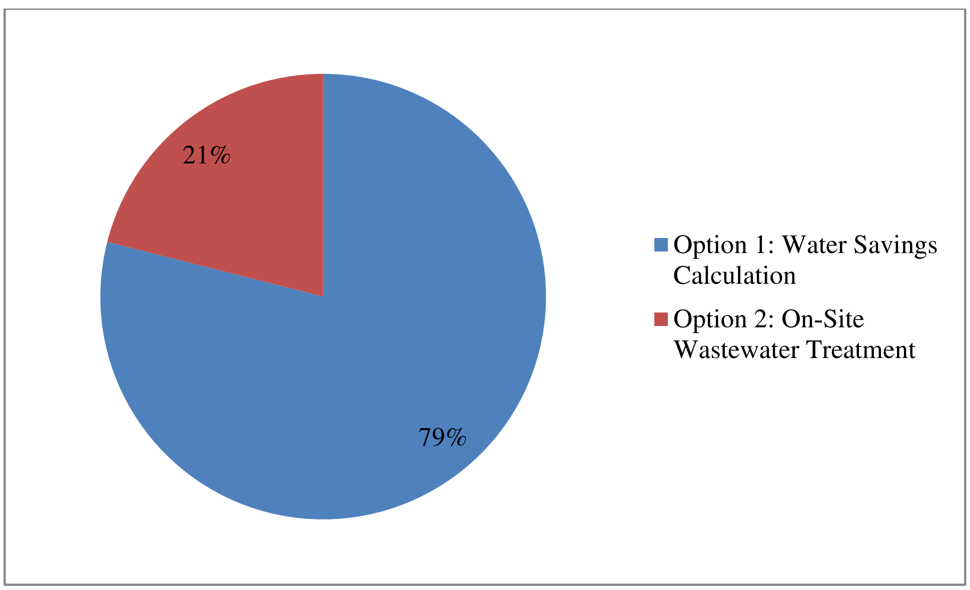

Figure 5: WEc2 Compliance path for sample

Although only the projects pursuing the water savings compliance path were required to specify flush fixture types, 54 of 57 (95%) projects achieving the credit provided a description of flush fixtures for the project. Therefore, flush fixtures are given as a percentage of these 54 projects that described flush types (Figure 6). Among these, high efficiency toilets and non-water urinals were the most common.

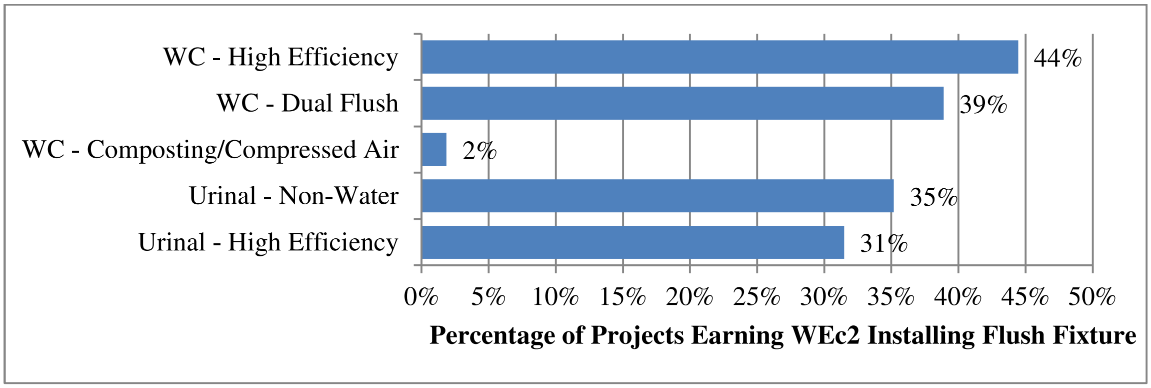

Figure 6: WEc2 Flush fixture type usage

WEc3: Water Use Reduction

Water efficiency credit 3 can be earned by reducing water use through efficient tap fittings and flush fixtures to reduce water use in the building by at least 20% for one credit or at least 30% for two credits. These classes are limited to water closets, urinals, lavatory faucets, showers, and kitchen, classroom, lab, or janitor sinks. Projects used some or all of these classes, and some used more than one type within a class. Flush fixture use is given as a percentage of the projects earning WEc3 that used each fixture type for compliance (Figure 7). Dual-Flush was the most common type of water closet used, and high efficiency urinals were more commonly used than non-water.

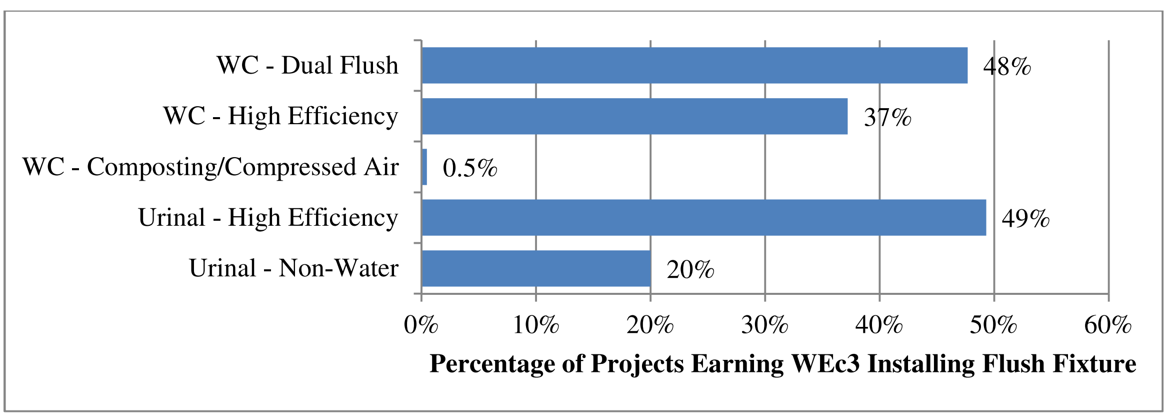

Figure 7: WEc3 Flush fixture type usage

Tap fittings described on forms include showers and several classes of sinks. Projects may have multiple taps, so results are presented by type. Use is given as the five most common design flow rates for each fitting type, as a percentage of the type. The average reduction of flow rate from EPAct baseline to design is also given (Table 2). The greatest average reduction was in lavatory sinks, at about twice that of the other types.

Table 2: WEc3 Tap fitting average flow reductions

Tap Fitting Type	Number of Fittings Examined	Average Percent Flow Reduction
Shower	249	35%
Sink - Lavatory	474	73%
Sink - Kitchen	322	35%
Sink - Janitor	48	34%
Sink - Class/Lab	19	43%

Tap fitting types were analyzed to find the most common flow rates for each. Projects may have multiple taps, so results are presented by type. Each fitting type had a different distribution of commonly used flow rates (Table 3). The most pronounced preference was for 0.5 GPM faucets in lavatory sinks.

Table 3: WEc3 Most utilized flow rates for each tap fitting type

Tap Fitting Type	Fitting Examined	Most Common Flow Rates (GPM)	Percent of Fittings Using Flow Rate
Shower	249	1.5	43%
		2	15%
		1.8	12%
		1.75	10%
		Other	21%
Sink - Lavatory	474	0.5	78%
		1.5	8%
		1	3%
		2.2	2%
		Other	8%
Sink - Kitchen	322	2.2	32%
		1.5	26%
		0.5	14%
		1.8	8%
		Other	20%
Sink - Janitor	48	2	29%
		2.2	23%
		1.5	17%
		0.5	13%
		Other	19%
Sink - Class/Lab	19	1.5	32%
		0.5	21%
		2.2	16%
		1.6	11%
		Other	21%

Results were compiled for all sink fittings, and 0.5 GPM faucets were the most commonly used (Figure 8).

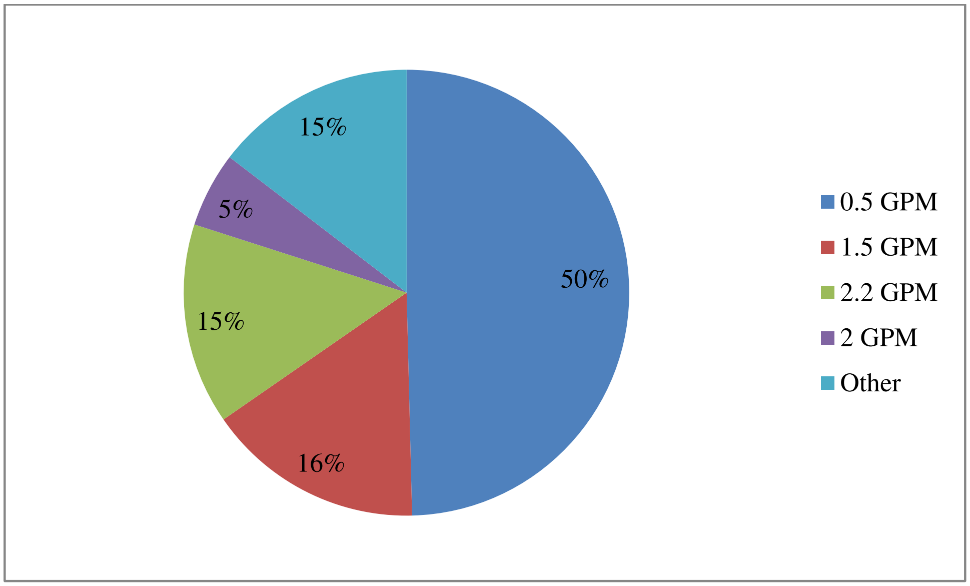

Figure 8: WEc3 Most common flow rates for sink fittings

Discussion

The analysis of WEc1: Water Efficient Landscaping forms showed that non-potable water sources were not used nearly as much as irrigation reduction or elimination. This might be related to the availability of municipal non-potable water, local restrictions on rain or grey water collection, or the simplicity of not having an installed irrigation system. A study of these choices by climate and municipal non-potable availability could be a useful future study. Of the sources mentioned, the heavy skew away from grey and wastewater also bears investigation, perhaps into local ordinance patterns.

With WEc2: Innovative Wastewater Technologies, on site wastewater treatment did not see much use, possibly because the other option of sewage conveyance reduction was partially already covered by flush fixtures used to earn WEc3: Water Use Reduction. This might have provided an easier path to compliance with WEc2 than installing water treatment on-site, as the sewage conveyance reduction was already mostly met for WEc3. There is a difference to be noted between the flush fixture selections, specifically that WEc2, which required a greater wastewater flow reduction, showed majorities for high efficiency water closets and non-water urinals. On the other hand, WEc3, with its lower requirements, tended towards dual-flush water closets and high efficiency urinals. This could indicate that non-water urinals and pure high efficiency water closets are less desirable than the other options when water use restrictions are not as high.

Conclusions

While it is true that projects employ many different techniques to earn each water efficiency credit, it is clear from the results of this study that some are much more common than others.

WEc1 earners tended towards removing permanent irrigation altogether, and when non-potable water sources were used, they preferred rainwater and public non-potable sources. WEc2 earners tended to avoid on-site wastewater treatment in favor of conveyance reduction, and used non-water urinals and high efficiency water closets to that end. WEc3 earners selected high efficiency urinals over non-water urinals, and tended to select dual-flush water closets over high efficiency water closets. Efficient tap fittings were most commonly used in lavatory sinks, and typically used 0.5 GPM faucets.

As the use of water efficiency techniques in the built environment becomes more common, it becomes even more important to study how it is being achieved by projects. By doing so, practices can be analyzed and improved. This report provides a starting point for future research, pointing to the most commonly used techniques on LEED projects. In this way, research can be directed towards the most useful questions first. Why is rainwater the preferred non-potable water source? What makes projects select dual flush toilets over low-flow? Why are waterless urinals less used than low-flow? Answering these questions could make it easier for future builders to make selections of their own, and for more projects to include water efficient features.

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Chapter 4: Water Systems in Green Buildings: Innovation Selection and Climate

Water Systems in Green Buildings: Innovation Selection and Climate

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Abstract

The variation of water efficiency measures in green buildings as a function of climate regions was quantified using project certification documents from the Leadership in Energy and Environmental Design (LEED) for New Construction v2.2 system. These documents included design decisions about landscape irrigation and toilet selections. The distributions of decisions were compared across two climate region classification systems: those used by the National Oceanic and Atmospheric Administration (NOAA) and the US Department of Energy's Energy Efficiency and Renewable Energy (EERE) office. Significant differences were demonstrated in several decisions, including landscape irrigation water reduction choices, which varied in both systems. Water closet choices showed some difference, with dual flush toilets being selected significantly more in the EERE Marine and NOAA Northwest region. High efficiency toilets were selected significantly less in the EERE Marine and NOAA Northwest regions than at least one other region. High efficiency urinals showed differences in only one climate classification system, being selected significantly more in the EERE Marine region than in the Hot-Dry and Mixed-Humid regions. Non-water urinals showed no significant differences.

Introduction

Water use in buildings accounts for about 11% of fresh water withdrawals in the US (Barber 2009). Utility scale water extraction, treatment, and distribution are all major operations with significant environmental and public health impacts. To make the most of scarce water resources, a number of strategies have been employed over the years in the building industry.

The Energy Policy Act of 1992 (EPAct) took a step towards reducing the impacts of building water use by imposing flow restrictions on bathroom fixtures. Since then, many technological advances have been made which can further reduce water impacts while delivering the same level of service expected by building occupants.

More recently, policy and habits in environmentally conscious construction and maintenance have been influenced by green building rating and certification systems, such as the US Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) program. The LEED certification system has been adopted by some of the largest agencies in the US Federal Government, including the General Services Administration (US General Services Administration, 2013), and is by far the most used certification system in the US with over 14,000 certified projects (US Green Building Council, 2012). LEED promotes water efficiency by giving projects credits toward certification through several avenues, including efficient toilets, sinks, and landscape irrigation strategies.

There are a number of rating systems within LEED, designed to cover different types of construction, renovations, or operations. This paper focused on the version designed for new construction. In order to achieve LEED certification, projects earn credits for including sustainable features and practices in their designs. To earn these credits, they must submit documentation describing design details related to whichever credits are being sought.

The first few iterations of LEED were meant to be broadly applicable to encourage participation, and as such did not have any region or climate specific guidelines. They did, however, allow participants freedom in selection of options for reduction of water use. Water issues vary markedly by region in the U.S., with very high stress in deserts and little stress in less populated and high rainfall regions. Projects therefore had the ability to be climate specific in their selections, but had no explicit incentive or suggestion in the certification system to do so. Starting in LEED version 3, regional priority credits were included to promote this behavior, and water use reduction became mandatory.

The USGBC has published information about trends in LEED participation in its Green Building Information Gateway (GBIG) project (US Green Building Council, 2013), as well as a number of details about individual projects. GBIG provides a credit-level resolution, showing what goals have been achieved by projects.

Prior to this investigation, no studies had been done on LEED water efficiency credits at a resolution that shows how they were earned. The goal of this research was to identify the types of approaches that achieve LEED water efficiency credits across different climate regions in the continental United States.

Research Scope

This study examined LEED NC v2.2 certification documents for Water Efficiency credits 1 and 3. These certification documents describe how projects intend to comply with LEED requirements. The first credit examined was WEc1: Water Efficient Landscaping. It requires projects to reduce the use of potable water in landscaping, either by reducing the need for water or by using non-potable sources. This study compared the four basic options for compliance: reduced irrigation consumption only, non-potable irrigation source only, reduction and non-potable source, and no permanent irrigation. The other credit examined was WEc3: Water Use Reduction. It requires projects to reduce the use of water within the building through efficient plumbing fixtures and fittings within structures. This study compares the use of the most common categories of toilets in LEED NC v2.2 buildings: high-efficiency and dual flush water closets, and high efficiency and non-water urinals (Chambers et al., 2013). High-efficiency is defined for water closets as 1.28 gallons per flush or less and 0.5 gallons per flush or less for urinals. WEc2: Innovative Wastewater Technologies was omitted from this study because of the low number of projects earning it, and because the most common means of compliance is the use of efficient toilets, which overlaps with WEc3.

Within the framework of these data, the question became:

For projects achieving LEED NCv2.2, how did landscape irrigation choices used to earn WEc1 and flush fixture choices used to earn WEc3 vary by climate region?

Research Methodology

Water use reduction choices for a sample of LEED certified projects earning water efficiency credits under LEED for New Construction v2.2 were analyzed for differences using two climate classification schemes.

Sample Selection

Green buildings were defined as structures intended to be environmentally responsible. There are multiple sets of guidelines and certification programs used to help designers achieve this goal, but not all projects are actually registered with the programs. As such, it is difficult to determine how many such buildings exist. The USGBC was selected as a large source of project information, with over 12,000 projects certified at the time of sample selection. Within the USGBC's LEED program, one specific rating scheme was selected for comparison, LEED for New Construction v2.2. This version was chosen because of the number of projects earning it and because its certification data formatting was in an easier form than the other versions offered. The USGBC provided a list of all non-confidential projects earning Water Efficiency (WE) credits 1 and 3 under LEED NC v2.2 in the continental United States. The USGBC provides a publicly accessible database of all LEED certified projects online, containing some basic project information (US Green Building Council, 2012). Owner types and locations were obtained from this public database for each of the 3518 non-confidential projects earning these credits. A stratified random sample was then taken of the projects based on owner type. The result was a sample of 448 projects earning at least one of WE credits 1 and 3, including 391 WEc1 projects and 422 WEc3 projects.

Water Efficiency Choices

Within WEc1, the certification documents covered potable water use in landscaping. This was shown through the ability to select one of four options:

- A: Reduced Irrigation Consumption Only
- B: Non-Potable Irrigation Source Only
- C: Reduced Irrigation and Non-Potable Irrigation Source
- D: No Permanent Irrigation

Projects also offered some extra details describing water quantities and non-potable sources, depending on their selections. The main decision, selecting one of these four options, was the best indicator of landscape irrigation water efficiency techniques, so it was selected as the WEc1 characteristic to analyze.

To earn WEc3, projects were asked to describe a number of details about fittings and fixtures. The necessity of using toilets and urinals, the common classification of each in two main categories, and the nature of the data led to their selection as the characteristics from WEc3 to analyze. The toilet types examined were dual flush water closets, high efficiency water closets, high efficiency urinals, and non-water urinals.

Climate Regions

Two separate climate classification systems were examined to relate LEED water saving features to climate, including a system used by the National Oceanic and Atmospheric Administration (NOAA) (Figure 9) and a system used by the US Department of Energy's Energy Efficiency and Renewable Energy (EERE) office for their Building Technologies program (Figure 10). The NOAA system is based on research done by the National Climatic Data Center (Karl and Koss 1984), and consists of nine groups of adjacent states that have similar climate regimes. The EERE system is based on heating degree days, average temperatures, and precipitation (US Department of Energy, 2010). It divides the continental United States into five regions and two sub-regions, with boundaries following county lines.

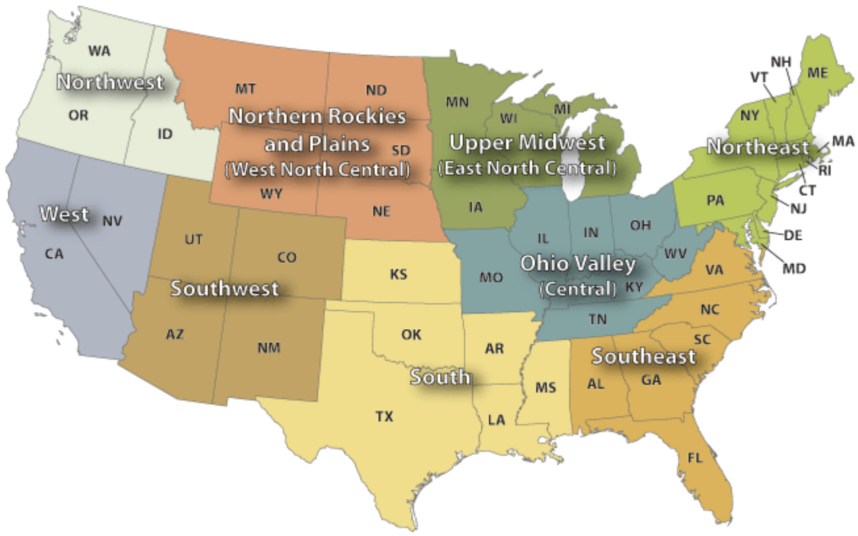

Figure 9: NOAA Climate Regions (National Oceanic and Atmospheric Administration, 2013)

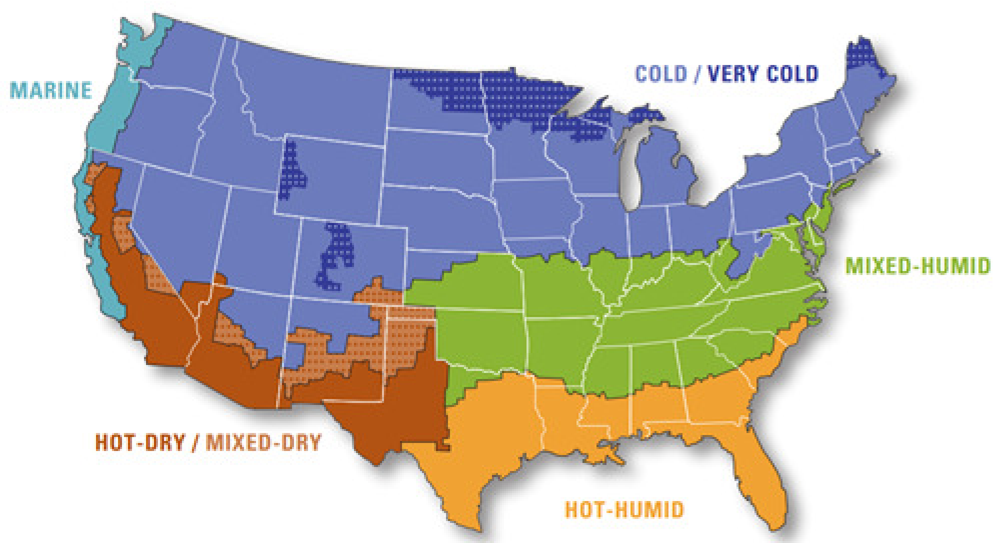

Figure 10: EERE Climate Regions (US Department of Energy, 2010)

Data Analysis

To check sample representativeness, credits earned and owner types were analyzed. The percentages of projects earning each WE credit were approximately equal in the population and the sample. The stratified random sampling by owner type was verified with the percentages of projects mentioning each owner type being equal in the population and the sample.

The data source was forms filled out by project representatives. These documents only indicate design choices, and so represent the intentions that are the focus of this study. The design of the forms allowed for the flexibility in compliance that the USGBC intended. As a consequence of this flexibility, there was significant variability in how technologies used to achieve compliance with WEc3 were described on the forms. Where possible, toilet makes and models as described were used as the defining characteristic for these fixtures, and fixture types and flush rates entered on the forms were standardized, verified, and updated as necessary to achieve consistency with product specifications for the models on the forms. When no make or model was provided, provided fixture types and flow rates were taken as correct. WEc1 did not have this problem for the characteristic examined, as it allowed projects to select one of four mutually exclusive options on the form indicating a reduction in potable water use, a non-potable water source, a combination of the two, or no permanent irrigation whatsoever.

Locations in the USGBC project database are entered by project representatives. They provide cities and states for each project. The cities were given county designations by geographical locations using ArcGIS, and these counties along with state designations were used to assign climate regions from NOAA and EERE classification systems.

Contingency analysis was performed on the data, to determine whether differences existed in distributions for each characteristic across climate regions under each system. Tukey pairwise comparison was also performed for each characteristic and climate classification system to determine which regions differed from each other under a rigorous test. This test identified groups of regions that were not statistically different from each other, and assigned regions to all groups that they fit into. For all tests, an alpha of 0.05 was used for a confidence of 95%.

Results

The tests of characteristic variations within each climate region classification system indicated that significant differences likely existed for all but two cases (Table 4), non-water urinals in the EERE system and high efficiency urinals in the NOAA system. What follows are details for each characteristic examined. Tukey's pairwise analysis was performed for a rigorous test of characteristic-region combinations. These tests show which regions differ from each other for each characteristic.

Table 4: Results of statistical analysis of differences within each climate region classification system

Characteristic	EERE		NOAA	
	Result	P-Value	Result	P-Value
WEc1				
Option	Difference	<0.0001	Difference	<0.0001
WEc3				
Urinal - High Efficiency	Difference	0.0473	No Difference	0.3582
Urinal - Non Water	No Difference	0.2612	Difference	0.0413
WC - Dual Flush	Difference	0.0005	Difference	<0.0001
WC - High Efficiency	Difference	0.0379	Difference	0.0031

WEc1: Option for Water Efficient Landscaping

Projects seeking credits under WEc1 had the choice of one of four options:

- A: Reduced Irrigation Consumption Only
- B: Non-Potable Irrigation Source Only
- C: Reduced Irrigation and Non-Potable Irrigation Source
- D: No Permanent Irrigation

The analysis showed that option selection differences between climate regions in both classification systems were statistically significant (Table 4). Mosaic plots (Figure 11, Figure 12) were generated to illustrate this graphically. In these plots, column widths represent the proportion of the sample present in that region, totaling 100% of the sample, illustrating the different number of projects from the sample in each region. An 'overall' column is also provided, to see the percentage of the entire sample selecting the characteristic. Pairwise analysis (Figure 5, Table 6), which compares two regions to each other at a time, proves this with most comparisons showing a p-value below 0.05, indicating a greater than 95% confidence in the result. Differences were shown to exist between all EERE regions, and most NOAA regions.

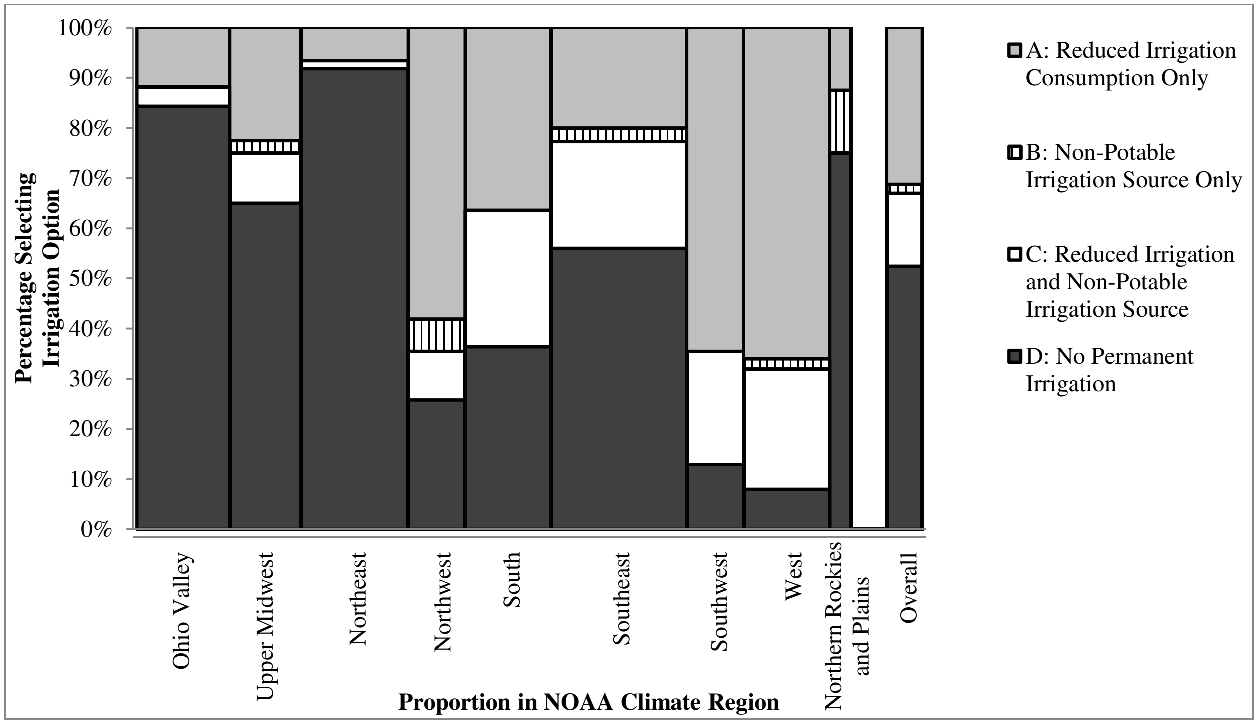

Figure 11: NOAA Irrigation Option Mosaic Plot

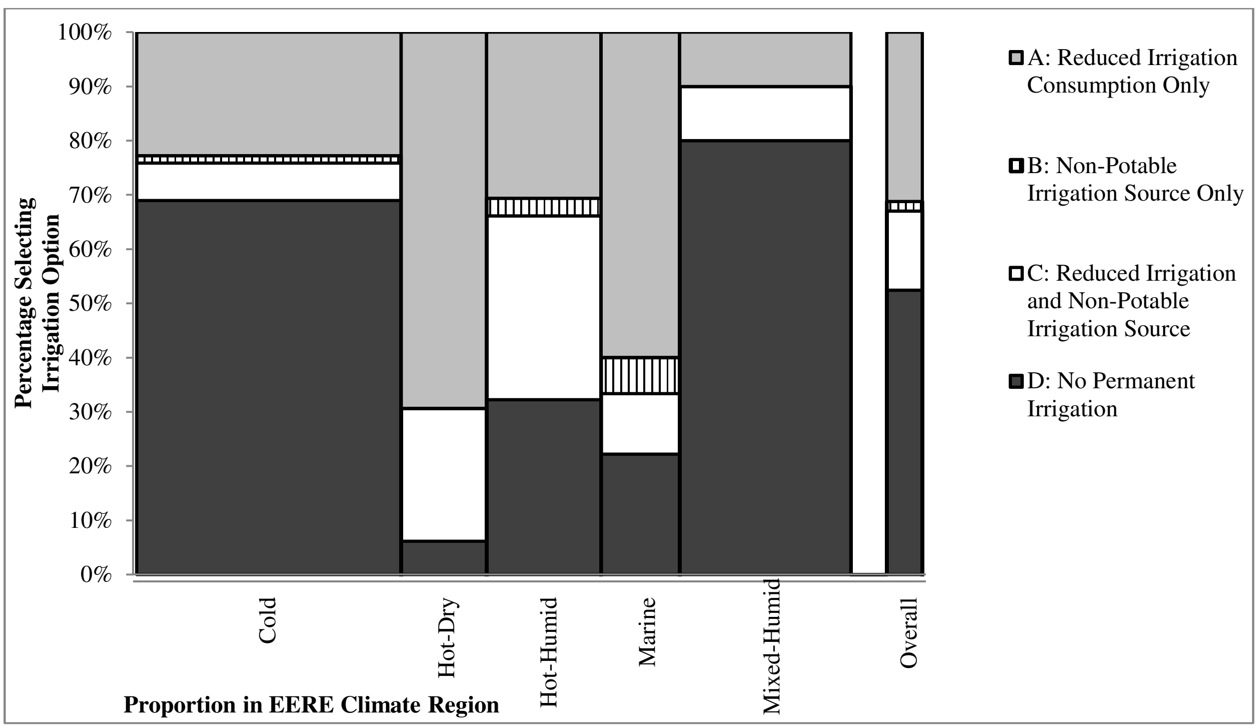

Figure 12: EERE Irrigation Option Mosaic Plot

Table 5: NOAA Irrigation Option comparison p-values.

	Ohio Valley	Upper Midwest	Northwest	South	Southeast	Southwest	West	Northern Rockies & Plains
Ohio Valley	0.1346	0.4583	<0.0001	<0.0001	0.0022	<0.0001	<0.0001	0.1988
Upper Midwest		0.0070	0.0060	0.0206	0.4676	<0.0001	<0.0001	0.3773
Northeast			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.1660
Northwest				0.0277	0.0009	0.1175	0.0586	0.0320
South					0.0632	0.0270	0.0021	0.0104
Southeast						<0.0001	<0.0001	0.1602
Southwest							0.6961	0.0004
West								<0.0001
Key:	>99.99% Confidence	>95% Confidence						

Table 6: EERE Irrigation Option comparison p-values.

	Hot-Dry	Hot-Humid	Marine	Mixed-Humid
Cold	<0.0001	<0.0001	<0.0001	0.0294
Hot-Dry		<0.0001	0.0362	<0.0001
Hot-Humid			0.0049	<0.0001
Marine				<0.0001
Key:	>99.99% Confidence	>95% Confidence		

WEc3 Characteristics

Some differences in WEc3 existed between regions in both climate systems, but these were not as pronounced as within WEc1. Within the NOAA system (Table 7), only the water closets showed some inter-regional differences. The Northwest region showed this the most, differentiating itself from all but the Northeast and Southwest regions with dual flush water closets. The Northwest also differed to a lesser extent with high efficiency water closets, showing differences only with the Southeast and Northern Rockies & Plains regions. Within the EERE system (Table 8), more differentiation was shown. The Marine region differed from all others with dual flush water closets. With high efficiency water closets, the Marine and Hot-Humid regions differed only from each other. This system, unlike the other, showed some difference in high efficiency urinals, with the Hot-Dry region differing from the Mixed-Humid and Marine regions.

Table 7: NOAA statistically significant differences from pairwise analysis.

Feature Selection	**Statistically Significant NOAA Region Differences**		
	Selected Feature	**More Than**	**Selected Feature**
Water Closet - Dual Flush	Northwest	>	Ohio Valley
		>	Upper Midwest
		>	South
		>	Southeast
		>	West
		>	Northern Rockies & Plains
Water Closet - High Efficiency	Southeast	>	Northwest
	Northern Rockies & Plains	>	Northwest
Urinal - Non Water	(None)		
Urinal - High Efficiency	(None)		

Table 8: EERE statistically significant differences from pairwise analysis.

Feature Selection	**Statistically Significant EERE Region Differences**		
	Selected Feature	**More Than**	**Selected Feature**
Water Closet - Dual Flush	Marine	>	Cold
		>	Hot-Dry
		>	Hot-Humid
		>	Mixed-Humid
Water Closet - High Efficiency	Hot-Humid	>	Marine
Urinal - Non Water	(None)		
Urinal - High Efficiency	Hot-Dry	>	Marine
		>	Mixed-Humid

WEc3: Water Closet – Dual Flush

Statistical analysis (Table 4) showed that dual flush water closet use differs between NOAA climate regions, as well as between EERE climate regions. The mosaic plots (

Figure 13, Figure 14) make the differences visible. Pairwise analysis confirmed the difference. For the NOAA system, the Northwest region had the highest inclusion rate, and showed statistically significant difference from all but the Northeast and Southwest regions (Table 7). Other differences existed, such as the low selection rate in the Northern Rockies & Plains region, but these were not statistically significant. For the EERE system, the Marine region was shown to differ from the rest, using dual flush water closets more than the other regions (Table 7).

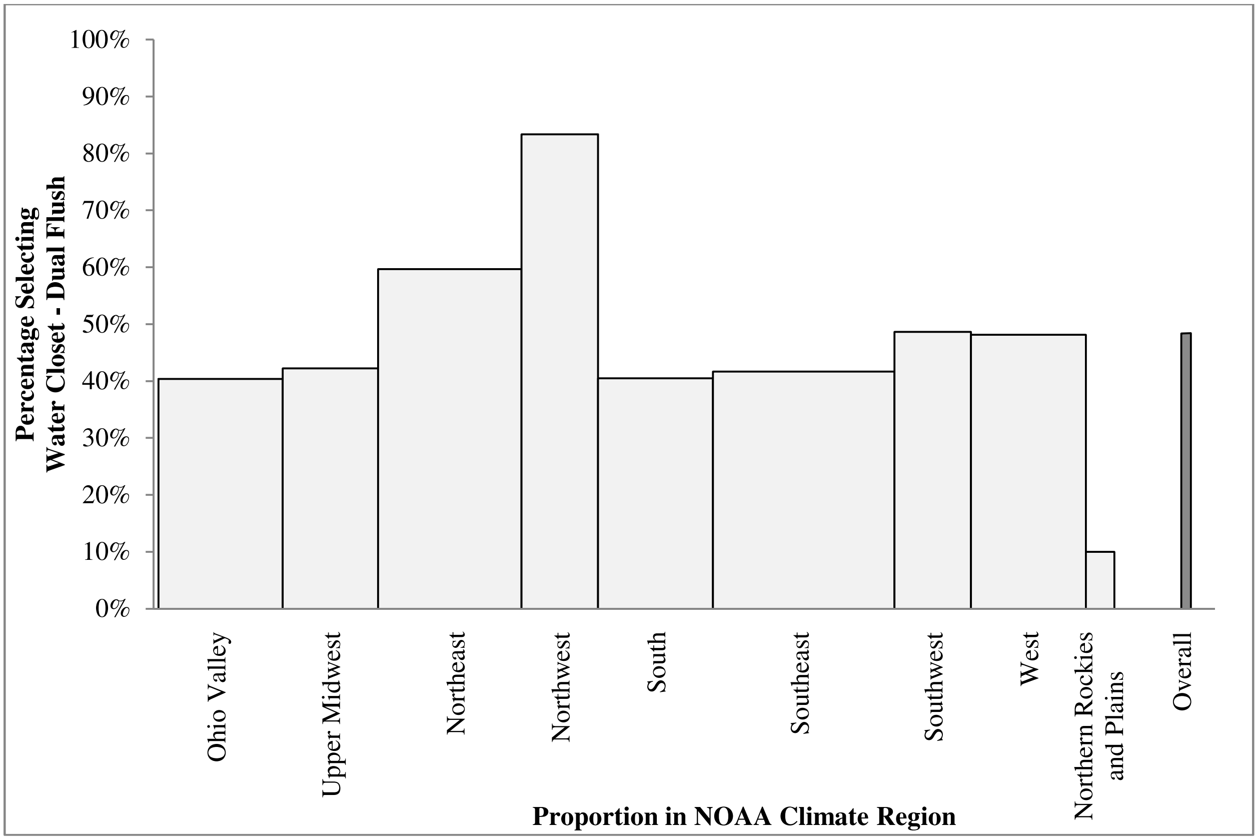

Figure 13: NOAA Dual Flush Water Closet use.

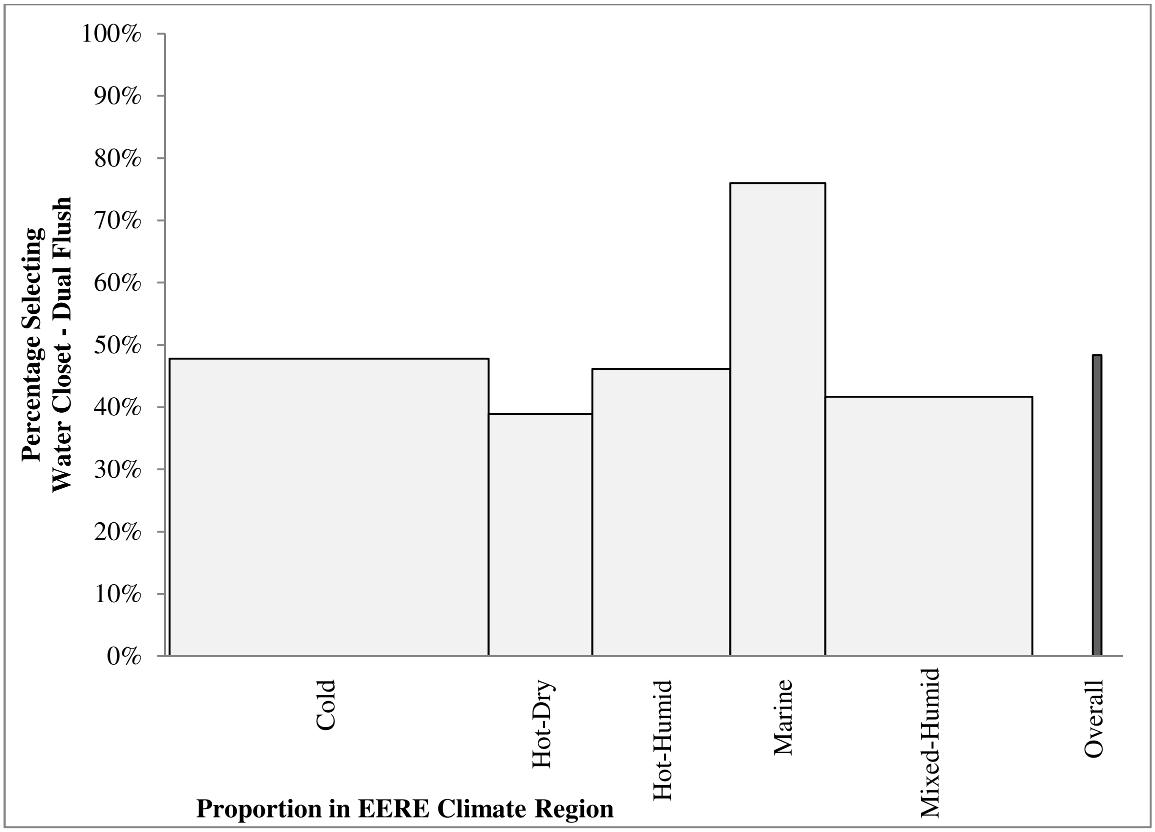

Figure 14: EERE Dual Flush Water Closet use.

WEc3: Water Closet – High Efficiency

Statistical analysis (Table 4) showed that high efficiency water closet use differs between NOAA climate regions, as well as between EERE climate regions. The mosaic plots (Figure 15, Figure 16) make the differences visible. Pairwise analysis confirmed this. For the NOAA system, the Northwest region selected these features significantly less than the Southeast and Northern Rockies & Plains regions, but did not differ in a statistically significant degree from the other regions (Table 7). The EERE system showed differences between the Hot-Humid region's high selection rate and Marine region's low selection rate (Table 8).

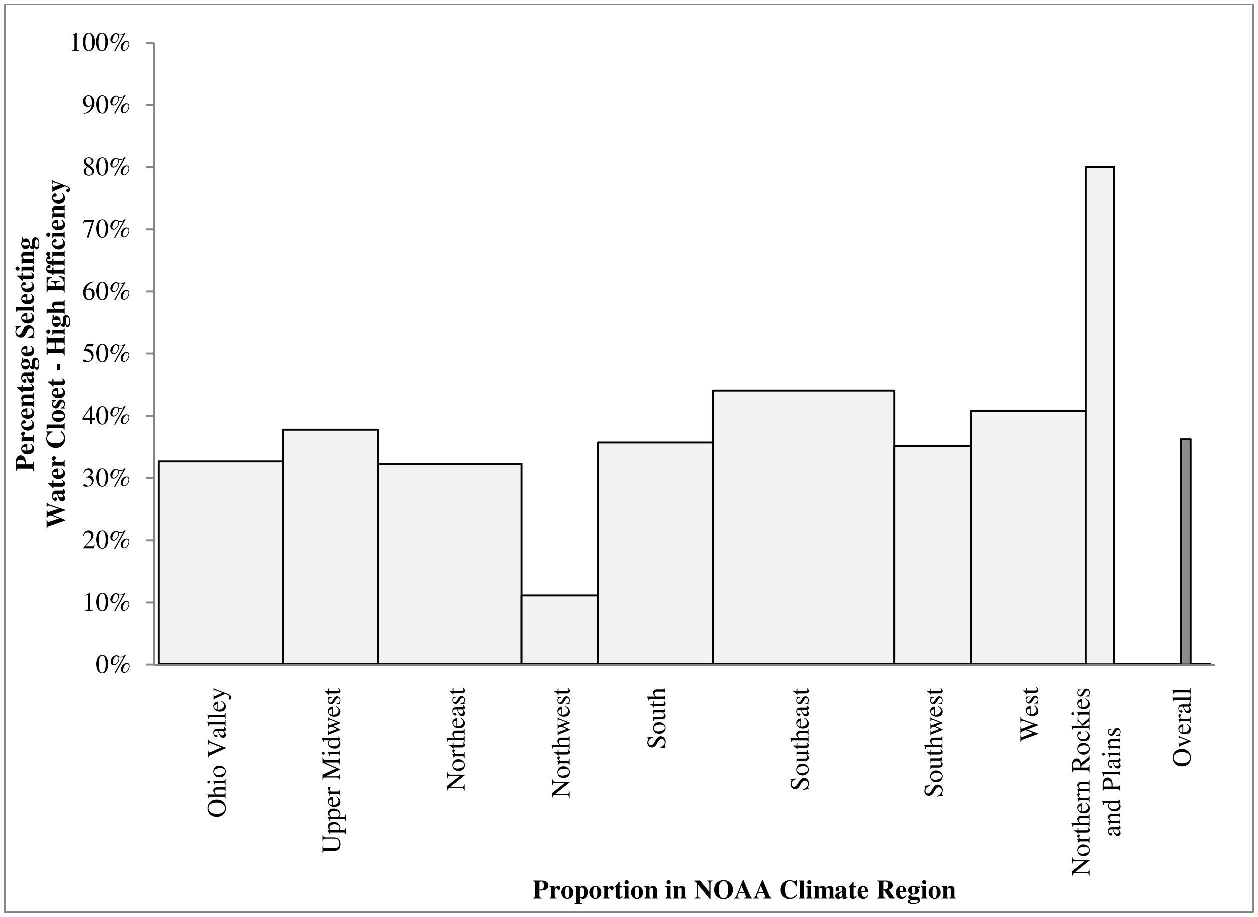

Figure 15: NOAA High Efficiency Water Closet use.

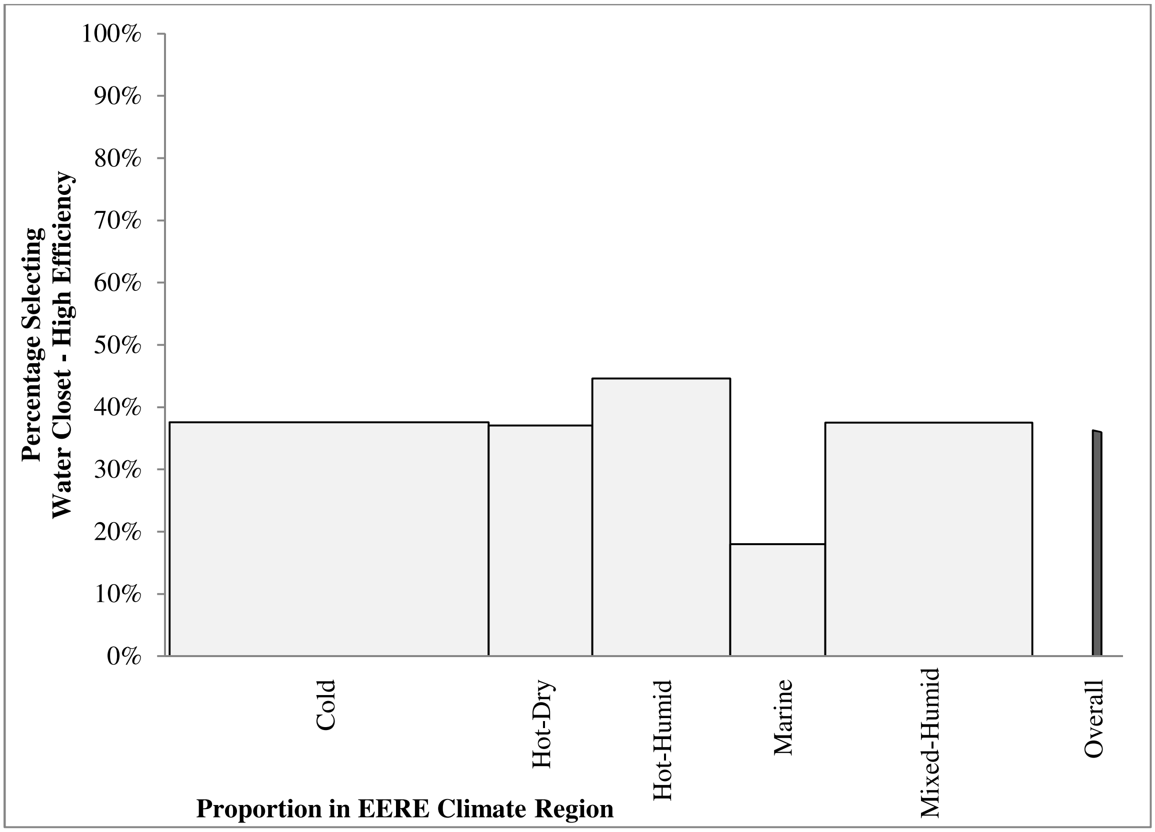

Figure 16: EERE High Efficiency Water Closet use.

WEc3: Urinal – High Efficiency

Statistical analysis (Table 4) showed that high efficiency water closet use differs between EERE climate regions but not NOAA regions. The mosaic plots (Figure 17, Figure 18) show the distributions. Pairwise analysis confirmed the difference in the EERE system (Table 7) and lack of difference in the NOAA system (Table 7). The Mixed-Humid and Marine regions showed statistically significant difference from the Hot-Dry region.

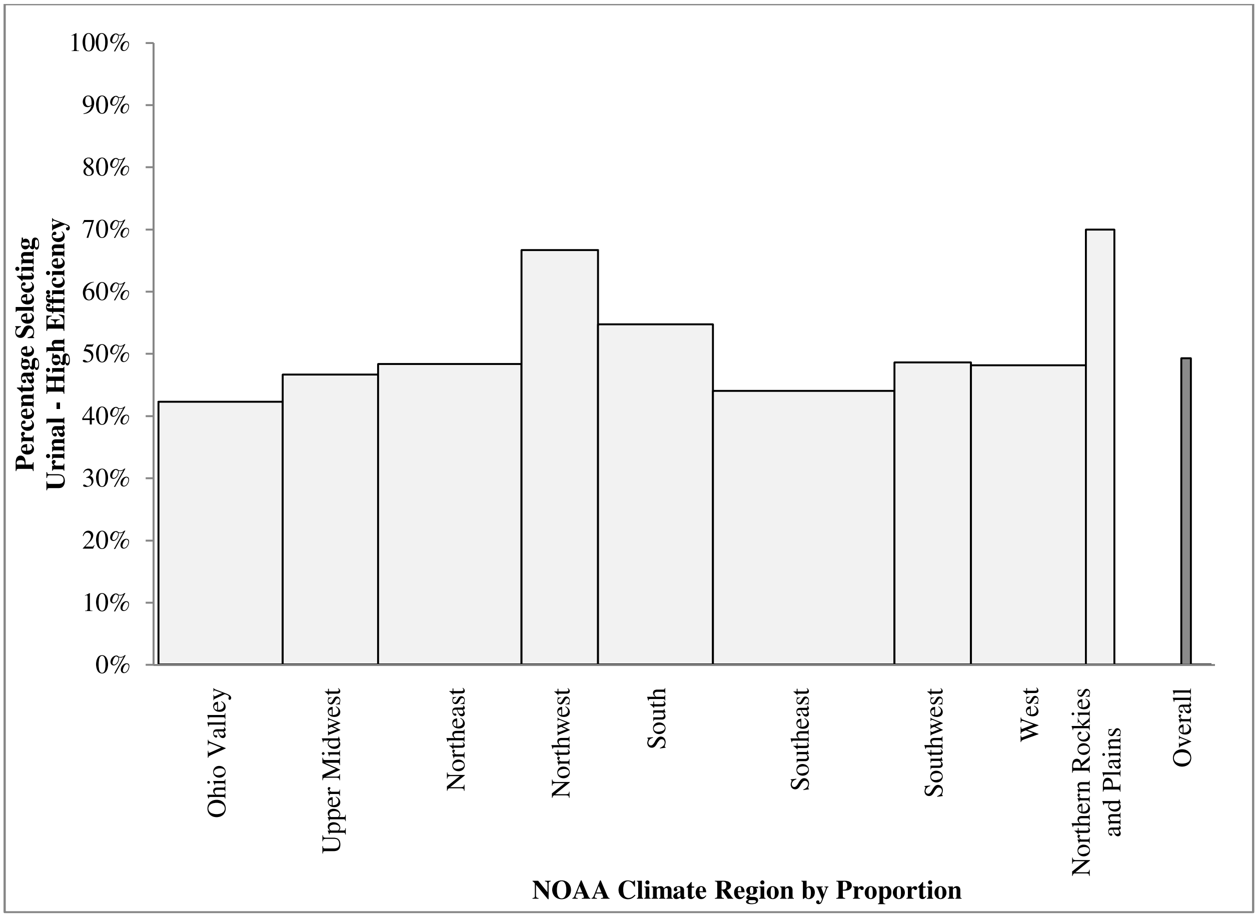

Figure 17: NOAA High Efficiency Urinal use.

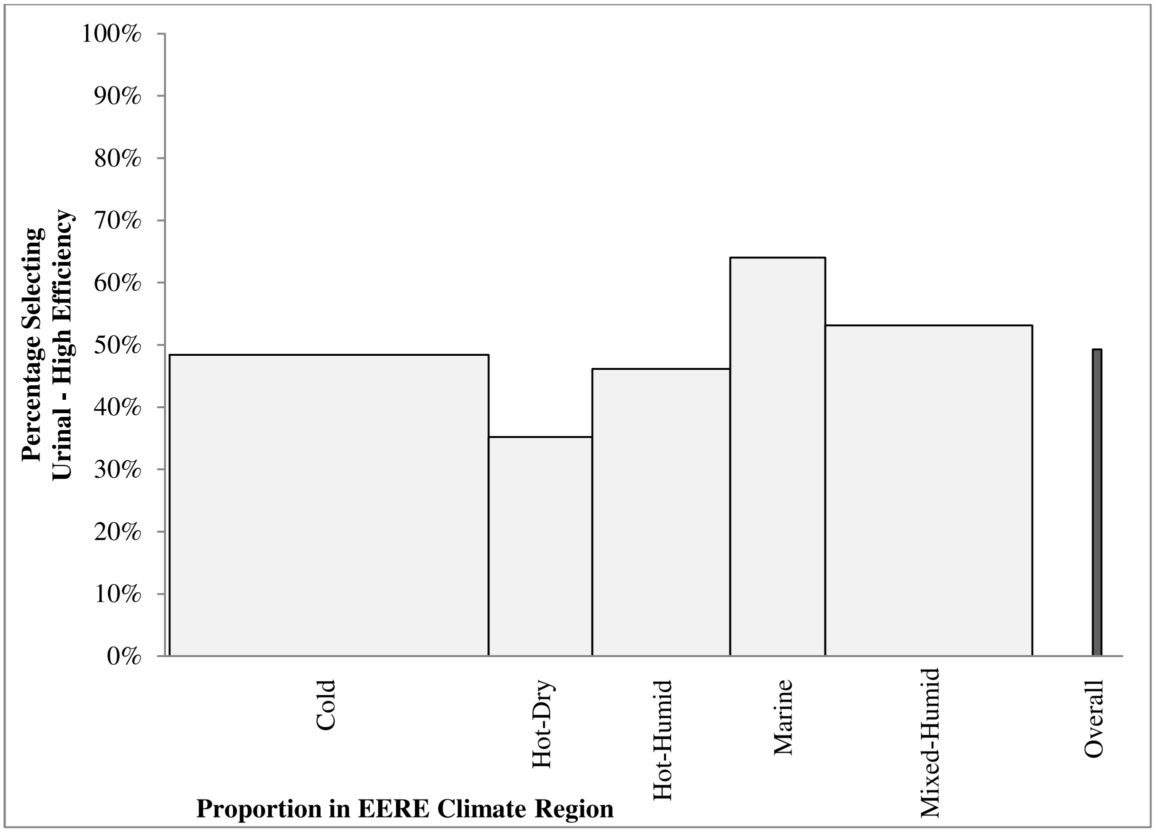

Figure 18: EERE High Efficiency Urinal use.

WEc3: Urinal – Non Water

Statistical analysis (Table 4) suggested that high efficiency water closet use differs between NOAA climate regions but not EERE regions. The mosaic plots (Figure 19, Figure 20) make the differences visible. Interestingly, the more conservative pairwise analysis (Table 7) shows that this conclusion about differences in NOAA regions is not actually strong enough to call significant. The lack of significant difference in EERE regions is borne up under the Tukey test (Table 8).

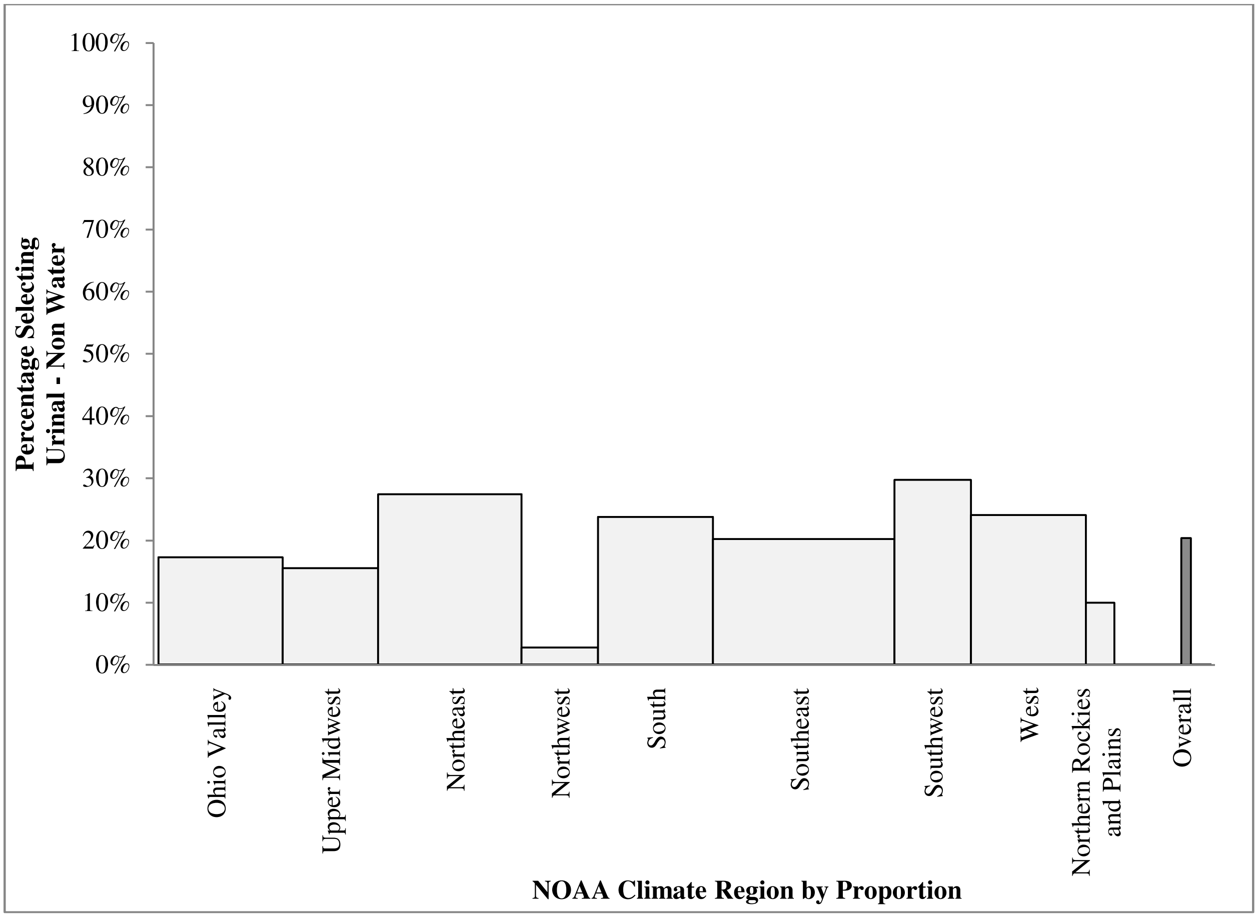

Figure 19: NOAA Non Water Urinal use.

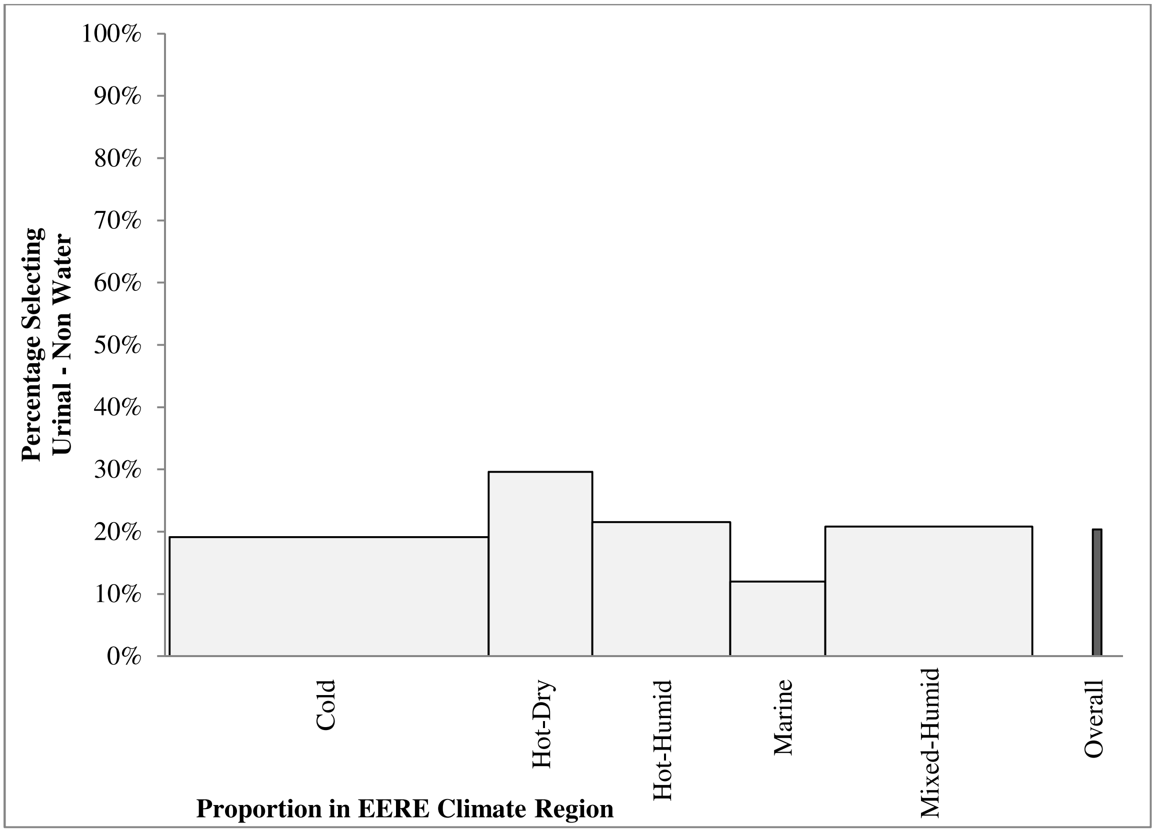

Figure 20: EERE Non Water Urinal use.

Conclusions

These results suggest that landscape water use design decisions for LEED NC v2.2 projects were influenced by climate factors. This may have to do with practices already in place in those regions, or because the impact of regional rain water availability is most visible outside in the landscaping.

Irrigation selections showed differences between most regions under both climate systems. It should be noted that the choice of no permanent irrigation was least used in the Hot-Dry EERE region and three western NOAA regions. This may be related to societal expectations for landscaping that require more water than is naturally available in that region.

Toilet selections showed differences between fewer regions than did irrigation selections, and in fact were not significant in non-water urinals. The higher selection rates of dual flush water closets and lower selection rates of high efficiency water closets in the NOAA Northwest and EERE Marine environments suggests that in these water rich regions, there is a preference for dual flush toilets. With non-water urinals, the name clearly indicates lower water usage, so one might expect them to be significantly more popular in water-sensitive regions. The distribution graphs indicate that they are included in designs in the hot-dry climate region more often than other EERE regions, but the difference is not statistically significant.

It should be noted that the two climate systems have similar results, at least in terms of the existence of statistically significant differences. Given the geographical basis of the NOAA system and the larger scale climate basis of the EERE system, this suggests that selections are different between geographical regions as well as climate regions. It is hard to draw a comparison between the two systems, given that the EERE regions tend to overlap so many NOAA regions. However, the EERE Marine region is quite small, and overlaps most of the more densely populated areas in the NOAA Northwest region. This could explain the very strong similarity between these two regions in several categories, most notably dual flush water closets.

These results indicate that while some LEED v2.2 water efficiency design decisions were different between climate regions, there was still room for further climate specificity. The inclusion of climate specific guidelines within the newer green building rating systems could make climate specificity more prevalent in green building water efficiency strategies, especially with regard to plumbing fixtures.

Future Research

This research demonstrated that differences existed in some water efficiency design choices, but the data examined did not include any information about why these design choices were made. Future research is needed to identify these reasons. Some possible influences to investigate are the input of various stakeholders in the design process, local and regional water efficiency legislation, and local water sensitivity related to non-climate factors such as demand.

Another limitation of this study was that no comparison was made with projects where regional climate needs were mentioned in the rating system. As climate specificity becomes prevalent in green building guidelines and certification programs, it would be interesting to learn whether projects are actually making a point of selecting water efficiency measures appropriate for the climate and the region's water resource sensitivity.

Acknowledgments

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Chapter 5: Green Building Water Systems: User Satisfaction and Experiences

Green Building Water Systems: User Satisfaction and Experiences

Benjamin D. Chambers, Annie R. Pearce, Marc A. Edwards, Randel L. Dymond

Abstract

An internet survey was developed to synthesize experiences of green building professionals with water conservation related innovations. The survey was distributed by the US Green Building Council and other venues, including LinkedIn and several mailing lists. Participants rated their experiences with 33 types of innovations, and indicated problems they had experienced. The most common problems were due to pipe leaks and clogs, insufficient hot water, premature system failure, and complaints about taste, odor, or coloration. A majority of respondent ratings were positive or neutral. Green landscaping innovations were overwhelmingly positive in all categories. Non-water urinals and toilets had the most negative response distributions, followed by blackwater and greywater recovery systems.

Introduction

Many green buildings utilize innovations that reduce dependency on external resources by reducing the use of potable water or limit the production of wastewater. Multiple environmental, ethical, and financial factors are involved in implementation of such systems, but an important incentive is criteria for green building certifications such as the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) program, which has certified over ten thousand projects in the United States (US Green Building Council, 2013).

The paths to compliance in contemporary green building rating systems typically allow for a wide range of techniques and technologies to be employed in a project. Because the requirements for water use in these green buildings are different from traditional buildings, the water solutions used may of necessity be atypical or new innovations.

The reactions of early adopters to these innovations can greatly influence public opinion and future adoption of the innovations (Rogers, 2003). Anecdotal evidence exists to support the conclusion that some systems are creating negative experiences. These include pipe corrosion and bad smells associated with non-water urinals (Guevarra, 2010; Shapiro, 2010), increased water usage from long showers (Walker, 2009), and site inappropriate system installation (Bray and McCurry, 2006). Some technologies have been studied systematically, especially with regard to opportunistic pathogens in water heater systems (Bagh et al., 2004; Brazeau and Edwards, 2011; Codony et al., 2002; Mathys et al., 2008). However, a review of the literature yields no comprehensive study of water systems in green buildings or any scholarly synthesis of water system experiences and satisfaction.

This research addressed this issue by collecting green building professionals' perceptions of innovations related to water conservation in buildings through an internet survey. Participation was open to any green building professional that had experience with water conservation related systems. The USGBC's network of these professionals was initially utilized, and several other professional and government organizations were added to increase participation.

Innovations considered included technologies and operational practices intended to assist in water conservation in green buildings. A comprehensive list of innovation types was created by the researchers, in order to help participants describe their experiences. The survey identified which of these innovation types were generating positive and negative experiences, as well as the most common problems.

Research Methodology

An internet survey queried adopters about known problems, gave participants the opportunity to rate their satisfaction with various systems, and allowed them to describe these experiences.

Distribution

The survey was initially distributed by the US Green Building Council (USGBC) through several of their internet-based social networking tools (USGBC Yammer, USGBC Chapter Newsletters, USGBC Education Portal, USGBC National Newsletter), as well as through their contact for an official post at LEEDUser.com. To gather additional responses, several contacts were used to distribute the survey to a list of federal facility managers through the US General Services Administration, the US Department of Energy, and the US Interagency Sustainability Working Group. Distribution was also made through the Society of Building Science Educators listserv, the Water Research Foundation mailing list, the Green Building Alliance newsletter, and direct email to a list of members of the Associated General Contractors (AGC). Several postings were also made to LinkedIn on various green building boards. It is impossible to know how many individuals saw or received the invitation, as membership in most of these mailing lists is confidential, as is the number of reads the pages receive. What is known is that the AGC mailing list used was 4008 members strong, and that the USBGC and LinkedIn forums are active. The survey link was opened by 166 distinct IP addresses.

Survey Content

Because of the length and breadth of the survey, respondents were first taken to a ‘short’ overview page, where they were asked whether they had experienced any of the problems that researchers suspected might be most common. These known problems were based on the literature and the experiences of the researchers. Nine general issues were described (Table 9).

Table 9: Known problems asked about on survey.

One or more water-related systems have had to be replaced before the end of their design life.
There have been user complaints about water taste, odors, or coloration.
There have been user complaints about water temperature.
There have been complaints about insufficient hot water.
A significant number of building users drink bottled water instead of tap water.
There have been leaks or clogging of pipes.
There have been capacity problems, including inability to handle water demand or undesired accumulation/diversion of wastewater/stormwater.
Building occupants have perceived illness (or other health concerns) as being related to green water systems.
Water tests show contamination.

To get the breadth of water conservation related innovations, a comprehensive list of innovation types was created (Table 10). This list contained 33 innovations, divided into 9 categories. The list was based on facility features mentioned in LEED documentation and the professional experience of the research team.

Table 10: Categories of innovations included in user satisfaction portion of survey.

Category	Innovation
Toilet and Urinal	Water Conserving Toilets Waterless Toilets Waterless Urinals Alternative Flushometer Valves
Shower and Faucet Fixtures	Low Flow Fixtures Alternative Controls Self-Powering
Plumbing	Alternative Piping Manifold Distribution Cured-in-Place Pipe Lining High Performance Epoxies
Water Heating	Recirculation On-Demand Solar Heat Recovery
Appliances	Water-Efficient Dishwashers Water-Efficient Clothes Washers Water-Efficient Icemakers
Alternative Water Sources	Rainwater Harvesting Greywater Reuse Blackwater Reuse Process Water Recycling/Reuse Condensate Recovery Municipal Nonpotable
Landscaping	High Efficiency Irrigation Water Conserving Plant Selection Green Stormwater Retention and Infiltration Grey Stormwater Retention and Infiltration
Performance Monitoring	Water Audits Sub-Metering
User Education	Feedback on Water Use Signage and Educational Materials Behavioral Policies and Incentives

Survey Format

In order to gather information on professional experiences with water systems in green buildings, an internet survey was created using the tools provided by Qualtrics. The survey was broken into several sections, with a 'short form' at the beginning asking about the known problem types (Table 9), to help with classification of negative experiences. Respondents were asked to check boxes for each problem experienced, and were given an opportunity to describe other problems. This was followed by questions about the 33 innovations (Table 10), with a page for each of the nine categories. Respondents were asked to rate experiences with innovations in each category on a Likert scale, with the options No Experience, Extremely Disappointing, Somewhat Disappointing, Indifferent, Satisfying, and Far Exceeded Expectations. Respondents were able to select more than one rating for each innovation. Negative responses were followed with open ended questions about the types of innovations, the problems, and their resolution. Responses of Far Exceeded Expectations were followed with open ended questions about the types of innovations and their success.

Results

The survey link was opened by a total of 166 distinct IP addresses. Of those that opened the link, 95 individuals went past the introductory pages to report problems with green water systems, and 76 of those continued on to respond to some or all of the remaining innovation ratings pages. Response counts are provided in the data summary section. The predominant professional roles of respondents are presented in Table 11. Professional experiences with green building water systems are presented in Table 12.

Table 11: Predominant professional roles of respondents.

Role	Percentage
Constructor	3%
Designer	34%
Educator	13%
Facility Manager	5%
Inspector	7%
Occupant/User	4%
Operator/Maintainer	3%
Owner	4%
Planner	3%
Product Manufacturer	3%
Utility Service Provider	3%
Other	18%

Table 12: Experience questions.

Question	% Yes
Are you involved in building operations or maintenance?	38%
Have you ever been involved in the design, construction or operation of a building utilizing green water innovations?	84%
Have you ever been an occupant of a building utilizing green water technologies?	76%

Known Problem Types

Of the 95 respondents summarized in this report, nine did not provide any answers after the demographics page, suggesting that their responses should be omitted. However, other respondents did not indicate experience with any of the known water problems, but did share other experiences later. For this analysis it is assumed that the nine respondents did not experience the known water problems, and thus they are included in the total for this section. These responses for known water problems are collected below (Table 13). Problems with leaks or clogging of pipes were most reported, followed closely by complaints about hot water supply, early failure of systems, and complaints about water taste, odors, or coloration. Very few respondents reported occupants perceiving health concerns related to green water systems, and fewer reported demonstrated incidence of contamination verified by water tests.

Table 13: Known problem type results.

Problem Description	Percentage (of 95)
There have been leaks or clogging of pipes.	32%
There have been complaints about insufficient hot water.	31%
One or more water-related systems have had to be replaced before the end of their design life.	29%
There have been user complaints about water taste, odors, or coloration.	29%
A significant number of building users drink bottled water instead of tap water.	22%
There have been user complaints about water temperature.	21%
There have been capacity problems, including inability to handle water demand or undesired accumulation/diversion of wastewater/stormwater.	14%
Building occupants have perceived illness (or other health concerns) as being related to green water systems.	6%
Water tests show contamination.	2%
Other	18%

Innovation Ratings

When asked to describe their experiences with specific water-related innovations in buildings, respondents reported a variety of satisfaction levels and experiences. The nine categories of innovations are presented separately here, with charts describing the distribution of ratings for each innovation type. Not all respondents had experience with each innovation, so some innovations had relatively low rating counts. The count of ratings for each type is provided in the charts with type titles, as well as the number of respondents that viewed the category. Summaries paraphrasing free response data are also included to illustrate the experiences respondents had. Explanations of innovation types which were provided through mouse-over text on the surveys are also included in the summary tables.

Toilets

The Toilet category contained classes of toilets, urinals, and flushometer valves. Toilet responses (Figure 21) show a large share of negative experiences for non-water options, with 46% for non-water toilets and 58% for non-water urinals. Results were generally positive for water conserving toilets, as well as alternative flushometer valves.

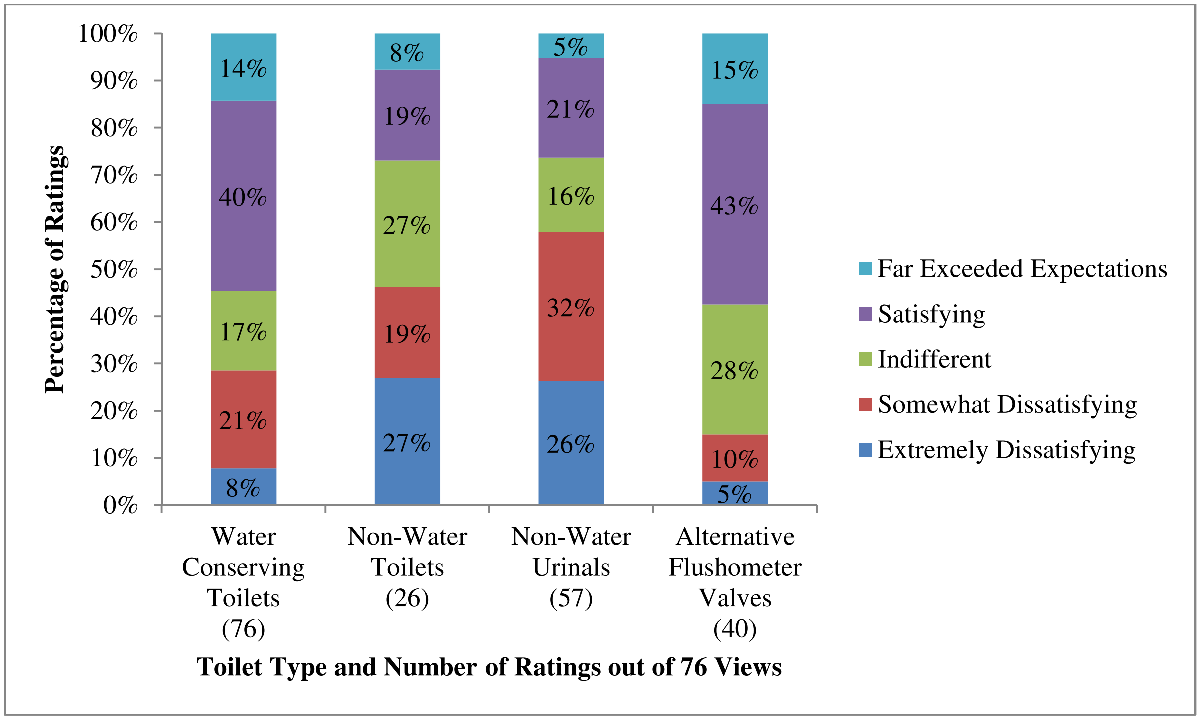

Figure 21: Response breakdown for Toilet category.

With toilet innovations, positive experiences reported by respondents focused mainly on effective function of the innovation in saving water (Table 14). Those that described them said they were pleased that the toilet worked well or as intended, and that they were happy about their ability to save water. Negative experiences were slightly more varied. Some respondents said that their water conserving toilets did not have sufficient flow to clean the bowl, or to carry waste through the lines, and required multiple flushes. Non-water options received negative responses related to odor, cleanliness, and difficult maintenance. Non-water urinal negative responses reported maintenance staff being unable or unwilling to deal with maintenance procedures. Clogging from salts was also reported. Alternative flushometer valves also received complaints. Respondents perceived that dual-flush valves were often used on the higher volume flush when a low volume would suffice, either through habit or ignorance. Automatic flush valves were triggered by mistake, either from poorly calibrated sensors or non-elimination uses of stalls, such as changing clothes.

Table 14: Experiences described for Toilet category.

Type & Alt Text	Positive Experiences	Negative Experiences
Water Conserving Toilets Low-flow, high efficiency toilets (HETs), dual-flush toilets, pressure-assisted toilets, etc.	• Worked well or as intended • Easy way to conserve water	• Insufficient flushing power to clear bowl • Insufficient water for line carry
Non-Water Toilets Composting, incinerating, foam-flush, vacuum-flush, etc.	• Worked well or as intended	• Odor • Difficult to maintain • Cleanliness
Non-Water Urinals	• Worked well or as intended • Water conservation	• Improperly trained maintenance staff led to failures • Odor • Line clogging from salts • Cleanliness
Alternative Flushometer Valves Dual-flush, automated flush, self-powered, timed, solar-powered, etc.	• Worked well or as intended • Water conservation	• Automatic flush sensors are triggered more than necessary • Dual flush valves often used on the wrong flush option

Shower and Faucet Fixtures

The Shower and Faucet Fixtures category included low flow fixtures, as well as controls and self-powering control mechanisms. Responses for shower and faucet fixtures (Figure 22) show similar degrees of positivity for each type. Low flow fixtures showed 33% dissatisfaction, with about twice as many ratings given as the other two types in this category. Alternative controls were met with 45% indifferent ratings.

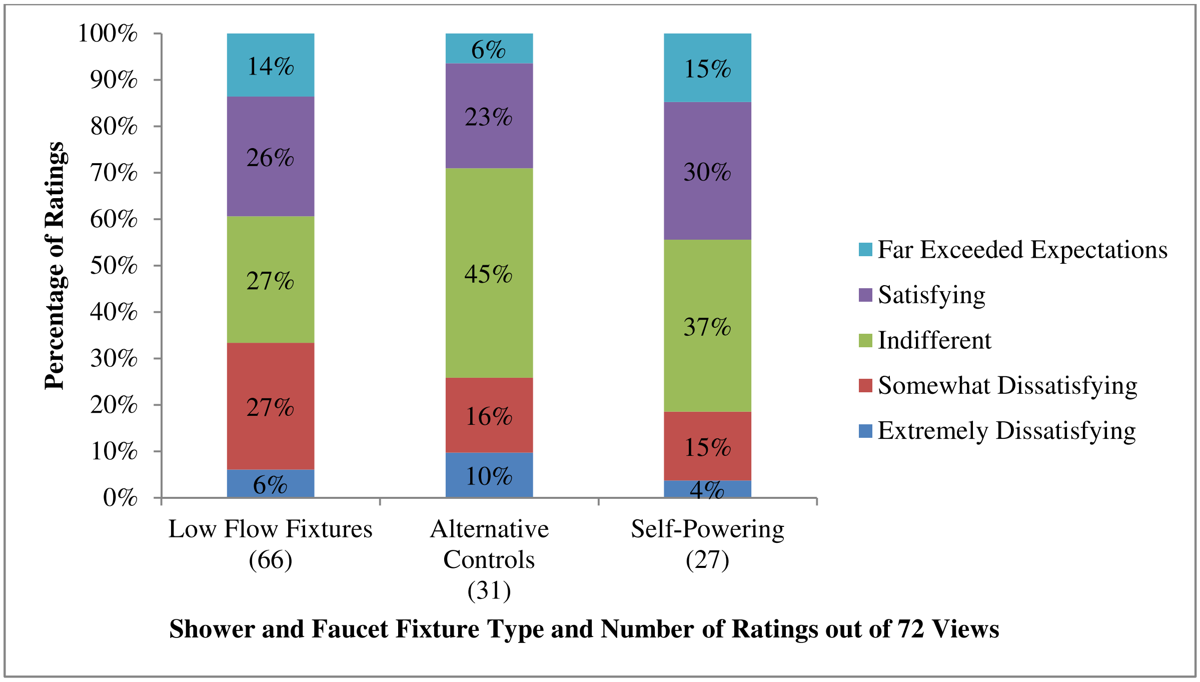

Figure 22: Response breakdown for Shower and Faucet Fixture category.

With low flow shower and faucet fixtures, positive experiences described mostly involved the fixtures working well, and pleasure at the ability to easily conserve water (Table 15). One respondent said that they were happy to note that their customers did not notice a switch to high efficiency bathroom sink faucets. Negative experiences involved inconsistent or too little flow, and extended waits for hot water. Respondents also indicated that the lower flow can be insufficient to clear and clean the drain pipes. In buildings requiring high water pressure or fire suppression systems, there were complaints about excessive splashing in sinks. Positive alternative control experiences involved the controls working well, and users being pleased about not having to touch controls in public bathrooms. Complaints were about cycle length and sensor mechanisms that were difficult to trigger. For self-powering fixtures, positive experiences given only described fixtures working well. Negative experiences involved early battery failures.

Table 15: Experiences described for Shower and Faucet Fixture type.

Type & Alt Text	Positive Experiences	Negative Experiences
Low Flow Fixtures Restricted, aerated, laminar flow, etc. Better than code requirements	• Worked well or as intended • Users did not notice switch • Water conservation	• Increased hot water delivery time • Too little flow in shower • Inconsistent flow • Splashing in buildings that maintain high water pressure for fire suppression system • Insufficient water for line carry
Alternative Controls Metered, timed, trickle valves, sensor-activation, foot activation, etc.	• Worked well or as intended • Enjoyed not having to touch controls	• Cycle too short • Automatic sink sensors difficult to trigger or keep triggered
Self-Powering Microturbine powered, solar powered, etc.	• Worked well or as intended	• Early battery failures

Plumbing

The Plumbing category included alternative piping materials, manifold distribution, cured-in-place pipe lining, and high performance epoxies for joints and sealing. The lining and epoxies types had the lowest number of ratings of any innovation type in this study. Plumbing responses (Figure 23) were largely positive or indifferent for alternative piping and manifold distribution, with all types having over 40% indifferent responses. Very few respondents reported experience with cured-in-place pipe lining or high performance epoxies.

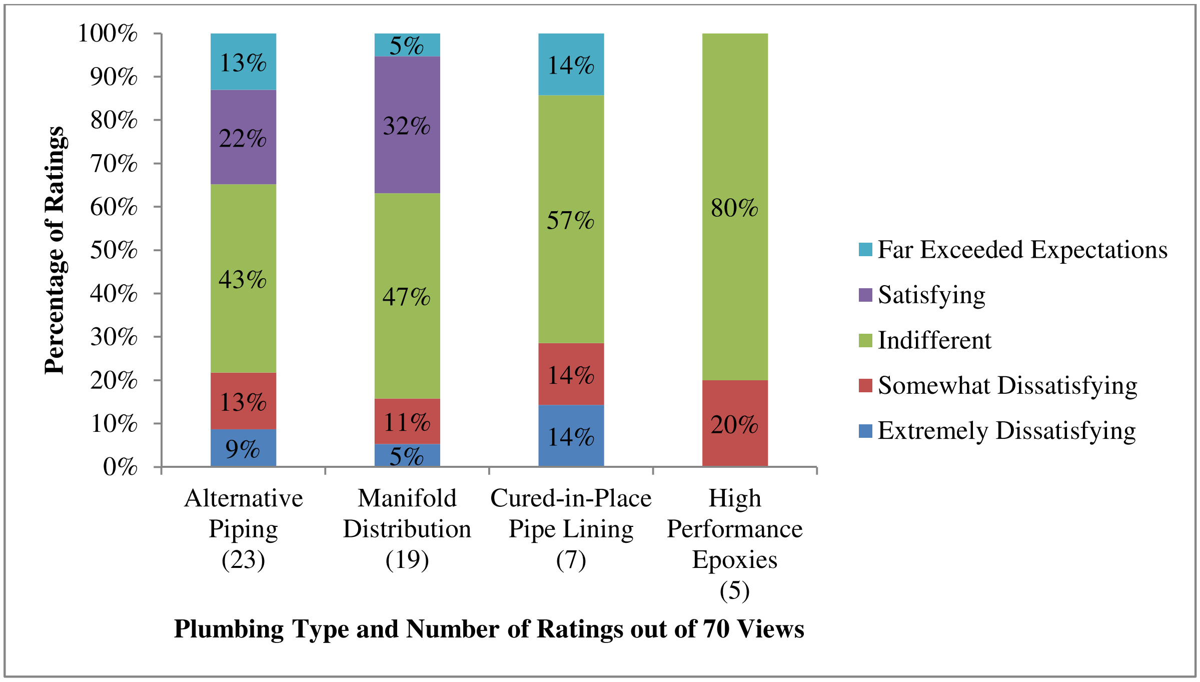

Figure 23: Response breakdown for Plumbing category.

For alternative piping (Table 16), all experiences described were about cross-linked polyethylene (PEX) piping. Respondents indicating positive experiences described PEX as having improved pressure and flow compared to copper, and respondents were pleased with the ease of installation and repair. Leaking was reported in PEX piping, as was air and dirt pockets forming from slag in the PEX piping. Manifold distribution was perceived as easy to install, manage, and repair. Negative experiences involved leaking. Positive reports said cured-in-place pipe lining was more durable and had better flow than the original pipes. The negative experiences involved epoxy lining project being expensive and lacking quality control. No experiences were described for high performance epoxies.

Table 16: Experiences described for Plumbing type.

Type & Alt Text	Positive Experiences	Negative Experiences
Alternative Piping PEX, Aluminum-Plastic composite, Recycled PVC, fused polypropylene, etc. Also includes alternative types of pipe insulation	• PEX had better pressure and flow than copper. • PEX easy to install and repair	• PEX with slag creating air and dirt pockets • PEX leaking
Manifold Distribution	• Easy to install and manage	• Leaking
Cured-In-Place Pipe Lining	• Improved durability and flow characteristics over original pipe	• Lining for copper pipe was expensive and lacked quality control
High Performance Epoxies	• None given	• None given

Water Heating

The Water Heating category included recirculating systems, on-demand (instant) heating, solar heating, and heat recovery systems. Responses for water heating innovations were very positive across the board (Figure 24).

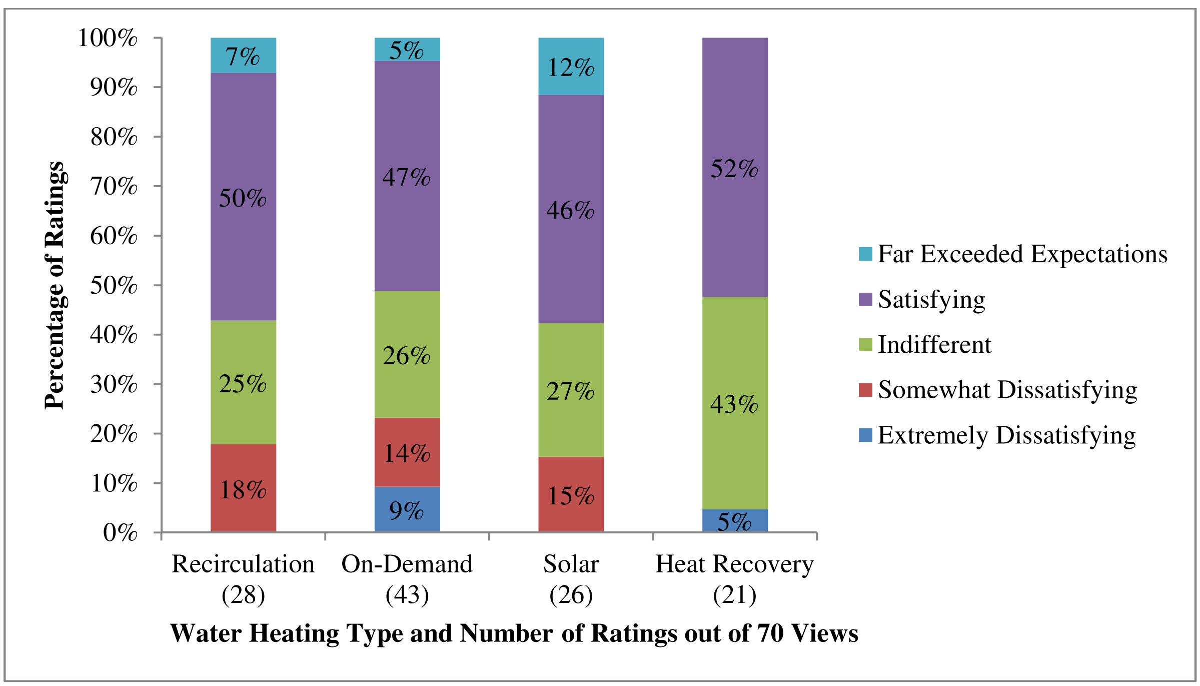

Figure 24: Response breakdown for Water Heating category.

Positive experiences with recirculation systems (Table 17) included installations that worked well or as intended, with users happy not to have to wait for hot water. In one case, pipe leaks due to cavitation occurred. Positive experiences with on-demand water heating systems described respondents pleased by quick supplies of hot water that did not run out. The negative experiences involved insufficient heating capacity, which forced users to choose between heat and flow rate. Systems in cold environments, such as basements, were reported to be excessively noisy when coming up to temperature. Positive solar water heating experiences involved systems working well, or as intended. A short payback period was also mentioned. Negative experiences involved expense and long payback periods for the larger, more advanced systems.

Table 17: Experiences described for Water Heating type.

Type & Alt Text	Positive Experiences	Negative Experiences
Recirculation Hot water recirculation systems	• Worked well or as intended • No wait for hot water	• Pipe leaks due to cavitation
On-Demand Centralized or point of use, instantaneous	• Worked well or as intended • Quick supply of hot water • Hot water does not run out	• Insufficient heating capacity • Inconsistent temperature • Excessive noise in cold environments
Solar Solar water heating	• Worked well or as intended • Short payback period	• Long payback period
Heat Recovery Water heat recovery systems, from greywater, geothermal, HVAC, etc.	• Worked well or better than intended • Energy savings	• Hot water demand and wastewater generation not always synchronized

Appliances

The Appliances category included dishwashers, clothes washers, and icemakers. Icemakers had the third lowest number of ratings in this study. Responses for appliances were largely positive or indifferent (Figure 25).

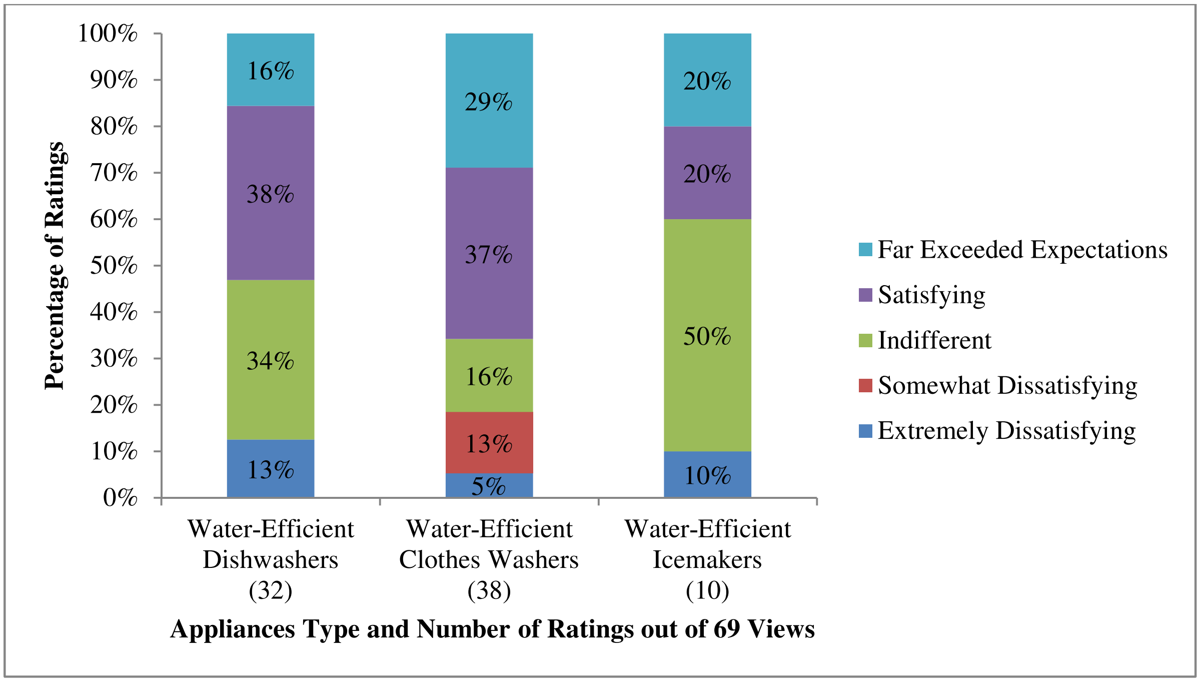

Figure 25: Response breakdown for Appliances category.

For all appliance types, respondents reported positive perceptions of the savings that they experienced (Table 18). Positive experiences for water-efficient dishwashers were said to be caused by the dishwashers working well and quietly. The negative experiences were with dishwashers that failed to properly wash dishes. Positive responses for water-efficient clothes washers indicated washers working well or better than expected. Negative experiences included user difficulties with front loading machines, where clothes were dropped on the floor during removal from the drum. Respondents indicated that some machines developed a mildew odor and did not wash clothes well, which they thought might be due to inadequate rinse and draining. Water efficient icemakers created positive experiences with better taste than respondents were used to. Negative experiences involved the perception of ice-making cycles as lengthy.

Table 18: Experiences described for Appliances type.

Type & Alt Text	Positive Experiences	Negative Experiences
Water-Efficient Dishwashers	• Worked well or as intended • Water and energy savings • Quiet	• Dishes not washed well
Water-Efficient Clothes Washers	• Worked well or better than intended • Water and energy savings	• Mildew odor from inadequate rinse or draining • Clothes fell to floor out of front-loading machine • Clothes not washed well
Water-Efficient Icemakers	• Better taste than conventional • Energy savings	• Lengthy cycle

Alternative Water Sources

The Alternative Water Sources category covered sources of non-potable water, including rainwater, greywater, blackwater, process water, condensate, and municipal supply. Responses for alternative water sources varied somewhat, but were largely satisfactory (Figure 26). Municipal nonpotable sources met with a large amount of indifference. Process water recycling/reuse and condensate recovery were very well liked, with 77% and 73% positive responses, respectively. Greywater and blackwater reuse both had 15-25% proportions of strong responses on both ends of the spectrum.

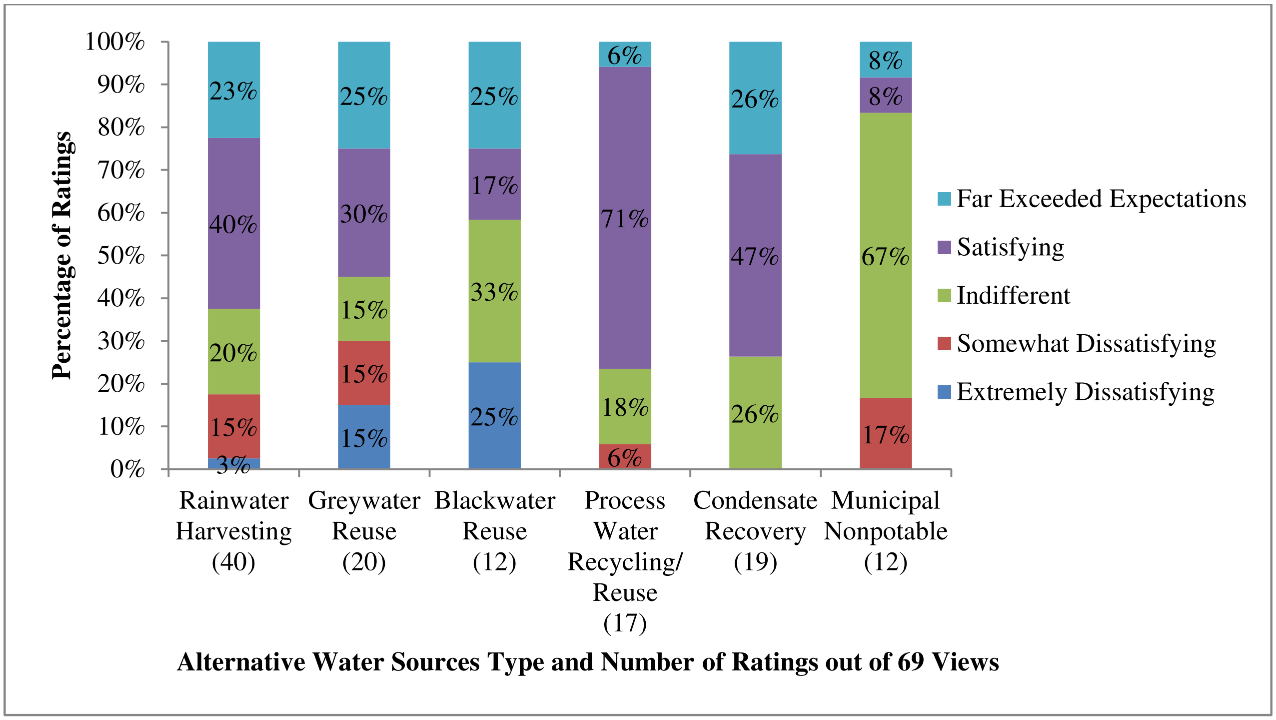

Figure 26: Response breakdown for Alternative Water Sources category.

Positive experiences reported for alternative water sources often included mention of water savings, and systems performing well or better than expected (Table 19). Negative experiences with rainwater harvesting included expensive maintenance and treatment, freezing failures, the difficulty of finding turnkey systems, and issues where the lack of pressurization required addition of pumps, sometimes post-installation. Negative experiences with greywater reuse revolved around poor designs and bad filters that caused odors, sepsis, and complete system failure. Blackwater reuse was seen very positively by respondents whose systems were automated or remotely controlled by the installer. Negative experience reports indicated high costs and poor process design. Chlorine treatment was also reported to cause pipe failures, which was attributed to treatment process design flaws. Process water recycling/reuse gave positive experiences with water savings and a reduced need for chemical treatment. Condensate recovery gave positive experiences for similar reasons, by providing users with very clean water. Negative experiences with municipal nonpotable water sourcing included the necessity of polishing on site, as well as complaints about the cost of infrastructure installation.

Table 19: Experiences described for Alternative Water Sources type.

Type & Alt Text	Positive Experiences	Negative Experiences
Rainwater Harvesting Rainwater and stormwater collection	• Water savings • Worked well or as intended	• Expensive to maintain • Lack of pressurization required addition of pumps • Freezing related failures • Hard to find turnkey systems
Greywater Reuse Greywater treatment and reuse	• Worked well or better than intended	• Systems went septic quickly • Bad filters • Odors
Blackwater Reuse Blackwater treatment and reuse	• Automated and remotely controlled systems make life easy • Worked well or better than intended	• Water treatment causes pipe failures elsewhere in building • High operating costs • Poor process design
Process Water Recycling/Reuse Industrial process water	• Water savings • Reduced need for chemical treatment	• None given
Condensate Recovery HVAC condensate recovery	• Water savings • Cleaner water	• None given
Municipal Nonpotable Municipal Nonpotable sources (purple pipe)	• None given	• Cost of infrastructure • Required polishing

Landscaping

The Landscaping category included efficient irrigation, plant selection, and green and grey (living and non-living) stormwater management. Landscaping innovations were very well received at 75% or more positive responses (Figure 27). Only green stormwater retention and infiltration had any dissatisfying experiences reported, with 6% of responses.

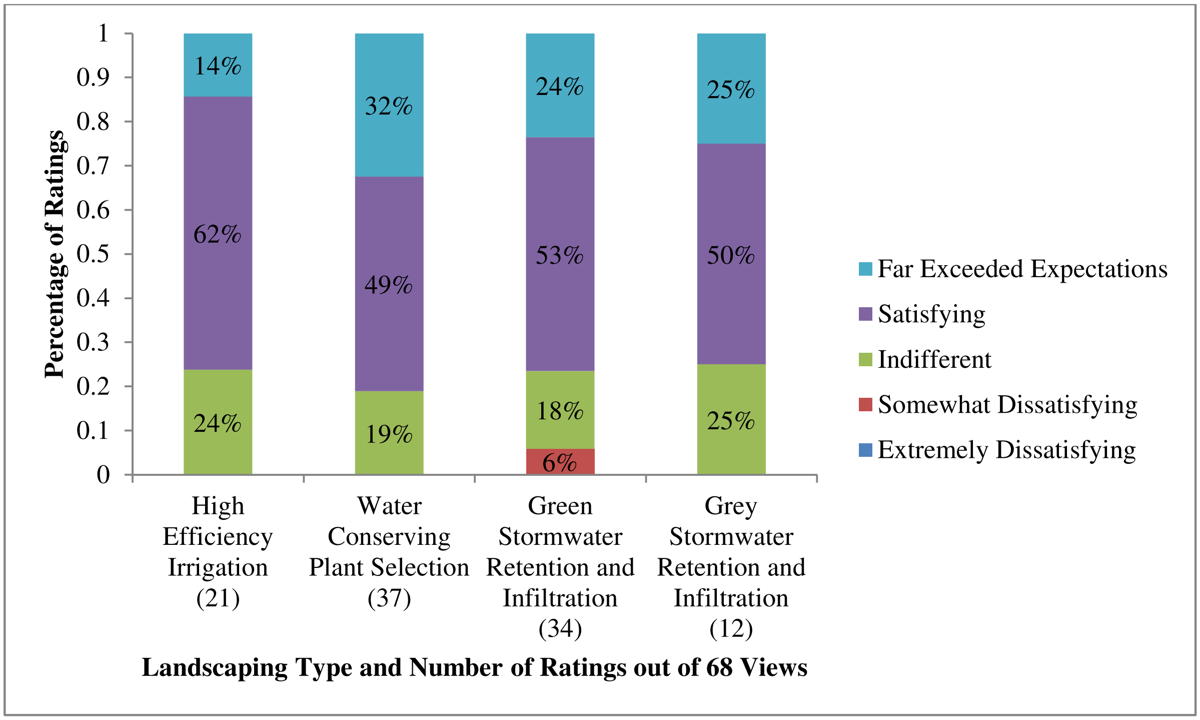

Figure 27: Response breakdown for Landscaping category.

Landscaping innovations were very positively received (Table 20). High efficiency irrigation created positive experiences by saving water, and also improved the perception of landscape management by not watering areas that don't need water, like sidewalks. Positive experiences with water conserving plant selection involved water savings, minimal upkeep, and pleasure with the health and beauty of native plant selections. Green stormwater management created positive experiences associated with low maintenance and aesthetics, and by working well. This is the only landscaping type to mention negative experiences, which resulted from water gardens often being built incorrectly by unqualified contractors. Grey stormwater management systems were perceived positively for working well, and because respondents reported enjoying watching porous pavement drain.

Table 20: Experiences described for Landscaping type.

Type & Alt Text	Positive Experiences	Negative Experiences
High Efficiency Irrigation Alternative controls, high efficiency distribution, tailwater reuse, etc.	• Water savings • Reduced perception of wasted water by not spraying sidewalks, etc.	• None given
Water Conserving Plant Selection Native plants, xeriscaping, etc.	• Water savings • Minimal upkeep • Native plants	• None given
Green Stormwater Retention and Infiltration Biological systems such as vegetated roofs, Bioswales, rain gardens, infiltration basins, etc.	• Low maintenance • Aesthetically pleasing • Worked well or as intended	• Water gardens often built incorrectly by non-experts
Grey Stormwater Retention and Infiltration Non-biological systems such as pervious paving, storage, etc.	• Porous pavement fun to watch drain • Worked well or as intended	• None given

Performance Monitoring

The Performance Monitoring category included water audits and sub-metering of water use. Performance monitoring innovation experiences were mostly rated as satisfying or indifferent (Figure 28), with under 20% negative experiences for both types.

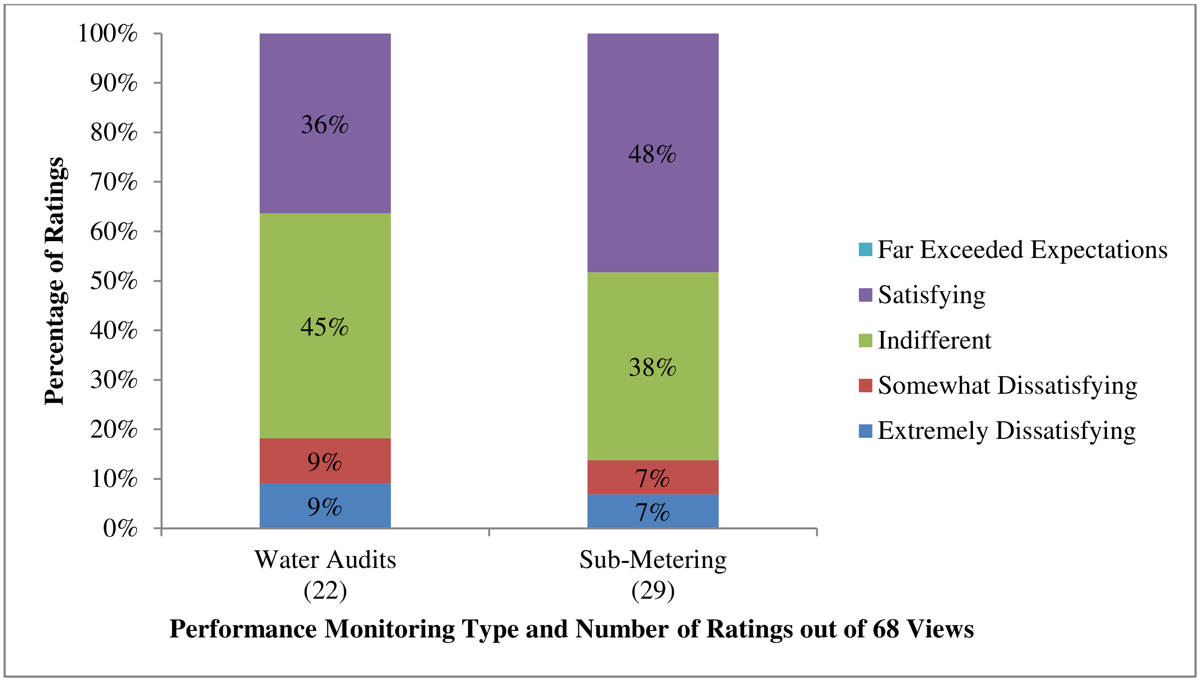

Figure 28: Response breakdown for Performance Monitoring category.

Positive experiences described for water audits involved good return on investment, and a sense of becoming informed (Table 21). In one case, a dissatisfied respondent had an audit with very poor return on investment. Sub-metering created positive experiences where demand was reduced, and firm documentation was available for questions of use and billing. The complaints included a high initial cost and difficult installation.

Table 21: Experiences described for Performance Monitoring type.

Type & Alt Text	**Positive Experiences**	**Negative Experiences**
Water Audits Audits of building water use, water bill analysis, etc.	• Informative about waste • Good return on investment	• Poor return on investment
Sub-Metering Sub metering of occupants and rooms for detailed usage data	• Reduced demand • Firm documentation for use and billing	• High initial cost • Difficult installation

User Education

The User Education category included feedback, signage and educational materials, and behavioral policies and incentives. User Education innovation experiences were mostly described as satisfying or indifferent (Figure 29).

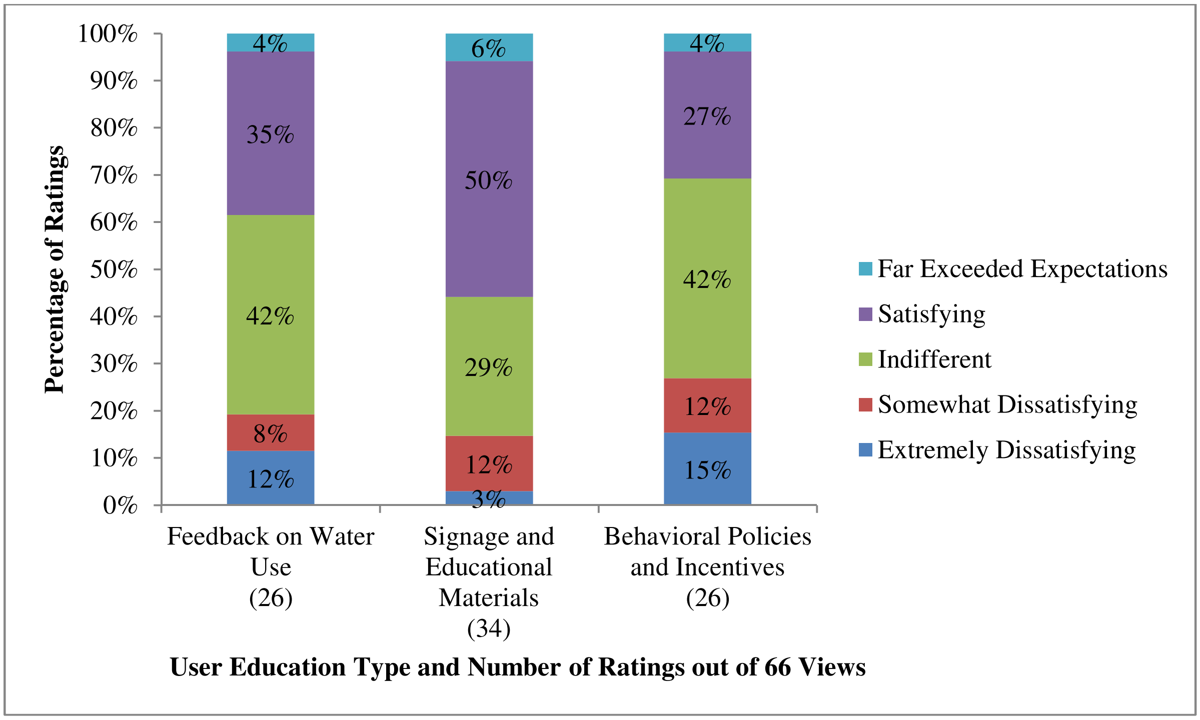

Figure 29: Response breakdown for User Education category.

Feedback on water use was successful in creating water and power savings, and respondents suggested that in their experience, tracking was very effective when an average or benchmark was provided (Table 22). Negative experiences involved lack of engagement with leadership and facilities managers. Some respondents were also upset when feedback was only provided for negative behaviors. Respondents reported positive experiences with signage and educational materials related to easy implementation and scalability, as well as positive influences on user perceptions. Negative experiences involved the lack of useable data, and cases when users ignored signage, continuing in their old habits. Behavioral policies and incentives were reported as very effective where rebates were concerned, but were ignored in the experience of other respondents.

Table 22: Experiences described for User Education type.

Type & Alt Text	Positive Experiences	Negative Experiences
Feedback on Water Use User/occupant feedback on water use	• Water and power savings • Tracking especially effective with points of comparison	• Lack of engagement with leadership • Only supplied for negative problems
Signage and Educational Materials Signage and educational materials explaining how and why to conserve water	• Easily implemented • Scalable • Promotes positive views in users	• No useable data • Ignored in favor of habit
Behavioral Policies and Incentives Incentives for users to conserve water	• Rebates very effective	• Ignored by users

Summary and Conclusions

Though the survey was distributed to thousands of individuals, only 95 individuals were motivated enough to participate in the survey. There are many possible explanations for this being so low. One is that a majority of consumers are very satisfied with their systems, or are not aware of problems, so felt no need to participate.

The known problems most reported were noted by about a third of respondents. These included leaks and clogging of pipes, user complaints about insufficient hot water, early system failure, and water taste, odor, or color. These are all symptomatic issues, but do give indicators on which managers should focus monitoring efforts, and to use for other studies.

For all categories of innovations, negative satisfaction ratings were reported by a minority of respondents, indicating that these technologies are perceived to be working effectively in the majority of cases. These experiences are likely to support further diffusion of these technologies given what we know about experiences of early adopters. Some innovation types, such as landscaping measures, had little or no negative experiences reported. Toilets and Urinals, especially the non-water varieties, had the most negative response. The largest proportions of severe negative experiences also seem to have occurred in these non-water toilet innovations, followed by blackwater and then greywater reuse. It may be that these sewage related innovations inspire the strongest negative feelings because of the pathogen risk and humanity's evolved aversion to bodily waste. However, blackwater and greywater systems also have amongst the highest percentage of extremely positive responses as well.

Negative experiences were described for most of the innovations considered, and positive experiences were described for all but one. These experiences involve design, process, and human behavior, and suggest many topics for improvement and future research. Positive experiences tended towards systems working as intended, and few surprises were reported. Respondents were satisfied with cost and water savings for many innovations. The negative experience descriptions had several common themes. Water conserving fixtures and fittings failed to clear waste or to carry it through wastewater pipes, due to insufficient flow. Maintenance difficulties were also reported for many innovations, either through difficulty with the innovation itself, or through failures to communicate with maintenance staff. Negative perceptions about high costs were also reported for innovations in several categories.

These results suggest several areas of future research. Quantifying the impacts of these experiences on adoption rates would be very relevant to designers and vendors. The prevalence of both unmet and exceeded paybacks suggests future research into understanding and improving the accuracy of financial expectations for these innovations. Furthermore, research could be done to develop more robust innovations that leverage the positive responses identified in this study, as well as address negative responses.

Acknowledgements

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Chapter 6: Engineering Significance

These results provide some insight into how water conservation innovations are used in green buildings. These can not only help to direct future research, but could also aid individuals designing green buildings in their water technology selections.

Chapter 2, the literature review, presents a framework for understanding and defining the unanticipated consequences of using water related innovations. Describing the root causes of these consequences may help to understand how to avoid negative consequences, and any future issues. The fact that several problems were found to be the focus of multiple studies suggests that there is already some awareness of the negative consequences of these innovations. Additionally, there may be some other serious problems yet to be found.

Chapter 3 addressed the question of what water related innovations are being adopted in green buildings. A broad spectrum of bathroom and irrigation features was identified as being used. The results presented in chapter 5 show that respondents had experience with all of the innovations featured in the survey. Together, these suggest that a broad spectrum of water innovations is being used and that many are used widely. With so many features in use, there is likely a need to focus future research on the most common features first. The results of these studies provide numbers for comparison, which could help to direct that future research. These results also suggest future research into why some features and feature types are selected more than others.

Chapter 4 sought to answer the question of where innovations are being selected. The results suggest that while there is regional and climate variation in innovation selection, the flush features examined are used across the country with a fairly even distribution. This suggests that at the time these projects applied for LEED certification, most regions had a similar set of considerations in their flush fixture selection. This suggests future research into what differences were present in those regions that were significantly different, such as the high percentage of dual-flush toilets used in marine (EERE) and Northwest (NOAA) regions. Some possibilities include legislation and regional availability of products. The large number of statistically significant differences found in irrigation option selections suggests that designers did consider regional climate for their irrigation features. Future research is suggested on how these selections are made in the context of green buildings, and what aspects of climate and available landscaping plants drive these selections.

Chapter 5 sought to answer the question of what unanticipated consequences are being experienced as a result of the adoption of water related innovations in green buildings. A list was created, representing most of the innovations examined. The fact that so many opportunities and explicit requests for detail were supplied to participants but few gave many details or descriptions suggests that experiences are predominantly as expected by users. These stories could help to direct future research into why they are occurring, and help to improve on the innovations.

Chapter 5 also sought to answer the question of how green building professionals perceive water related innovations in green buildings. Relatively few negative responses were recorded for all innovations examined. This, along with the results of the explanations of ratings given by participants, suggests that perceptions are generally good. Those innovations with higher percentages of extremely satisfied or dissatisfied responses might be good targets for future research, and use or avoidance by designers.

Together, these results suggest that water related innovations in green buildings are prevalent in many forms, and geographically widespread in their use. They also appear to mostly work as intended, and to be generally positively perceived.

Appendix A: LEED Data Sampling Methodology

These are the data sampling methodology notes.

- Given list of all projects available on USGBC website, which omits LEED for homes.
- Given list of all non-confidential projects earning WE 1.1, 2, 3.1, SS 6.1, 6.2 for LEED NC 2.2, and list of all non-confidential projects earning WE 1, 2, 3 and SS 6.1, 6.2 for LEED NC 2009.
- Removed all projects outside of USA.
- For each rating system, the following were done separately:
  - Ran pivot table on remaining projects, to get proportion of projects with each owner type. Multiple owner type combinations were given their own categories in the breakdown (ie, projects labeled as "for-profit" were counted separately from those labeled as "for-profit, federal government"). Percentages of the whole were assigned to each category, for sampling distributions.
  - The list of projects was split by owner type, and each project was assigned a number from 1 to N, where N was the number of projects with that owner type.
  - For each owner type, MS Excel was used to generate a non-repeating list of X random numbers between 1 and N, where N was the number of projects with that owner type, and X was a portion of the sample size equal to the portion of the entire population that that owner type represented. For each random number, the corresponding project ID was retrieved.
- The resulting product was a sample of projects for each rating system, randomly selected by owner type.

Appendix B: LEED Sampling Code

```
'This is VBA code written for MS Excel
Private Sub CommandButton1_Click()

Dim TypeCount, Col, ListRow, TestCol, Random, Checker As Integer

ListRow = 32

For TypeCount = 6 To 28

   For Col = 3 To (2 + Cells(TypeCount, 2).Value)
      Do
         Random = Int((Cells(TypeCount, 1).Value) * Rnd() + 1)
         Checker = 0
         For TestCol = 3 To Col
            If Random = Cells(TypeCount, TestCol) Then
               Checker = 1
            End If
         Next
      Loop While Checker = 1
      Cells(TypeCount, Col).Value = Random
      Cells(ListRow, 1).Value = Random

      Cells(ListRow, 2).Value = Sheets("IDs For OwnerCats").Cells(5 + Random, TypeCount -
4).Value
      ListRow = ListRow + 1
   Next
Next

End Sub
```

Appendix C: LEED PDFill Shell Code

```
'This is VBA code written for MS Excel
Private Sub btnExtract_Click()

Dim FSO As New FileSystemObject
Dim fls As Files
Dim SourceFolder As String
Dim DestFolder As String
Dim excelFile As String
Dim WBS As Workbooks
Dim row As Integer
Dim i, m As Integer
Dim OtherFile As Object

ThisWorkbook.Save

'get folders to deal with
If Right(Cells(4, 2).Value, 1) <> "\" Then
   Cells(4, 2).Value = Cells(4, 2).Value & "\"
End If
If Right(Cells(5, 2).Value, 1) <> "\" Then
   Cells(5, 2).Value = Cells(5, 2).Value & "\"
End If
SourceFolder = Cells(4, 2).Value
DestFolder = Cells(5, 2).Value
row = 8

Range("A8:D1000").Clear

Set fls = FSO.GetFolder(SourceFolder).Files
```

```
'get the files to deal with.
For Each f In fls
    Cells(row, 1).Value = Left(f.Name, 8)
    Cells(row, 2).Value = f.Path
    Cells(row, 3).Value = DestFolder & Left(f.Name, 8) & ".xls"

    row = row + 1
Next
'Exit Sub

'set row to last filled row
row = row - 1

'shell pdfill
Shell "C:\Program Files (x86)\PlotSoft\PDFill\PDFill.exe", vbNormalFocus
Application.Wait (Now() + TimeValue("00:00:03"))

For i = 8 To row 'change to row
    AppActivate "PDFill PDF Editor"

    'open next file
    Application.SendKeys "^o"
    Application.Wait (Now() + TimeValue("00:00:03"))
    Application.SendKeys Cells(i, 2).Value & "~"
    Application.Wait (Now() + TimeValue("00:00:12"))

    'open form processor
    Application.SendKeys "%"
    Application.SendKeys
"{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DO
WN}~"
    Application.Wait (Now() + TimeValue("00:00:01"))
```

```
    'extract
    Application.SendKeys "{TAB}{TAB}{TAB}{TAB}{TAB}{TAB}{TAB} " 'adds tooltips
    Application.Wait (Now() + TimeValue("00:00:01"))
    Application.SendKeys "{TAB}{TAB}~" 'saves as excel
    Application.Wait (Now() + TimeValue("00:00:03"))
    Application.SendKeys Cells(i, 3).Value & "~"
    Application.Wait (Now() + TimeValue("00:00:03"))
    Application.SendKeys "{esc}"
    Application.Wait (Now() + TimeValue("00:00:03"))
    AppActivate "PDFill PDF Editor"
    Application.SendKeys "%"
    Application.SendKeys
"{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DOWN}{DO
WN}{DOWN}~"
    Application.SendKeys "{esc}"
    Application.SendKeys "{tab} "

    'kill the opened excel file
    Cells(i, 4).Value = Cells(i, 1).Value & ".xls"
    excelFile = Cells(i, 3).Value
    Set OtherFile = GetObject(excelFile)
    OtherFile.Close savechanges:=False

    Application.Wait (Now() + TimeValue("00:00:02"))
    AppActivate "PDFill PDF Editor"

Next

End Sub
```

Appendix D: LEED Data Combination Code

```
‘This is VBA code written for MS Excel
Private Sub btnCombine_Click()

Dim fso As New FileSystemObject
Dim fls As Files
Dim ActFilePath As String
Dim ActFileObj As Object
Dim ActFile As String
Dim OutputFolder As String
Dim InputFolder As String
Dim i, m, j, k As Long
Dim FieldRow As Long
Dim Row As Integer
Dim Col As Integer
Dim NewFilePath As String
Dim FieldMods As Integer
Dim OutputFile As String
Dim ThisProgram As String
Dim Found As Boolean
Dim DataRow, DataCol As Integer


Application.ScreenUpdating = False
ThisWorkbook.Save
ThisProgram = ThisWorkbook.Name
FieldMods = 0
Range("A9:B1000").Clear

'set folders
If Right(Cells(4, 2).Value, 1) <> "\" Then
   Cells(4, 2).Value = Cells(4, 2).Value & "\"
```

```
End If
If Right(Cells(5, 2).Value, 1) <> "\" Then
   Cells(5, 2).Value = Cells(5, 2).Value & "\"
End If
InputFolder = Cells(4, 2).Value
OutputFolder = Cells(5, 2).Value


'create new output file
OutputFile = "Combo Run " & Cells(6, 2).Value & ".xlsx"
NewFilePath = OutputFolder & OutputFile
AddNewWBook (NewFilePath)

'setup output file
Workbooks(OutputFile).Sheets("Sheet1").Cells(1, 1) = "Time"
Workbooks(OutputFile).Sheets("Sheet1").Cells(1, 2) = Now()
Workbooks(OutputFile).Sheets("Sheet1").Cells(2, 1) = "FieldMods"
Workbooks(OutputFile).Sheets("Sheet1").Cells(2, 2) = FieldMods
Workbooks(OutputFile).Sheets("Sheet1").Cells(4, 1) = "Field"
Workbooks(OutputFile).Sheets("Sheet1").Cells(5, 1) = "FileName"


'get files to play with
i = 9   'starting row
Set fls = fso.GetFolder(InputFolder).Files
For Each f In fls
   Cells(i, 1).Value = f.Name
   Cells(i, 2).Value = f.Path
   i = i + 1
Next
i = i - 1
```

```
'deal with data files
DataCol = 3
For m = 9 To i
    'open file
    ActFilePath = Cells(m, 2).Value
    ActFile = Cells(m, 1).Value
    Application.Workbooks.Open (ActFilePath)


    'create tooltip set
    If FieldMods = 0 Then
        j = 2
        FieldRow = 6
        Do
            Workbooks(OutputFile).Sheets("Sheet1").Cells(FieldRow, 1).Value =
Workbooks(ActFile).Sheets("Sheet1").Cells(j, 1).Value
            Workbooks(OutputFile).Sheets("Sheet1").Cells(FieldRow, 2).Value =
Workbooks(ActFile).Sheets("Sheet1").Cells(j, 3).Value
            j = j + 1
            FieldRow = FieldRow + 1
        Loop Until Workbooks(ActFile).Sheets("Sheet1").Cells(j, 1).Value = ""
        FieldMods = 1
        FieldRow = FieldRow - 1

    End If

    'get filename
    Workbooks(OutputFile).Sheets("Sheet1").Cells(5, DataCol).Value = Left(ActFile, 8)

    'check tooltips & copy data
    j = 2
```

```
    Do
        'check tooltip
        DataRow = 6
        Found = False
        Do
            If Workbooks(OutputFile).Sheets("Sheet1").Cells(DataRow, 1).Value =
Workbooks(ActFile).Sheets("Sheet1").Cells(j, 1).Value Then
                Found = True
            Else
                DataRow = DataRow + 1
            End If
        Loop Until Found = True Or DataRow = (FieldRow + 1)

        'at this point, DataRow is the row to put the value into.



        'add missing fields
        If Found = False Then
            Workbooks(OutputFile).Sheets("Sheet1").Cells(DataRow, 1).Value =
Workbooks(ActFile).Sheets("Sheet1").Cells(j, 1).Value
            Workbooks(OutputFile).Sheets("Sheet1").Cells(DataRow, 2).Value =
Workbooks(ActFile).Sheets("Sheet1").Cells(j, 3).Value
            FieldRow = FieldRow + 1
            FieldMods = FieldMods + 1
        End If

        'add data
        Workbooks(OutputFile).Sheets("Sheet1").Cells(DataRow, DataCol).Value =
Workbooks(ActFile).Sheets("Sheet1").Cells(j, 2).Value

        j = j + 1
    Loop Until Workbooks(ActFile).Sheets("Sheet1").Cells(j, 1).Value = ""
```

```
    DataCol = DataCol + 1
    Workbooks(ActFile).Close
Next

Workbooks(OutputFile).Sheets("Sheet1").Cells(2, 2) = FieldMods
Workbooks(OutputFile).Save
'Workbooks(OutputFile).Close

Cells(6, 2).Value = Cells(6, 2).Value + 1
Application.ScreenUpdating = True

End Sub




Sub AddNewWBook(ByVal NewFilePath As String)
    Dim wbNew As Workbook
    Set wbNew = Workbooks.Add()

    wbNew.SaveAs FileName:=NewFilePath
End Sub
```

Appendix E: LEED Data Moving Code

```
'This is VBA code written for MS Excel
Private Sub BtnRearrangeForms_Click()

'declare variables

Dim FSO As New FileSystemObject
Dim ProjectFolders As Folders
Dim fls As Files
Dim LEEDFolder As String
Dim m As Long
Dim i As Long
Dim Project As String
Dim Row As Integer
Dim Col As Integer
Dim DataPath As String
Dim SourceEnd As String

'get data package project folders
Set ProjectFolders = FSO.GetFolder("C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LOv3").SubFolders

i = 5

For Row = 5 To 49
   Set fls = FSO.GetFolder("C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LOv3\" & Cells(Row, 10).Value).Files
   For Each f In fls
      'getting file names and paths
      Cells(i, 1).Value = Cells(Row, 10).Value
      Cells(i, 2).Value = f.Name
      Cells(i, 3).Value = f.Path
```

```
        'developing new name
        If f.Name = "wec1.pdf" Then
            DataPath = "C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LEEDv3\wec1\" & Cells(Row, 10).Value & f.Name
        End If
        If f.Name = "wec2.pdf" Then
            DataPath = "C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LEEDv3\wec2\" & Cells(Row, 10).Value & f.Name
        End If
        If f.Name = "wec3.pdf" Then
            DataPath = "C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LEEDv3\wec3\" & Cells(Row, 10).Value & f.Name
        End If
        If f.Name = "ssc6.1.pdf" Then
            DataPath = "C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LEEDv3\ssc61\" & Cells(Row, 10).Value & f.Name
        End If
        If f.Name = "ssc6.2.pdf" Then
            DataPath = "C:\Users\Ben\Desktop\Research\USGBC Internship\Data
Forms\LEEDv3\ssc62\" & Cells(Row, 10).Value & f.Name
        End If
        Cells(i, 4).Value = DataPath

        FileCopy f.Path, DataPath

        i = i + 1
    Next
Next

End Sub
```

Appendix F: LEED NCv2.2 WEc1 Sanitized Sample Form

Used under fair use, 2013

LEED-NC
LEED FOR NEW CONSTRUCTION

LEED-NC 2.2 Submittal Template
WE Credit 1: Water Efficient Landscaping

design

(Responsible Individual) (Company Name)

I, [redacted] , from [redacted]

verify that the information provided below is accurate, to the best of my knowledge.

SELECT OPTION

Please select the appropriate compliance path option (this will activate the remainder of the submittal form)

○ **Option 1:** The landscaping and irrigation systems have been designed to reduce irrigation water consumption from a calculated baseline case (1 point).

○ **Option 2:** The irrigation water used on site is supplied by a non-potable source (1 point).

◉ **Option 3:** The landscaping and irrigation systems have been designed to reduce irrigation water consumption from a calculated baseline case, AND the irrigation water used on site is supplied by a non-potable source (up to 2 points).

○ **Option 4:** The landscaping installed does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment will be removed within one year of installation. (2 points).

CREDIT COMPLIANCE

Option 1 (WEc1.1): Landscaping and Irrigation Systems

_____ gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):

_____ gallons - Calculated Design Case Irrigation Water Consumption (Total Water Applied - TWA)

_____ gallons - Calculated Total Potable Water Applied - TPWA

_____ % - **Percentage Reduction of Potable Water**

A 50% reduction in Potable Water Use is required for 1 point. A 100% reduction in potable water use, and a 50% reduction of total water is required for 2 points.

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LEED-NC 2.2 Submittal Template | Last Modified: April 2006

Option 2 (WEc1.1) : Non-Potable Source

	gallons	- Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):
	gallons	- Non-Potable Water Supply
	gallons	- Calculated Total Potable Water Applied - TPWA
	%	- **Percentage Reduction of Potable Water**

A 50% reduction in Potable Water Use is required for 1 point. A 100% reduction in potable water use, and a 50% reduction of total water is required for 2 points.

Please select the applicable non-potable water source(s) below:

- [ ] On-Site Captured Rainwater
- [ ] On-Site Treated Wastewater
- [ ] On-Site Captured Greywater
- [ ] Public Agency Sourced, Non-Potable Treated Water

Option 3 (WEc1.2): Both

249,338	gallons	- Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):
39,575	gallons	- Calculated Design Case Irrigation Water Consumption (Total Water Applied - TWA)
47,610	gallons	- Non-Potable Water Supply
	gallons	- Calculated Total Potable Water Applied - TPWA
100	%	- **Percentage Reduction of Potable Water**
84.1	%	- **Percent Reduction of Total Water**

A 50% reduction in Potable Water Use is required for 1 point. A 100% reduction in potable water use, and a 50% reduction of total water is required for 2 points.

Please select the applicable non-potable water source(s) below:

- [x] On-Site Captured Rainwater
- [ ] On-Site Treated Wastewater
- [ ] On-Site Captured Greywater
- [ ] Public Agency Sourced, Non-Potable Treated Water

SUPPORTING DOCUMENTATION

The project landscape plan(s) have been uploaded. The drawing(s) show the location of landscaped areas for the project

Sheet Description Log

Please include sheet name, sheet number and file name for each uploaded, referenced drawing (e.g. A-101, Site Plan, siteplan.pdf)

Landscape Plan, C-3, Landscape Plan C-3.pdf
Architectural Site Plan, A-001R, Architectural Site Plan A-001R.pdf

- [x] I have provided the appropriate supporting documentation in the document upload section of LEED Online. Please refer to the above sheets.

NARRATIVE (Required)

Please provide a detailed narrative describing the landscaping and irrigation design strategies employed by the project. Please include specific information regarding the water use calculation methodology used to determine savings. For projects using non-potable water, please provide specific information regarding source and available quantity of non-potable supplies.

The approach to the water efficient landscaping is to minimize the landscape areas that require irrigation by planting native moderately drought resistant vegetation and to use no potable water for irrigation. NO POTABLE WATER WILL BE USED FOR IRRIGATING PURPOSES ON THIS SITE. The non-potable water source is an underground cistern that stores harvested rainwater from the buildings roof to irrigate the landscape.

The landscape was designed to minimize landscape areas that required irrigation. The landscape is divided into three (3) different vegetation types: turf grass, planting beds and prairie grass areas. The turf grass areas to the north and directly adjacent to the building will be irrigated. The plants in the planting beds were chosen to be moderately drought resistant. The planting beds will receive 4? of shredded bark mulch to retain moisture in the soil. The planting beds will be shaded by the building at various part of the day which will reduce their water demand. The planting beds will receive drip irrigation. A 6-inch layer of topsoil will be placed under all irrigated turf areas and planting bed areas that will help retain moisture.

The remainder of the site will be seeded with prairie grasses and forbs. The varieties of prairie grasses and forbs selected for this site have extensive root systems and are drought resistant varieties native to this region. The prairie grass areas will not be irrigated.

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

☐ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. *(Indicate the number of points documented in the field below).*

Alternative Compliance Points Documented

Project Name: [redacted]

Credit: WE Credit 1: Water Efficient Landscaping

Points Documented: 2

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this template.

[redacted]

First Name	Last Name	Date	Username (Email Address)	Password

SAVE TEMPLATE TO LEED-ONLINE | PRINT TEMPLATE

T0000503

Letter Template Version A1 .

Appendix G: LEED NCv2.2 WEc1 Form Map

Used under fair use, 2013

LEED-NC
LEED FOR NEW CONSTRUCTION

LEED-NC 2.2 Submittal Template
WE Credit 1: Water Efficient Landscaping

design

(Responsible Individual) (Company Name)

I, [1] , from [2]

verify that the information provided below is accurate, to the best of my knowledge.

SELECT OPTION

Please select the appropriate compliance path option (this will activate the remainder of the submittal form)

3

Option 1: The landscaping and irrigation systems have been designed to reduce irrigation water consumption from a calculated baseline case (1 point).

Option 2: The irrigation water used on site is supplied by a non-potable source (1 point).

Option 3: The landscaping and irrigation systems have been designed to reduce irrigation water consumption from a calculated baseline case, AND the irrigation water used on site is supplied by a non-potable source (up to 2 points).

Option 4: The landscaping installed does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment will be removed within one year of installation. (2 points).

CREDIT COMPLIANCE

Option 1 (WEc1.1): Landscaping and Irrigation Systems

[4] gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):

[5] gallons - Calculated Design Case Irrigation Water Consumption (Total Water Applied - TWA)

(8)

[6] gallons - Calculated Total Potable Water Applied - TPWA

[7] % - **Percentage Reduction of Potable Water**

A 50% reduction in Potable Water Use is required for 1 point. A 100% reduction in potable water use, and a 50% reduction of total water is required for 2 points.

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LEED-NC 2.2 Submittal Template | Last Modified: April 2006

Option 2 (WEc1.1) : Non-Potable Source

9 gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):

10 gallons - Non-Potable Water Supply

11 gallons - Calculated Total Potable Water Applied - TPWA

12 % - **Percentage Reduction of Potable Water**

A 50% reduction in Potable Water Use is required for 1 point. A 100% reduction in potable water use, and a 50% reduction of total water is required for 2 points.

Please select the applicable non-potable water source(s) below:

13 ☐ On-Site Captured Rainwater

14 ☐ On-Site Treated Wastewater

15 ☐ On-Site Captured Greywater

16 ☐ Public Agency Sourced, Non-Potable Treated Water

Option 3 (WEc1.2): Both

17 gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):

18 gallons - Calculated Design Case Irrigation Water Consumption (Total Water Applied - TWA)

19 gallons - Non-Potable Water Supply

20 gallons - Calculated Total Potable Water Applied - TPWA

21 % - **Percentage Reduction of Potable Water**

22 % - **Percent Reduction of Total Water**

A 50% reduction in Potable Water Use is required for 1 point. A 100% reduction in potable water use, and a 50% reduction of total water is required for 2 points.

Please select the applicable non-potable water source(s) below:

23 ☐ On-Site Captured Rainwater

24 ☐ On-Site Treated Wastewater

25 ☐ On-Site Captured Greywater

26 ☐ Public Agency Sourced, Non-Potable Treated Water

SUPPORTING DOCUMENTATION

The project landscape plan(s) have been uploaded. The drawing(s) show the location of landscaped areas for the project

Sheet Description Log

Please include sheet name, sheet number and file name for each uploaded, referenced drawing (e.g. A-101, Site Plan, siteplan. pdf)

27

28 ☒ I have provided the appropriate supporting documentation in the document upload section of LEED Online. Please refer to the above sheets.

NARRATIVE (Required)

Please provide a detailed narrative describing the landscaping and irrigation design strategies employed by the project. Please include specific information regarding the water use calculation methodology used to determine savings. For projects using non-potable water, please provide specific information regarding source and available quantity of non-potable supplies.

29

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

30

31 ☐ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. *(Indicate the number of points documented in the field below).*

32 Alternative Compliance Points Documented

Project Name: 34

Credit: 35

Points Documented: 33

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this template.

36	37	38	39	40
First Name	Last Name	Date	Username (Email Address)	Password

SAVE TEMPLATE TO LEED-ONLINE PRINT TEMPLATE

Letter Template Version A1 . 41

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Appendix H: LEED NCv2.2 WEc1 Data Key

Table 23: LEED NCv2.2 WEc1 Data Key

Map	Form Region	NewID	DataType	Description
0		ProjID	Number	Project ID Number
1	General	FilingInd	Text	Name of person filling out the form
2	General	FilingCo	Text	Company of person filling out the form
3	General	Option	Number	Option selected for completion
4	Option 1	Op1BaseIrWatCons	Number	Option 1 gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):
5	Option 1	Op1DesIrWatCons	Number	Option 1 gallons - Calculated Design Case Irrigation Water Consumption (Total Water Applied - TWA)
6	Option 1	Op1TPWA	Number	Option 1 gallons - Calculated Total Potable Water Applied - TPWA
7	Option 1	Op1PWRed	Number	Option 1 % Percentage Reduction of Potable Water
8	Option 1	Op1Blank	Number	Always empty, is a mistake of the PDF generation
9	Option 2	Op2BaseIrWatCons	Number	Option 2 gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):
10	Option 2	Op2NPWS	Number	Option 2 gallons - Non-Potable Water Supply
11	Option 2	Op2TPWA	Number	Option 2 gallons - Calculated Total Potable Water Applied - TPWA
12	Option 2	Op2PWRed	Number	Option 2 % - Percentage Reduction of Potable Water
13	Option 2	Op2Rain	Text	Option 2 On-Site Captured Rainwater
14	Option 2	Op2TrWaste	Text	Option 2 On-Site Treated Wastewater
15	Option 2	Op2Grey	Text	Option 2 On-Site Captured Greywater
16	Option 2	Op2PubSrc	Text	Option 2 Public Agency Sourced, Non-Potable Treated Water
17	Option 3	Op3BaseIrWatCons	Number	Option 3 gallons - Calculated Baseline Irrigation Water Consumption (Total Water Applied - TWA):
18	Option 3	Op3DesIrWatCons	Number	Option 3 gallons - Calculated Design Case Irrigation Water Consumption (Total Water Applied - TWA)
19	Option 3	Op3NPWS	Number	Option 3 gallons - Non-Potable Water Supply
20	Option 3	Op3TPWA	Number	Option 3 gallons - Calculated Total Potable Water Applied - TPWA
21	Option 3	Op3PWRed	Number	Option 3 % - Percentage Reduction of Potable Water
22	Option 3	Op3TWRed	Number	Option 3 % - Percent Reduction of Total Water

23	Option 3	Op3Rain	Text	Option 3 On-Site Captured Rainwater
24	Option 3	Op3TrWaste	Text	Option 3 On-Site Treated Wastewater
25	Option 3	Op3Grey	Text	Option 3 On-Site Captured Greywater
26	Option 3	Op3PubSrc	Text	Option 3 Public Agency Sourced, Non-Potable Treated Water
27	General	SupportingDocs	Text	List of supporting documents
28	General	SupportingDocsChk	Text	Confirmation that supporting documents have been uploaded
29	Narrative	Narrative1	Text	Narrative for compliance
30	Narrative	Narrative2	Text	Special circumstances narrative
31	Narrative	AltComp	Text	Alternative compliance approach is used
32	Narrative	AltCompPts	Number	Points documented for alternative compliance
33	General	PointsDocumented	Number	Number of points documented on form
35	General	CreditAttempted	Text	Credit attempted on form
35	General	ProjName	Text	Name of project
36	General	SubFirstName	Text	Submitter's first name
37	General	SubLastName	Text	Submitter's last name
38	General	SubDate	Text	Submission date
39	General	SubUsername	Text	Submitter's user name
40	General	SubPW	Text	Submitter's password
41	General	TemplateVer	Text	Page template version
42	General	FormVerID	Number	Form version ID

Appendix I: LEED NCv2.2 WEc1 Cleaning Log

- Added count column to see if any fields failed to translate.
    - Op1Blank had none, but it is a 'fake' field and doesn't matter
    - SubPW had none, but it is a password field and not needed or in any forms
- Checked for form versions. only one found
    - 10000503
- Filled all empty numeric fields with 0
- Changed "Off/1" field values to "Off/On"
- Modified option Field values to equal option numbers
- Discovered that 10003775 is a mostly blank form and says "see uploaded template", needs to be either deleted or added. Selected to throw it out.
- reformatted submission dates that were not in standard date format

Appendix J: LEED NCv2.2 WEc1 Cleaning Code

```
‘VBA code for MS Excel
Private Sub CommandButton1_Click()
'1 to 401 -> 5 to 405
Dim i, j As Integer
For i = 2 To 43
   For j = 5 To 405
      If Sheets("Data").Cells(i, j).Value = "" Then
         Sheets("Clean Data").Cells(i, j - 1).Value = 0
      Else
         Sheets("Clean Data").Cells(i, j - 1).Value = Sheets("Data").Cells(i, j).Value
      End If
   Next
Next
For i = 14 To 17
   For j = 4 To 404
      If Sheets("Clean Data").Cells(i, j).Value = 1 Then
         Sheets("Clean Data").Cells(i, j).Value = "On"
      End If
   Next
Next
For i = 24 To 27
   For j = 4 To 404
      If Sheets("Clean Data").Cells(i, j).Value = 1 Then
         Sheets("Clean Data").Cells(i, j).Value = "On"
      End If
   Next
Next
For i = 29 To 29
   For j = 4 To 404
      If Sheets("Clean Data").Cells(i, j).Value = 1 Then
         Sheets("Clean Data").Cells(i, j).Value = "On"
```

```
        End If
    Next
Next
For i = 32 To 32
    For j = 4 To 404
        If Sheets("Clean Data").Cells(i, j).Value = 1 Then
            Sheets("Clean Data").Cells(i, j).Value = "On"
        End If
    Next
Next
For i = 4 To 4
    For j = 4 To 404
        Sheets("Tables").Cells(9, 6).Value = j
        Sheets("Clean Data").Cells(i, j).Value = Sheets("Clean Data").Cells(i, j).Value + 1
    Next
Next
For i = 28 To 28
    For j = 4 To 404
        If Sheets("Clean Data").Cells(i, j).Value = 0 Then
            Sheets("Clean Data").Cells(i, j).Value = ""
        End If
    Next
Next
For i = 30 To 31
    For j = 4 To 404
        If Sheets("Clean Data").Cells(i, j).Value = 0 Then
            Sheets("Clean Data").Cells(i, j).Value = ""
        End If
    Next
Next

End Sub
```

Appendix K: LEED NCv2.2 WEc2 Sanitized Sample Form

Used under fair use, 2013

LEED-NC
LEED FOR NEW CONSTRUCTION

LEED-NC 2.2 Submittal Template
WE Credit 2: Innovative Wastewater Technologies

design

(Responsible Individual) (Company Name)

I, [redacted] , from [redacted]

verify that the information provided below is accurate, to the best of my knowledge.

SELECT OPTION

Please select the appropriate option to determine innovative wastewater technologies (this will activate the remainder of the submittal form)

○ **Option 1:** Water Savings Calculation

◉ **Option 2:** On-Site Wastewater Treatment

GENERAL PROJECT INFORMATION

Please enter the following general project information for either Option 1 or Option 2:

◉ Use Default Male / Female Occupancy Breakdown (50% / 50%).
ENTER THE TOTAL OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.01 BELOW

○ Special Male/Female Occupancy Breakdown
ENTER THE MALE AND FEMALE OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.02 BELOW. PROVIDE A NARRATIVE DESCRIPTION AT THE END OF THIS FORM TO EXPLAIN THE UNIQUE MALE/FEMALE OCCUPANCY BREAKDOWN.

Table 1.01 - Occupancy Breakdown (Default Male / Female Occupancy)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other:
Total	2	9			
Male	1	4			
Female	1	5			

Table 1.02 - Occupancy Breakdown (Special Male / Female Occupancy Breakdown)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other:
Total					
Male					
Female					

Percent of male restrooms with urinals:

Annual Days of Operation (1-365): 260

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LEED-NC 2.2 Submittal Template | Last Modified: April, 2006

WASTEWATER CALCULATION

1 - Baseline Case

Table 1.1 reflects the default baseline flush fixtures for the project.

To edit the baseline, deselect the "Included in Project?" checkbox for any baseline fixtures that don't apply to your project. The default flush rates, and daily uses per person match those in the reference guide, and should not be altered unless justification for these changes is provided in the narrative at the end of this form. Provide daily use per person input for "other" occupants (if applicable), and justify these values in the required narrative.

Table 1.1 - Flush Fixture Data - Baseline Case

Fixture Reference	Baseline Fixture Type	Gender	Flush Rate (GPF)	Daily Uses Per Person					Included in Project?
				FTE	Student / Visitor	Retail Customer	Residential		
1	Conventional Water Closet	Neutral	1.6	3.0	0.5				☒
2	Conventional Water Closet	Male	1.6						☐
3	Conventional Urinal	Male	1.0						☐

Annual Baseline Flush Fixture Water Usage:	4,368	gallons/year

2 - Design Case

Document the Design Case flush fixtures in Tables 2.1. The daily uses per person for each fixture type should equal those listed for the comparable fixture type in the Baseline case. If the design case fixture type is not listed in the dropdownlist, simply type in the appropriate fixture type.

Provide the fixture manufacturer and model number , and the flush or flow rate for each fixture type.

Multiple corresponding fixture types: If the project has multiple design case fixtures that correspond to a single Baseline comparison system fixture type , enter the "Percent of Occupants" field to reflect the percentage of each fixture (e.g. for a project with 25% non-water urinals and 75% low-flow urinals corresponding to Fixture Reference # 3 - "Conventional Urinals" in the Baseline design, enter the "Percent of Occupants" as 25% for non-water urinals. Then, in a blank line, select Fixture Reference #3, and enter the "Percent of Occupants" as 75% for low-flow urinals).

Dual-Flush Water Closets: If the project has dual-flush water closets , utilize the "Percent of Occupants" field to enter 33% for "Dual-Flush Water Closets, Full-Flush" (for solid waste use). Then, in a blank line, select Fixture Reference #1, and enter the "Percent of Occupants" as 67% for "Dual-Flush Water Closets, Low-Flush" (for liquid waste). Note: This clarification is not applicable for males when urinals are used.

Table 2.1 - Flush Fixture Data - Design Case

Fixture Reference	Design Case Fixture Type	Gender	Fixture Manufacturer	Fixture Model	Flush Rate (GPF)	Percent of Occupants	Daily Uses Per Person				
							FTE	Student / Visitor	Retail Customer	Residential	
1	Low-Flow Water Closet	Neutral	Toto	MS854114EL	1.3	100	3.0	0.5			
2											
3											

Annual Design Case Flush Fixture Water Usage:	**3,494**	**gallons/year**

OPTION 1

Enter the following data for Option 1 (if applicable)

Non-Potable Source Water

Enter the annual amount of on-site collected / treated water used for sewage conveyance. (Click "CLEAR" to clear a row of data. Enter the Annual Quantity as a whole number without commas.)

Water Source	Annual Quantity (gal)	
Grey Water Re-Use		CLEAR
Rainwater Re-Use		CLEAR
		CLEAR
		CLEAR
Total on-site nonpotable water:		

Option 1 Wastewater Use Summary

Baseline Case - Annual Water Consumption (gal):	4,368	gallons/year
Design Case - Annual Water Consumption (gal):	3,494	gallons/year
Total Annual Non-Potable Water Consumption (gal):		gallons/year
Total Water Savings:	20	%

For credit compliance, a sewage conveyance reduction of at least 50% earns 1 LEED point.

OPTION 2: ON-SITE WASTEWATER TREATMENT

☒ The project has been designed to treat on-site generated wastewater to tertiary standards. All treated wastewater is either infiltrated or used on-site.

Supporting Documentation

The project plumbing drawing(s) have been uploaded. The drawing(s) provide information regarding the on-site water treatment capabilities.

Sheet Description Log

Please include sheet name, sheet number and file name for each uploaded, referenced drawing (e.g. A-101, Site

alternative septic system.pdf
microFAST wastewater treatment.pdf
geoflow drip irrigation.pdf

☒ I have provided the appropriate supporting documentation in the document upload section of LEED Online. Please refer to the above sheets.

On-Site Water Treatment

Enter the annual amount of on-site collected / treated water used for sewage conveyance. The sum of the Infiltrated plus Reused water must equal the annual quantity treated. (Enter all quantities as whole numbers without commas.)

Water Source	Annual Quantity Treated (gal)	Annual Quantity Infiltrated (gal)	Annual Quantity Reused On-Site (gal)

water closet	3,494	3,494		CLEAR
				CLEAR
				CLEAR
Total:	3,494	3,494		

Option 2 Wastewater Summary

Design Case - Annual Flush Fixture Water Usage :	3,494	gallons/year
Total Annual On-Site Water Treatment:	3,494	gallons/year
Total Sewage Conveyance Reduction :	100	**%**

For credit compliance, 50% of wastewater must be treated on-site to earn 1 LEED point.

NARRATIVE (Required)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach. Please also describe the strategies employed by the project for reducing the use of potable water for sewage conveyance and/or reducing wastewater generation. Please include specific information regarding any reclaimed water usage (greywater re-use / rainwater reuse / on-site or municipally treated wastewater). If the project is treating wastewater on-site to tertiary standards, please include specific information regarding the use(s) of the treated wastewater.

Sub-surface drip system: 100% of wastewater is treated on-site to tertiary standards via a microFAST wastewater treatment system (see attached microFAST wastewater treatment.pdf), and then infiltrated through drip irrigation (see attached geoflow drip irrigation.pdf.)

Exemplary performance has been demonstrated, qualifying for one additional point under the Innovation in Design category.

NOTE: System is sized for future residence, to be built once all lots in the development are sold.

For LEED purposes, total sewage conveyance is calculated based on the actual number of fixtures installed.

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

*PLEASE NOTE: although all proper documentation has been entered and the calculations indicate that total wastewater reduction is 100%, the template shows "0 points documented". Please correct.

☐ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. *(Indicate the number of points documented in the Alternate Compliance Points Documented field below).*

Alternative Compliance Points Documented

Project Name: The Perch: Aerie Sales Studio

Credit: WE Credit 2: Innovative Wastewater Technologies

Points Documented: 1

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this

[redacted]

First Name	Last Name	Date	Username (Email Address)	Password

SAVE TEMPLATE TO LEED-ONLINE | PRINT TEMPLATE

Letter Template 10000456
Version A1 .

Appendix L: LEED NCv2.2 WEc2 Form Map

Used under fair use, 2013

LEED-NC
LEED FOR NEW CONSTRUCTION

LEED-NC 2.2 Submittal Template
WE Credit 2: Innovative Wastewater Technologies

design

(Responsible Individual) (Company Name)

I, 1 , from 2

verify that the information provided below is accurate, to the best of my knowledge.

SELECT OPTION

Please select the appropriate option to determine innovative wastewater technologies (this will activate the remainder of the submittal form)

3
- ◉ **Option 1:** Water Savings Calculation
- ◯ **Option 2:** On-Site Wastewater Treatment

GENERAL PROJECT INFORMATION

Please enter the following general project information for either Option 1 or Option 2:

4
- ◉ Use Default Male / Female Occupancy Breakdown (50% / 50%).
  ENTER THE TOTAL OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.01 BELOW
- ◯ Special Male/Female Occupancy Breakdown
  ENTER THE MALE AND FEMALE OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.02 BELOW. PROVIDE A NARRATIVE DESCRIPTION AT THE END OF THIS FORM TO EXPLAIN THE UNIQUE MALE/FEMALE OCCUPANCY BREAKDOWN.

Table 1.01 - Occupancy Breakdown (Default Male / Female Occupancy)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other: 20
Total	5	6	7	8	9
21	10	11	12	13	14
22	15	16	17	18	19

Table 1.02 - Occupancy Breakdown (Special Male / Female Occupancy Breakdown)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other: 38
Total	23	24	25	26	27
39	28	29	30	31	32
40	33	34	35	36	37

Percent of male restrooms with urinals: 41 %

Annual Days of Operation (1-365): 42

Powered by Adobe LiveCycle

LEED-NC 2.2 Submittal Template | Last Modified: April, 2006

WASTEWATER CALCULATION

1 - Baseline Case

Table 1.1 reflects the default baseline flush fixtures for the project.

To edit the baseline, deselect the "Included in Project?" checkbox for any baseline fixtures that don't apply to your project. The default flush rates, and daily uses per person match those in the reference guide, and should not be altered unless justification for these changes is provided in the narrative at the end of this form. Provide daily use per person input for "other" occupants (if applicable), and justify these values in the required narrative.

Table 1.1 - Flush Fixture Data - Baseline Case

Fixture Reference	Baseline Fixture Type	Gender	Flush Rate (GPF)	Daily Uses Per Person					Included in Project?
				FTE	Student / Visitor	Retail Customer	Residential	73	
43	44	45	46	47	48	49	50	51	52 ☒
53	54	55	56	57	58	59	60	61	62 ☒
63	64	65	66	67	68	69	70	71	72 ☒

Annual Baseline Flush Fixture Water Usage: 74 gallons/year

2 - Design Case

Document the Design Case flush fixtures in Tables 2.1. The daily uses per person for each fixture type should equal those listed for the comparable fixture type in the Baseline case. If the design case fixture type is not listed in the dropdownlist, simply type in the appropriate fixture type.

Provide the fixture manufacturer and model number , and the flush or flow rate for each fixture type.

Multiple corresponding fixture types: If the project has multiple design case fixtures that correspond to a single Baseline comparison system fixture type , enter the "Percent of Occupants" field to reflect the percentage of each fixture (e.g. for a project with 25% non-water urinals and 75% low-flow urinals corresponding to Fixture Reference # 3 - "Conventional Urinals" in the Baseline design, enter the "Percent of Occupants" as 25% for non-water urinals. Then, in a blank line, select Fixture Reference #3, and enter the "Percent of Occupants" as 75% for low-flow urinals).

Dual-Flush Water Closets: If the project has dual-flush water closets , utilize the "Percent of Occupants" field to enter 33% for "Dual-Flush Water Closets, Full-Flush" (for solid waste use). Then, in a blank line, select Fixture Reference #1, and enter the "Percent of Occupants" as 67% for "Dual-Flush Water Closets, Low-Flush" (for liquid waste). Note: This clarification is not applicable for males when urinals are used.

Table 2.1 - Flush Fixture Data - Design Case

Fixture Reference	Design Case Fixture Type	Gender	Fixture Manufacturer	Fixture Model	Flush Rate (GPF)	Percent of Occupants	Daily Uses Per Person: FTE	Student / Visitor	Retail Customer	Residential	75
76	77	78	79	80	81	82 %	83	84	85	86	87
88	89	90	91	92	93	94 %	95	96	97	98	99
100	101	102	103	104	105	106%	107	108	109	110	111
112	113	114	115	116	117	118 %	119	120	121	122	123
124	125	126	127	128	129	130%	131	132	133	134	135
136	137	138	139	140	141	142%	143	144	145	146	147

148

Annual Design Case Flush Fixture Water Usage: 149 gallons/year

OPTION 1

Enter the following data for Option 1 (if applicable)

Non-Potable Source Water

Enter the annual amount of on-site collected / treated water used for sewage conveyance. (Click "CLEAR" to clear a row of data. Enter the Annual Quantity as a whole number without commas.)

Water Source	Annual Quantity (gal)	
150	151	CLEAR
152	153	CLEAR
154	155	CLEAR
156	157	CLEAR
Total on-site nonpotable water:	158	

Option 1 Wastewater Use Summary

Baseline Case - Annual Water Consumption (gal):	159	gallons/year
Design Case - Annual Water Consumption (gal):	160	gallons/year
Total Annual Non-Potable Water Consumption (gal):	161	gallons/year
Total Water Savings:	162	%

For credit compliance, a sewage conveyance reduction of at least 50% earns 1 LEED point.

OPTION 2: ON-SITE WASTEWATER TREATMENT

163 ☐ The project has been designed to treat on-site generated wastewater to tertiary standards. All treated wastewater is either infiltrated or used on-site.

Supporting Documentation

The project plumbing drawing(s) have been uploaded. The drawing(s) provide information regarding the on-site water treatment capabilities.

Sheet Description Log

Please include sheet name, sheet number and file name for each uploaded, referenced drawing (e.g. A-101, Site Plan, siteplan. pdf)

164

165 ☐ I have provided the appropriate supporting documentation in the document upload section of LEED Online. Please refer to the above sheets.

On-Site Water Treatment

Enter the annual amount of on-site collected / treated water used for sewage conveyance. The sum of the Infiltrated plus Reused water must equal the annual quantity treated. (Enter all quantities as whole numbers without commas.)

Water Source	Annual Quantity Treated (gal)	Annual Quantity Infiltrated (gal)	Annual Quantity Reused On-Site (gal)	
166	167	168	169	CLEAR
170	171	172	173	CLEAR
174	175	176	177	CLEAR
Total:	178	179	180	

Option 2 Wastewater Summary

Design Case - Annual Flush Fixture Water Usage :	181	gallons/year
Total Annual On-Site Water Treatment:	182	gallons/year
Total Sewage Conveyance Reduction :	183	%

For credit compliance, 50% of wastewater must be treated on-site to earn 1 LEED point.

NARRATIVE (Required)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach. Please also describe the strategies employed by the project for reducing the use of potable water for sewage conveyance and/or reducing wastewater generation. Please include specific information regarding any reclaimed water usage (greywater re-use / rainwater reuse / on-site or municipally treated wastewater). If the project is treating wastewater on-site to tertiary standards, please include specific information regarding the use(s) of the treated wastewater.

184

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

185

186 ☐ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. *(Indicate the number of points documented in the Alternate Compliance Points Documented field below).*

187 Alternative Compliance Points Documented

Project Name: 188

Credit: 189

Points Documented: 190

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this template.

191	192	193	194	195
First Name	Last Name	Date	Username (Email Address)	Password

196 Letter Template Version A1 . 197

Appendix M: LEED NCv2.2 WEc2 Data Key

Table 24: LEED NCv2.2 WEc2 Data Key

Map	Form Region	NewID	DataType	Description
1	General	FilingInd	Text	Name of person filling out the form
2	General	FilingCo	Text	Company of person filling out the form
3	General	Option	Number	Option selected for credit completion
4	General	OccupancyBreakdown	Number	Option for type of occupancy breakdown
5	Occupancy	OccDTFTE	Number	Item from Table 1.01 - Default Occupancy Breakdown
6	Occupancy	OccDTSV	Number	Item from Table 1.01 - Default Occupancy Breakdown
7	Occupancy	OccDTRC	Number	Item from Table 1.01 - Default Occupancy Breakdown
8	Occupancy	OccDTRes	Number	Item from Table 1.01 - Default Occupancy Breakdown
9	Occupancy	OccDTOth	Number	Item from Table 1.01 - Default Occupancy Breakdown
10	Occupancy	OccDMFTE	Number	Item from Table 1.01 - Default Occupancy Breakdown
11	Occupancy	OccDMSV	Number	Item from Table 1.01 - Default Occupancy Breakdown
12	Occupancy	OccDMRC	Number	Item from Table 1.01 - Default Occupancy Breakdown
13	Occupancy	OccDMRes	Number	Item from Table 1.01 - Default Occupancy Breakdown
14	Occupancy	OccDMOth	Number	Item from Table 1.01 - Default Occupancy Breakdown
15	Occupancy	OccDFFTE	Number	Item from Table 1.01 - Default Occupancy Breakdown
16	Occupancy	OccDFSV	Number	Item from Table 1.01 - Default Occupancy Breakdown
17	Occupancy	OccDFRC	Number	Item from Table 1.01 - Default Occupancy Breakdown
18	Occupancy	OccDFRes	Number	Item from Table 1.01 - Default Occupancy Breakdown
19	Occupancy	OccDFOth	Number	Item from Table 1.01 - Default Occupancy Breakdown
20	Occupancy	OccDOtherType	Text	Item from Table 1.01 - Default Occupancy Breakdown
21	Occupancy	OccDMaleTitle	Text	Item from Table 1.01 - Default Occupancy Breakdown
22	Occupancy	OccDFemaleTitle	Text	Item from Table 1.01 - Default Occupancy Breakdown
23	Occupancy	OccSTFTE	Number	Item from Table 1.02 - Special Occupancy Breakdown
24	Occupancy	OccSTSV	Number	Item from Table 1.02 - Special Occupancy Breakdown
25	Occupancy	OccSTRC	Number	Item from Table 1.02 - Special Occupancy Breakdown
26	Occupancy	OccSTRes	Number	Item from Table 1.02 - Special Occupancy Breakdown
27	Occupancy	OccSTOth	Number	Item from Table 1.02 - Special Occupancy Breakdown
28	Occupancy	OccSMFTE	Number	Item from Table 1.02 - Special Occupancy Breakdown
29	Occupancy	OccSMSV	Number	Item from Table 1.02 - Special Occupancy Breakdown
30	Occupancy	OccSMRC	Number	Item from Table 1.02 - Special Occupancy Breakdown
31	Occupancy	OccSMRes	Number	Item from Table 1.02 - Special Occupancy Breakdown
32	Occupancy	OccSMOth	Number	Item from Table 1.02 - Special Occupancy Breakdown
33	Occupancy	OccSFFTE	Number	Item from Table 1.02 - Special Occupancy Breakdown
34	Occupancy	OccSFSV	Number	Item from Table 1.02 - Special Occupancy Breakdown
35	Occupancy	OccSFRC	Number	Item from Table 1.02 - Special Occupancy Breakdown
36	Occupancy	OccSFRes	Number	Item from Table 1.02 - Special Occupancy Breakdown
37	Occupancy	OccSFOth	Number	Item from Table 1.02 - Special Occupancy Breakdown
38	Occupancy	OccSOtherType	Text	Item from Table 1.02 - Special Occupancy Breakdown
39	Occupancy	OccSMaleTitle	Text	Item from Table 1.02 - Special Occupancy Breakdown
40	Occupancy	OccSFemaleTitle	Text	Item from Table 1.02 - Special Occupancy Breakdown
41	Occupancy	RestWUrinals	Number	Percent of male restrooms with urinals
42	Occupancy	DaysOfOperation	Number	Annual Days of Operation (1-365)
43	Baseline	BaseRARef	Number	Item from Table 1.1 - Baseline Flush Fixture Case
44	Baseline	BaseRAType	Text	Item from Table 1.1 - Baseline Flush Fixture Case

45	Baseline	BaseRAGen	Text	Item from Table 1.1 - Baseline Flush Fixture Case
46	Baseline	BaseRAGPF	Number	Item from Table 1.1 - Baseline Flush Fixture Case
47	Baseline	BaseRAFTE	Number	Item from Table 1.1 - Baseline Flush Fixture Case
48	Baseline	BaseRASV	Number	Item from Table 1.1 - Baseline Flush Fixture Case
49	Baseline	BaseRARC	Number	Item from Table 1.1 - Baseline Flush Fixture Case
50	Baseline	BaseRARes	Number	Item from Table 1.1 - Baseline Flush Fixture Case
51	Baseline	BaseRAOth	Number	Item from Table 1.1 - Baseline Flush Fixture Case
52	Baseline	BaseRAInc	Number	Item from Table 1.1 - Baseline Flush Fixture Case
53	Baseline	BaseRBRef	Number	Item from Table 1.1 - Baseline Flush Fixture Case
54	Baseline	BaseRBType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
55	Baseline	BaseRBGen	Text	Item from Table 1.1 - Baseline Flush Fixture Case
56	Baseline	BaseRBGPF	Number	Item from Table 1.1 - Baseline Flush Fixture Case
57	Baseline	BaseRBFTE	Number	Item from Table 1.1 - Baseline Flush Fixture Case
58	Baseline	BaseRBSV	Number	Item from Table 1.1 - Baseline Flush Fixture Case
59	Baseline	BaseRBRC	Number	Item from Table 1.1 - Baseline Flush Fixture Case
60	Baseline	BaseRBRes	Number	Item from Table 1.1 - Baseline Flush Fixture Case
61	Baseline	BaseRBOth	Number	Item from Table 1.1 - Baseline Flush Fixture Case
62	Baseline	BaseRBInc	Number	Item from Table 1.1 - Baseline Flush Fixture Case
63	Baseline	BaseRCRef	Number	Item from Table 1.1 - Baseline Flush Fixture Case
64	Baseline	BaseRCType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
65	Baseline	BaseRCGen	Text	Item from Table 1.1 - Baseline Flush Fixture Case
66	Baseline	BaseRCGPF	Number	Item from Table 1.1 - Baseline Flush Fixture Case
67	Baseline	BaseRCFTE	Number	Item from Table 1.1 - Baseline Flush Fixture Case
68	Baseline	BaseRCSV	Number	Item from Table 1.1 - Baseline Flush Fixture Case
69	Baseline	BaseRCRC	Number	Item from Table 1.1 - Baseline Flush Fixture Case
70	Baseline	BaseRCRes	Number	Item from Table 1.1 - Baseline Flush Fixture Case
71	Baseline	BaseRCOth	Number	Item from Table 1.1 - Baseline Flush Fixture Case
72	Baseline	BaseRCInc	Number	Item from Table 1.1 - Baseline Flush Fixture Case
73	Baseline	BaseROtherType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
74	Baseline	BaseAnnFlushUse	Number	Annual Baseline Flush Fixture Water Usage
75	Design	DesROtherType	Text	Item from Table 2.1 - Design Flush Fixture Case
76	Design	DesRARef	Number	Item from Table 2.1 - Design Flush Fixture Case
77	Design	DesRAFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
78	Design	DesRAGen	Text	Item from Table 2.1 - Design Flush Fixture Case
79	Design	DesRAFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
80	Design	DesRAFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
81	Design	DesRAGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
82	Design	DesRACentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
83	Design	DesRAFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
84	Design	DesRASV	Number	Item from Table 2.1 - Design Flush Fixture Case
85	Design	DesRARC	Number	Item from Table 2.1 - Design Flush Fixture Case
86	Design	DesRARes	Number	Item from Table 2.1 - Design Flush Fixture Case
87	Design	DesRAOth	Number	Item from Table 2.1 - Design Flush Fixture Case
88	Design	DesRBRef	Number	Item from Table 2.1 - Design Flush Fixture Case
89	Design	DesRBFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
90	Design	DesRBGen	Text	Item from Table 2.1 - Design Flush Fixture Case
91	Design	DesRBFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
92	Design	DesRBFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
93	Design	DesRBGPF	Number	Item from Table 2.1 - Design Flush Fixture Case

94	Design	DesRBCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
95	Design	DesRBFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
96	Design	DesRBSV	Number	Item from Table 2.1 - Design Flush Fixture Case
97	Design	DesRBRC	Number	Item from Table 2.1 - Design Flush Fixture Case
98	Design	DesRBRes	Number	Item from Table 2.1 - Design Flush Fixture Case
99	Design	DesRBOth	Number	Item from Table 2.1 - Design Flush Fixture Case
100	Design	DesRCRef	Number	Item from Table 2.1 - Design Flush Fixture Case
101	Design	DesRCFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
102	Design	DesRCGen	Text	Item from Table 2.1 - Design Flush Fixture Case
103	Design	DesRCFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
104	Design	DesRCFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
105	Design	DesRCGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
106	Design	DesRCCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
107	Design	DesRCFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
108	Design	DesRCSV	Number	Item from Table 2.1 - Design Flush Fixture Case
109	Design	DesRCRC	Number	Item from Table 2.1 - Design Flush Fixture Case
110	Design	DesRCRes	Number	Item from Table 2.1 - Design Flush Fixture Case
111	Design	DesRCOth	Number	Item from Table 2.1 - Design Flush Fixture Case
112	Design	DesRDRef	Number	Item from Table 2.1 - Design Flush Fixture Case
113	Design	DesRDFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
114	Design	DesRDGen	Text	Item from Table 2.1 - Design Flush Fixture Case
115	Design	DesRDFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
116	Design	DesRDFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
117	Design	DesRDGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
118	Design	DesRDCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
119	Design	DesRDFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
120	Design	DesRDSV	Number	Item from Table 2.1 - Design Flush Fixture Case
121	Design	DesRDRC	Number	Item from Table 2.1 - Design Flush Fixture Case
122	Design	DesRDRes	Number	Item from Table 2.1 - Design Flush Fixture Case
123	Design	DesRDOth	Number	Item from Table 2.1 - Design Flush Fixture Case
124	Design	DesRERef	Number	Item from Table 2.1 - Design Flush Fixture Case
125	Design	DesREFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
126	Design	DesREGen	Text	Item from Table 2.1 - Design Flush Fixture Case
127	Design	DesREFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
128	Design	DesREFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
129	Design	DesREGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
130	Design	DesRECentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
131	Design	DesREFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
132	Design	DesRESV	Number	Item from Table 2.1 - Design Flush Fixture Case
133	Design	DesRERC	Number	Item from Table 2.1 - Design Flush Fixture Case
134	Design	DesRERes	Number	Item from Table 2.1 - Design Flush Fixture Case
135	Design	DesREOth	Number	Item from Table 2.1 - Design Flush Fixture Case
136	Design	DesRFRef	Number	Item from Table 2.1 - Design Flush Fixture Case
137	Design	DesRFFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
138	Design	DesRFGen	Text	Item from Table 2.1 - Design Flush Fixture Case
139	Design	DesRFFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
140	Design	DesRFFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
141	Design	DesRFGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
142	Design	DesRFCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case

143	Design	DesRFFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
144	Design	DesRFSV	Number	Item from Table 2.1 - Design Flush Fixture Case
145	Design	DesRFRC	Number	Item from Table 2.1 - Design Flush Fixture Case
146	Design	DesRFRes	Number	Item from Table 2.1 - Design Flush Fixture Case
147	Design	DesRFOth	Number	Item from Table 2.1 - Design Flush Fixture Case
148	Design	DesRErrors	Text	Item from Table 2.1 - Design Flush Fixture Case
149	Design	DesAnnFlushUse	Number	Annual Design Case Flush Fixture Water Usage
150	Savings	NonPotASource	Text	Source of non-potable water
151	Savings	NonPotAQuant	Number	Quantity from non-potable source
152	Savings	NonPotBSource	Text	Source of non-potable water
153	Savings	NonPotBQuant	Number	Quantity from non-potable source
154	Savings	NonPotCSource	Text	Source of non-potable water
155	Savings	NonPotCQuant	Number	Quantity from non-potable source
156	Savings	NonPotDSource	Text	Source of non-potable water
157	Savings	NonPotDQuant	Number	Quantity from non-potable source
158	Savings	NonPotTotal	Number	Total quantity from non-potable sources
159	Savings	BaseAWC	Number	Baseline Case - Annual Water Consumption (gal)
160	Savings	DesAWC	Number	Design Case - Annual Water Consumption (gal)
161	Savings	TotalAWC	Number	Total Annual Non-Potable Water Consumption (gal)
162	Savings	TotalWaterSavings	Number	Total Water Savings (gal)
163	Treatment	OnSiteWW	Text	Whether the project has been designed to treat on-site generated wastewater to tertiary standards. All treated wastewater is either infiltrated or used on-site.
164	Treatment	SupportingDocs	Text	List of supporting documents for option 2
165	Treatment	SupportingDocsChk	Text	Confirmation that supporting documents for option 2 have been uploaded
166	Treatment	WWASource	Text	Item from On-Site Water Treatment Table
167	Treatment	WWATreat	Number	Item from On-Site Water Treatment Table
168	Treatment	WWAInfilt	Number	Item from On-Site Water Treatment Table
169	Treatment	WWAReuse	Number	Item from On-Site Water Treatment Table
170	Treatment	WWBSource	Text	Item from On-Site Water Treatment Table
171	Treatment	WWBTreat	Number	Item from On-Site Water Treatment Table
172	Treatment	WWBInfilt	Number	Item from On-Site Water Treatment Table
173	Treatment	WWBReuse	Number	Item from On-Site Water Treatment Table
174	Treatment	WWCSource	Text	Item from On-Site Water Treatment Table
175	Treatment	WWCTreat	Number	Item from On-Site Water Treatment Table
176	Treatment	WWCInfilt	Number	Item from On-Site Water Treatment Table
177	Treatment	WWCReuse	Number	Item from On-Site Water Treatment Table
178	Treatment	WWTotTreat	Number	Item from On-Site Water Treatment Table
179	Treatment	WWTotInfilt	Number	Item from On-Site Water Treatment Table
180	Treatment	WWTotReuse	Number	Item from On-Site Water Treatment Table
181	Treatment	DesAnnFlushUseWW	Number	Design Case - Annual Flush Fixture Water Usage
182	Treatment	TotAnnOnSiteWWT	Number	Total Annual On-Site Water Treatment
183	Treatment	TotSewConvRed	Number	Total Sewage Conveyance Reduction
184	Narrative	Narrative1	Text	Narrative for compliance
185	Narrative	Narrative2	Text	Special circumstances narrative
186	Narrative	AltComp	Text	Alternative compliance approach is used
187	Narrative	AltCompPts	Number	Points documented for alternative compliance
188	General	ProjName	Text	Name of project

189	General	CreditAttempted	Text	Credit attempted on form
190	General	PointsDocumented	Number	Number of points documented on form
191	General	SubFirstName	Text	Submitter's first name
192	General	SubLastName	Text	Submitter's last name
193	General	SubDate	Text	Submission date
194	General	SubUsername	Text	Submitter's user name
195	General	SubPW	Text	Submitter's password
196	General	TemplateVer	Text	Page template version
197	General	FormVerID	Number	Form version ID

Appendix N: LEED NCv2.2 WEc2 Cleaning Log

- Added count column to see if any fields failed to translate.
    - OccSTRes
        - fine, compared v m&f, which had, but people entered zero. nothing in m&f, not a problem.
    - OccSTOth
        - fine, compared v m&f, which had, but people entered zero. nothing in m&f, not a problem.
    - SubPW
        - had none, but it is a password field and not needed or in any forms
    - DesRErrors
        - only for errors during form filling out, should be zero
    - NonPotDSource
        - for fourth type of nonpot source, projects maxed at 3
    - NonPotDQuant
        - for fourth type of nonpot source, projects maxed at 3
- Checked for form versions. only 1 found
    - 10000456
- Filled all empty numeric fields with 0
- Modified option Field values to equal option numbers
- standardized fixture type and water source
    - wrote programs to
        - separate into types of fields (type/source)
        - identify all unique entries
    - assigned standardized values to all unique entries (stored in separate document for reference)
    - added corresponding fields for each field with potential conflict with program
    - filled corresponding fields with standard entry with program
- Found that four projects do not have fixture types
    - List of projects
        - 10006719
            - Alt, no fixtures
        - 10028805
            - Lists models but not type. Found online, entered in cleaned fields.
        - 10240986
            - left off of form, no details except female 2
        - 10246415
            - nothing entered in form. some calculations attached but do not describe
- reformatted submission dates that were not in standard date format

Appendix O: LEED NCv2.2 WEc2 Cleaning Code

```
‘VBA code from MS Excel
Private Sub CommandButton1_Click()

Dim i, j As Integer

Application.ScreenUpdating = False
'57 records, 197 fields

For i = 2 To 199
   If Sheets("Raw").Cells(i, 4).Value = "Number" Then
      For j = 4 To 60
         Sheets("Clean").Cells(i, j).Value = Sheets("Raw").Cells(i, j + 1).Value
         If Sheets("Raw").Cells(i, j + 1).Value = "" Then
            Sheets("Clean").Cells(i, j).Value = 0
         End If
      Next
   Else
      For j = 4 To 60
         Sheets("Clean").Cells(i, j).Value = Sheets("Raw").Cells(i, j + 1).Value
      Next
   End If
Next

For j = 4 To 60
   Sheets("Clean").Cells(5, j).Value = Sheets("Clean").Cells(5, j).Value + 1
Next

End Sub
```

```
Private Sub CommandButton1_Click()

Dim i, j, ci, k As Integer
Dim colCount As Integer

k = Sheets("Standardization").Cells(2, 1).Value + 3
'Sheets("Standardization").Cells(2, 2).Value = k

i = 4
colCount = 3

Do While Sheets("Standardization").Cells(i, 1).Value <> ""

   'set up next round of columns
   Sheets("Standardization").Cells(3, colCount + 0).Value = "Copy"
   Sheets("Standardization").Cells(3, colCount + 1).Value = "Change to"
   Sheets("Standardization").Cells(2, colCount + 1).Value = Sheets("Standardization").Cells(i,
1).Value
   Sheets("Standardization").Cells(1, colCount + 1).Value = Sheets("Standardization").Cells(i,
2).Value

   'copy from clean data c4 to k
   ci = 2
   Do While Sheets("Clean").Cells(ci, 2).Value <> Sheets("Standardization").Cells(i, 1).Value
      ci = ci + 1
   Loop
   Sheets("Standardization").Cells(2, colCount + 1).Value = Sheets("Clean").Cells(ci, 2).Value
   Sheets("Standardization").Cells(2, colCount + 0).Value = Sheets("Clean").Cells(ci, 3).Value
   Sheets("Clean").Range(Sheets("Clean").Cells(ci, 4), Sheets("Clean").Cells(ci, k)).Copy
   Sheets("Standardization").Cells(4, colCount).PasteSpecial Transpose:=True

   'sort <<
   Sheets("Standardization").Range(Sheets("Standardization").Cells(4, colCount),
Sheets("Standardization").Cells(k, colCount)).Sort
key1:=Range(Sheets("Standardization").Cells(4, colCount), Sheets("Standardization").Cells(k,
colCount)), order1:=xlAscending, Header:=xlNo
   Sheets("Standardization").Range(Sheets("Standardization").Cells(4, colCount),
Sheets("Standardization").Cells(k, colCount)).RemoveDuplicates Columns:=1, Header:=xlNo
   '>>
   'copy then sort then remove duplicates
   Columns(colCount).Borders(xlEdgeLeft).LineStyle = xlContinuous
   'prep for next round
   i = i + 1
   colCount = colCount + 2
Loop
End Sub
```

```
Private Sub CommandButton1_Click()

Dim i, j, k, m, newRow As Integer
'Cells(i, 8).Value = Application.VLookup(Cells(i, 7).Value, Range(Cells(2, 1), Cells(11, 2)), 2,
False)

newRow = 199

'do while loop to check each class until empty
j = 1 'j is column with field numbers on Change Record sheet
Do While Sheets("Change Record").Cells(4, j).Value <> ""
   'do while loop for each field
   i = 4 'i is row of field in process
   Do While Sheets("Change Record").Cells(i, j).Value <> ""
      'find the column in cleanstandard
      k = 4 'k is row of field in CleanStandard
      Do While Sheets("CleanStandard").Cells(k, 2).Value <> ""
         If Sheets("CleanStandard").Cells(k, 2).Value = Sheets("Change Record").Cells(i,
j).Value Then
            'add replacement field
            Sheets("cleanstandard").Cells(newRow, 3).Value = Sheets("CleanStandard").Cells(k,
3).Value & "Cl"
            'add replacement values
            For m = 4 To 60 'm is column of record in CleanStandard
               'look up replacement
               If Sheets("CleanStandard").Cells(k, m).Value <> "" Then
                  Sheets("CleanStandard").Cells(newRow, m).Value =
Application.VLookup(Sheets("CleanStandard").Cells(k, m).Value, Sheets("Change
Record").Range(Sheets("Change Record").Cells(4, j + 1), Sheets("Change Record").Cells(100, j
+ 2)), 2, False)
               End If
            Next
            newRow = newRow + 1
            Exit Do
         End If

         k = k + 1
      Loop
      'for loop for each project
      i = i + 1
   Loop
   j = j + 3
Loop
End Sub
```

```
Private Sub CommandButton1_Click()

Dim h, i, j, k, m, Ccnt, Fcnt As Integer

'multiples
'classes
Ccnt = Sheets("Standardization").Cells(2, 2).Value
'fields
Fcnt = Sheets("Standardization").Cells(1, 2).Value

'prep for classes
For x = 1 To Ccnt 'x is the current class number
    Sheets("Classes").Cells(1, (1 + (3 * x))).Value = "Class"
    Sheets("Classes").Cells(1, (2 + (3 * x))).Value = x
    Sheets("Classes").Cells(3, (1 + (3 * x))).Value = "Fields with"
    Sheets("Classes").Cells(3, (2 + (3 * x))).Value = "Possibilities"
    Sheets("Classes").Cells(3, (3 + (3 * x))).Value = "Change to"

    'copy field numbers
    i = 4
    For y = 1 To Fcnt
        If Sheets("Standardization").Cells(3 + y, 2).Value = x Then
            Sheets("Classes").Cells(i, (1 + (3 * x))).Value = Sheets("Standardization").Cells(3 + y,
1).Value
            i = i + 1
        End If
    Next
    i = i - 1 'i is now the number of fields for the class

    'copy possibilities

    'for each field in the class
    k = 4
    For h = 1 To i
        'for until we find the column with matching fid, then exit for
        For j = 4 To (Fcnt * 2 + 2)
            If Sheets("Standardization").Cells(2, j).Value = Sheets("Classes").Cells(h + 3, (1 + (3 *
x))).Value Then
                m = 4
                Do While Sheets("Standardization").Cells(m, j - 1).Value <> ""
                    Sheets("Standardization").Cells(m, j).Value = "nabbed"
                    Sheets("Classes").Cells(k, (2 + (3 * x))).Value = Sheets("Standardization").Cells(m,
j - 1).Value
                    m = m + 1
                    k = k + 1
                Loop
```

```
            'Exit For
         End If
      Next
   Next

   'when all class fields are done, sort and then remove duplicates
   Sheets("Classes").Range(Sheets("Classes").Cells(4, (2 + (3 * x))), Sheets("Classes").Cells(k,
(2 + (3 * x)))).Sort key1:=Range(Sheets("Classes").Cells(4, (2 + (3 * x))),
Sheets("Classes").Cells(k, (2 + (3 * x)))), order1:=xlAscending, Header:=xlNo
   Sheets("Classes").Range(Sheets("Classes").Cells(4, (2 + (3 * x))), Sheets("Classes").Cells(k,
(2 + (3 * x)))).RemoveDuplicates Columns:=1, Header:=xlNo

   'add lines
   Columns(1 + (3 * x)).Borders(xlEdgeLeft).LineStyle = xlContinuous
Next


End Sub
```

Appendix P: LEED NCv2.2 WEc3 Sanitized Sample Form

Used under fair use, 2013

LEED-NC
LEED FOR NEW CONSTRUCTION

LEED-NC 2.2 Submittal Template
WE Credit 3: Water Use Reduction

design

(Responsible Individual) (Company Name)

I [redacted], from [redacted]

verify that the information provided below is accurate, to the best of my knowledge.

GENERAL INFORMATION

Please enter the following general project information:

(◉) Use Default Male / Female Occupancy Breakdown (50% / 50%).
ENTER THE TOTAL OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.01 BELOW

( ) Special Male/Female Occupancy Breakdown
ENTER THE MALE AND FEMALE OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.02 BELOW. PROVIDE A NARRATIVE DESCRIPTION AT THE END OF THIS FORM TO EXPLAIN THE UNIQUE MALE/FEMALE OCCUPANCY BREAKDOWN.

Table 1.01 - Occupancy Breakdown (Default Male / Female Occupancy)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other:
Total	4	500			
Male	2	250			
Female	2	250			

Table 1.02 - Occupancy Breakdown (Special Male / Female Occupancy Breakdown)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other:
Total					
Male					
Female					

Percent of male restrooms with urinals:	100

Annual Days of Operation (1-365):	250

WATER SAVINGS CALCULATION

Powered by Adobe LiveCycle

1 - Baseline Case

Tables 1.1 and 1.2 reflect the default baseline flush and flow fixtures for the project.

To edit the baseline, deselect the "Included in Project?" checkbox for any baseline fixtures that don't apply to your project. The default flush and flow rates, and daily uses per person match those in the reference guide, and should not be altered unless justification for these changes is provided in the narrative at the end of this form. Provide daily use per person input for "other" occupants (if applicable), and justify these values in the required narrative

Table 1.1 - Flush Fixture Data - Baseline Case

Fixture Reference	Baseline Fixture Type	Gender	Flush Rate (GPF)	Daily Uses Per Person					Included in Project?
				FTE	Student / Visitor	Retail Customer	Residential		
1	Conventional Water Closet	Female	1.6	3.0	0.5				☒
2	Conventional Water Closet	Male	1.6	1.0	0.1				☒
3	Conventional Urinal	Male	1.0	2.0	0.4				☒

Annual Baseline Flush Fixture Water Usage:	**89,200**	**gallons/year**

Table 1.2 - Flow Fixture Data - Baseline Case

Fixture Reference	Baseline Fixture Type	Flow Rate (GPM)	Duration (seconds)	Daily Uses Per Person					Included in Project?
				FTE	Student / Visitor	Retail Customer	Residential		
A	Conventional Lavatory	2.5	15	3.0	0.5				☒
B	Conventional Shower	2.5	300						☐
C	Kitchen Sink	2.5	15	1.0					☒
D	Janitor Sink								☐
E									☐

TOTAL ANNUAL BASELINE WATER USAGE:	**130,762**	**gallons/year**
Annual Baseline Flow Fixture Water Usage:	**41,562**	**gallons/year**

2 - Design Case

Document the Design Case flush and flow fixtures in Tables 2.1 and 2.2 respectively. The daily uses per person, and duration of use for each fixture type should equal those listed for the comparable fixture type in the Baseline case. If the design case fixture type is not listed in the dropdownlist, simply type in the appropriate fixture type.

Provide the fixture manufacturer and model number , and the flush or flow rate for each fixture type.

Multiple corresponding fixture types: If the project has multiple design case fixtures that correspond to a single Baseline comparison system fixture type , enter the "Percent of Occupants" field to reflect the percentage of each fixture (e.g. for a project with 25% non-water urinals and 75% low-flow urinals corresponding to Fixture Reference # 3 - "Conventional Urinals" in the Baseline design, enter the "Percent of Occupants" as 25% for non-water urinals. Then, in a blank line, select Fixture Reference #3, and enter the "Percent of Occupants" as 75% for low-flow urinals).

Dual-Flush Water Closets: If the project has dual-flush water closets , utilize the "Percent of Occupants" field to enter 33% for "Dual-Flush Water Closets, Full-Flush" (for solid waste use). Then, in a blank line, select Fixture Reference #1, and enter the "Percent of Occupants" as 67% for "Dual-Flush Water Closets, Low-Flush" (for liquid waste). Note: This clarification is not applicable for males when urinals are used.

Automatic Controls: If the flow fixutres include automatic faucet controls, you may adjust the Duration in Table 2.2 to reflect the impact of the automated controls. Justification for these input values, along with the identification of the faucet control manufacturer and model number must be provided in the required narrative.

Table 2.1 - Flush Fixture Data - Design Case

Fixture Reference	Design Case Fixture Type	Gender	Fixture Manufacturer	Fixture Model	Flush Rate (GPF)	Percent of Occupants	Daily Uses Per Person				
							FTE	Student / Visitor	Retail Customer	Residential	
1	Water Closet	Female	Kohler/Sloan	K-4330/Royal 111	1.6	100	3.0	0.5			
2	Water Closet	Male	Kohler/Sloan	K-4330/Royal 111	1.6	100	1.0	0.1			
3	Urinal	Male	Kohler/Sloan	K-4960-ET/Sloan 186-05	0.5	100	2.0	0.4			
1							3.0	0.5			
2							1.0	0.1			

Annual Design Case Flush Fixture Water Usage:	76,200	gallons/year

Table 2.2 - Flow Fixture Data - Design Case

Fixture Reference	Design Case Fixture Type	Fixture Manufacturer	Fixture Model	Flow Rate (GPF)	Percent of Occupants	Duration (seconds)	Daily Uses Per Person				
							FTE	Student / Visitor	Retail Customer	Residential	
A	Conventional Lavatory	Kohler/Chicago/Omni	K-20052200-4cp/L-400-0.5VR	0.5	100	15	3.0	0.5			
B					100	300					
C	Kitchen Sink	Elkay/Chicago/Omni	elv-2219/895-31/L-400-0.5VR	0.5	100	15	1.0				
D					100						

Annual Design Case Flow Fixture Water Usage:	8,312	gallons/year
Annual Design Case Flush and Flow Fixture Water Usage:	84,512	gallons/year

Non-Potable Source Water

Enter the annual amount of on-site collected / treated water used for flush or flow fixtures. (Click "CLEAR" to clear a row of data. Enter the Annual Quantity as a whole number without commas.)

Water Source	Annual Quantity (gal)	
Grey Water Re-Use		CLEAR
Rainwater Re-Use		CLEAR
		CLEAR
		CLEAR
Total on-site nonpotable water:		

WATER USE SUMMARY

Baseline Case - Annual Water Consumption (gal):	130,762	gallons/year
Design Case - Annual Water Consumption (gal):	84,512	gallons/year
Total Annual Non-Potable Water Consumption (gal):		gallons/year
Total Water Savings:	35.4	%

For credit compliance, a water savings of at least 20% earns 1 LEED point, and a water savings of at least 30% earns 2 LEED points.

NARRATIVE (Required)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach. Describe the water savings features of this project, and include specific data regarding any water saving fixtures and/or reclaimed water usage (greywater re-use / rainwater reuse).

The majority of the water use for [redacted] happens at the public rest rooms at the ground floor level. Water use efficiency was achieved by using low flow urinals, low flow lavatory aerators, and dual flush valve water closets. All operators of these fixtures are from manual level valves and faucets.

The Assembly Hall building primarily supports visitors such as students, lecturers/professors, custodians, and AV techs who are only in the building for short periods of time, less than two hours, to support classes in session. Within the Retail space 1 full time employee will be present. The template has been revised to include an FTE of 3.75 to account for the AV tech, custodian, visiting caterers, and the retail worker.

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

N/A

☐ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. *(Indicate the number of points documented in the Alternate Compliance Points Documented field below).*

Alternative Compliance Points Documented

Project Name: [redacted]

Credit: WE Credit 3: Water Use Reduction

Points Documented: 2

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this template.

[redacted]

First Name	Last Name	Date	Username (Email Address)	Password

SAVE TEMPLATE TO LEED-ONLINE

PRINT TEMPLATE

Letter Template 10000504
Version A1 .

Appendix Q: LEED NCv2.2 WEc3 Form Map

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LEED-NC
LEED FOR NEW CONSTRUCTION

LEED-NC 2.2 Submittal Template
WE Credit 3: Water Use Reduction

design

(Responsible Individual) (Company Name)

I, 1 , from 2

verify that the information provided below is accurate, to the best of my knowledge.

GENERAL INFORMATION

Please enter the following general project information:

3

- (•) Use Default Male / Female Occupancy Breakdown (50% / 50%).
  ENTER THE TOTAL OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.01 BELOW
- ( ) Special Male/Female Occupancy Breakdown
  ENTER THE MALE AND FEMALE OCCUPANCY FOR EACH OCCUPANCY TYPE IN TABLE 1.02 BELOW. PROVIDE A NARRATIVE DESCRIPTION AT THE END OF THIS FORM TO EXPLAIN THE UNIQUE MALE/FEMALE OCCUPANCY BREAKDOWN.

Table 1.01 - Occupancy Breakdown (Default Male / Female Occupancy)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other: 4
Total	5	6	7	8	9
9	10	11	12	13	14
14	15	16	17	18	19

Table 1.02 - Occupancy Breakdown (Special Male / Female Occupancy Breakdown)
Enter the values as whole numbers without any commas

	Full Time Equivalent (FTE):	Student/Visitor:	Retail Customer:	Residential:	Other: 38
Total	23	24	25	26	27
39	28	29	30	31	32
40	33	34	35	36	37

Percent of male restrooms with urinals: 41

Annual Days of Operation (1-365): 42

WATER SAVINGS CALCULATION

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1 - Baseline Case

Tables 1.1 and 1.2 reflect the default baseline flush and flow fixtures for the project.

To edit the baseline, deselect the "Included in Project?" checkbox for any baseline fixtures that don't apply to your project. The default flush and flow rates, and daily uses per person match those in the reference guide, and should not be altered unless justification for these changes is provided in the narrative at the end of this form. Provide daily use per person input for "other" occupants (if applicable), and justify these values in the required narrative

Table 1.1 - Flush Fixture Data - Baseline Case

Fixture Reference	Baseline Fixture Type	Gender	Flush Rate (GPF)	Daily Uses Per Person: FTE	Daily Uses Per Person: Student / Visitor	Daily Uses Per Person: Retail Customer	Daily Uses Per Person: Residential	Daily Uses Per Person: 73	Included in Project?
1 43	44	45	46	47	48	49	50	51	52 ☒
2 53	54	55	56	57	58	59	60	61	62 ☒
3 63	64	65	66	67	68	69	70	71	72 ☒

Annual Baseline Flush Fixture Water Usage:	74	gallons/year

Table 1.2 - Flow Fixture Data - Baseline Case

Fixture Reference	Baseline Fixture Type	Flow Rate (GPM)	Duration (seconds)	Daily Uses Per Person: FTE	Daily Uses Per Person: Student / Visitor	Daily Uses Per Person: Retail Customer	Daily Uses Per Person: Residential	Daily Uses Per Person: 163	Included in Project?
A 164	165	166	167	168	169	170	171	172	173 ☒
B 174	175	176	177	178	179	180	181	182	183 ☒
C 184	185	186	187	188	189	190	191	192	193 ☒
D 194	195	196	197	198	199	200	201	202	203 ☐
E 204	205	206	207	208	209	210	211	212	213 ☐

TOTAL ANNUAL BASELINE WATER USAGE:	214	gallons/year
Annual Baseline Flow Fixture Water Usage:	215	gallons/year

2 - Design Case

Document the Design Case flush and flow fixtures in Tables 2.1 and 2.2 respectively. The daily uses per person, and duration of use for each fixture type should equal those listed for the comparable fixture type in the Baseline case. If the design case fixture type is not listed in the dropdownlist, simply type in the appropriate fixture type.

Provide the fixture manufacturer and model number , and the flush or flow rate for each fixture type.

Multiple corresponding fixture types: If the project has multiple design case fixtures that correspond to a single Baseline comparison system fixture type , enter the "Percent of Occupants" field to reflect the percentage of each fixture (e.g. for a project with 25% non-water urinals and 75% low-flow urinals corresponding to Fixture Reference # 3 - "Conventional Urinals" in the Baseline design, enter the "Percent of Occupants" as 25% for non-water urinals. Then, in a blank line, select Fixture Reference #3, and enter the "Percent of Occupants" as 75% for low-flow urinals).

Dual-Flush Water Closets: If the project has dual-flush water closets , utilize the "Percent of Occupants" field to enter 33% for "Dual-Flush Water Closets, Full-Flush" (for solid waste use). Then, in a blank line, select Fixture Reference #1, and enter the "Percent of Occupants" as 67% for "Dual-Flush Water Closets, Low-Flush" (for liquid waste). Note: This clarification is not applicable for males when urinals are used.

Automatic Controls: If the flow fixutres include automatic faucet controls, you may adjust the Duration in Table 2.2 to reflect the impact of the automated controls. Justification for these input values, along with the identification of the faucet control manufacturer and model number must be provided in the required narrative.

Table 2.1 - Flush Fixture Data - Design Case

Fixture Reference	Design Case Fixture Type	Gender	Fixture Manufacturer	Fixture Model	Flush Rate (GPF)	Percent of Occupants	Daily Uses Per Person				
							FTE	Student / Visitor	Retail Customer	Residential	75
1 76	77	78	79	80	81	82	83	84	85	86	87
1 88	89	90	91	92	93	94	95	96	97	98	99
2 100	101	102	103	104	105	106	107	108	109	110	111
2 112	113	114	115	116	117	118	119	120	121	122	123
3 124	125	126	127	128	129	130	131	132	133	134	135
3 136	137	138	139	140	141	142	143	144	145	146	147

148

Annual Design Case Flush Fixture Water Usage:	149	gallons/year

Table 2.2 - Flow Fixture Data - Design Case

Fixture Reference	Design Case Fixture Type	Fixture Manufacturer	Fixture Model	Flow Rate (GPF)	Percent of Occupants	Duration (seconds)	Daily Uses Per Person: FTE	Student / Visitor	Retail Customer	Residential	216
A 217	218	219	220	221	222	223	224	225	226	227	228
B 229	230	231	232	233	234	235	236	237	238	239	240
C 241	242	243	244	245	246	247	248	249	250	251	252
D 253	254	255	256	257	258	259	260	261	262	263	264
265	266	267	268	269	270	271	272	273	274	275	276
277	278	279	280	281	282	283	284	285	286	287	288
289	290	291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310	311	312

313

Annual Design Case Flow Fixture Water Usage:	314	gallons/year
Annual Design Case Flush and Flow Fixture Water Usage:	315	gallons/year

Non-Potable Source Water

Enter the annual amount of on-site collected / treated water used for flush or flow fixtures. (Click "CLEAR" to clear a row of data. Enter the Annual Quantity as a whole number without commas.)

Water Source	Annual Quantity (gal)	
150	151	CLEAR
152	153	CLEAR
154	155	CLEAR
156	157	CLEAR
Total on-site nonpotable water:	158	

WATER USE SUMMARY

Baseline Case - Annual Water Consumption (gal):	159	gallons/year
Design Case - Annual Water Consumption (gal):	160	gallons/year
Total Annual Non-Potable Water Consumption (gal):	161	gallons/year
Total Water Savings:	162	%

For credit compliance, a water savings of at least 20% earns 1 LEED point, and a water savings of at least 30% earns 2 LEED points.

NARRATIVE (Required)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach. Describe the water savings features of this project, and include specific data regarding any water saving fixtures and/or reclaimed water usage (greywater re-use / rainwater reuse).

316

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

317

318 ☐ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. *(Indicate the number of points documented in the Alternate Compliance Points Documented field below).*

319 Alternative Compliance Points Documented

Project Name:	320		
Credit:	321	Points Documented:	322

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this

323	324	325	326	327
First Name	Last Name	Date	Username (Email Address)	Password

SAVE TEMPLATE TO LEED-ONLINE   PRINT TEMPLATE

328   329

Appendix R: LEED NCv2.2 WEc3 Data Key

Table 25: LEED NCv2.2 WEc3 Data Key

Map	Form Region	NewID	DataType	Description
2	General	FilingCo	Text	Company of person filling out the form
1	General	FilingInd	Text	Name of person filling out the form
3	General	Option	Number	Option selected for credit completion
5	Occupancy	OccDTFTE	Number	Item from Table 1.01 - Default Occupancy Breakdown
6	Occupancy	OccDTSV	Number	Item from Table 1.01 - Default Occupancy Breakdown
7	Occupancy	OccDTRC	Number	Item from Table 1.01 - Default Occupancy Breakdown
8	Occupancy	OccDTRes	Number	Item from Table 1.01 - Default Occupancy Breakdown
10	Occupancy	OccDMFTE	Number	Item from Table 1.01 - Default Occupancy Breakdown
15	Occupancy	OccDFFTE	Number	Item from Table 1.01 - Default Occupancy Breakdown
11	Occupancy	OccDMSV	Number	Item from Table 1.01 - Default Occupancy Breakdown
16	Occupancy	OccDFSV	Number	Item from Table 1.01 - Default Occupancy Breakdown
12	Occupancy	OccDMRC	Number	Item from Table 1.01 - Default Occupancy Breakdown
17	Occupancy	OccDFRC	Number	Item from Table 1.01 - Default Occupancy Breakdown
13	Occupancy	OccDMRes	Number	Item from Table 1.01 - Default Occupancy Breakdown
18	Occupancy	OccDFRes	Number	Item from Table 1.01 - Default Occupancy Breakdown
20	Occupancy	OccDMaleTitle	Text	Item from Table 1.01 - Default Occupancy Breakdown
21	Occupancy	OccDFemaleTitle	Text	Item from Table 1.01 - Default Occupancy Breakdown
9	Occupancy	OccDTOth	Number	Item from Table 1.01 - Default Occupancy Breakdown
14	Occupancy	OccDMOth	Number	Item from Table 1.01 - Default Occupancy Breakdown
19	Occupancy	OccDFOth	Number	Item from Table 1.01 - Default Occupancy Breakdown
4	Occupancy	OccDOtherType	Text	Item from Table 1.01 - Default Occupancy Breakdown
23	Occupancy	OccSTFTE	Number	Item from Table 1.02 - Special Occupancy Breakdown
24	Occupancy	OccSTSV	Number	Item from Table 1.02 - Special Occupancy Breakdown
25	Occupancy	OccSTRC	Number	Item from Table 1.02 - Special Occupancy Breakdown
26	Occupancy	OccSTRes	Number	Item from Table 1.02 - Special Occupancy Breakdown
28	Occupancy	OccSMFTE	Number	Item from Table 1.02 - Special Occupancy Breakdown
33	Occupancy	OccSFFTE	Number	Item from Table 1.02 - Special Occupancy Breakdown
29	Occupancy	OccSMSV	Number	Item from Table 1.02 - Special Occupancy Breakdown
34	Occupancy	OccSFSV	Number	Item from Table 1.02 - Special Occupancy Breakdown
30	Occupancy	OccSMRC	Number	Item from Table 1.02 - Special Occupancy Breakdown
35	Occupancy	OccSFRC	Number	Item from Table 1.02 - Special Occupancy Breakdown
31	Occupancy	OccSMRes	Number	Item from Table 1.02 - Special Occupancy Breakdown
36	Occupancy	OccSFRes	Number	Item from Table 1.02 - Special Occupancy Breakdown
39	Occupancy	OccSMaleTitle	Text	Item from Table 1.02 - Special Occupancy Breakdown
40	Occupancy	OccSFemaleTitle	Text	Item from Table 1.02 - Special Occupancy Breakdown
27	Occupancy	OccSTOth	Number	Item from Table 1.02 - Special Occupancy Breakdown

32	Occupancy	OccSMOth	Number	Item from Table 1.02 - Special Occupancy Breakdown
37	Occupancy	OccSFOth	Number	Item from Table 1.02 - Special Occupancy Breakdown
38	Occupancy	OccSOtherType	Text	Item from Table 1.02 - Special Occupancy Breakdown
41	Occupancy	RestWUrinals	Number	Percent of male restrooms with urinals
42	Occupancy	DaysOfOperation	Number	Annual Days of Operation (1-365)
73	Baseline	BflushshOtherType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
43	Baseline	BflushRARef	Number	Item from Table 1.1 - Baseline Flush Fixture Case
44	Baseline	BflushRAType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
45	Baseline	BflushRAGen	Text	Item from Table 1.1 - Baseline Flush Fixture Case
46	Baseline	BflushRAGPF	Number	Item from Table 1.1 - Baseline Flush Fixture Case
47	Baseline	BflushRAFTE	Number	Item from Table 1.1 - Baseline Flush Fixture Case
48	Baseline	BflushRASV	Number	Item from Table 1.1 - Baseline Flush Fixture Case
49	Baseline	BflushRARC	Number	Item from Table 1.1 - Baseline Flush Fixture Case
50	Baseline	BflushRARes	Number	Item from Table 1.1 - Baseline Flush Fixture Case
52	Baseline	BflushRAInc	Number	Item from Table 1.1 - Baseline Flush Fixture Case
51	Baseline	BflushRAOth	Number	Item from Table 1.1 - Baseline Flush Fixture Case
53	Baseline	BflushRBRef	Number	Item from Table 1.1 - Baseline Flush Fixture Case
54	Baseline	BflushRBType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
55	Baseline	BflushRBGen	Text	Item from Table 1.1 - Baseline Flush Fixture Case
56	Baseline	BflushRBGPF	Number	Item from Table 1.1 - Baseline Flush Fixture Case
57	Baseline	BflushRBFTE	Number	Item from Table 1.1 - Baseline Flush Fixture Case
58	Baseline	BflushRBSV	Number	Item from Table 1.1 - Baseline Flush Fixture Case
59	Baseline	BflushRBRC	Number	Item from Table 1.1 - Baseline Flush Fixture Case
60	Baseline	BflushRBRes	Number	Item from Table 1.1 - Baseline Flush Fixture Case
62	Baseline	BflushRBInc	Number	Item from Table 1.1 - Baseline Flush Fixture Case
61	Baseline	BflushRBOth	Number	Item from Table 1.1 - Baseline Flush Fixture Case
63	Baseline	BflushRCRef	Number	Item from Table 1.1 - Baseline Flush Fixture Case
64	Baseline	BflushRCType	Text	Item from Table 1.1 - Baseline Flush Fixture Case
65	Baseline	BflushRCGen	Text	Item from Table 1.1 - Baseline Flush Fixture Case
66	Baseline	BflushRCGPF	Number	Item from Table 1.1 - Baseline Flush Fixture Case
67	Baseline	BflushRCFTE	Number	Item from Table 1.1 - Baseline Flush Fixture Case
68	Baseline	BflushRCSV	Number	Item from Table 1.1 - Baseline Flush Fixture Case
69	Baseline	BflushRCRC	Number	Item from Table 1.1 - Baseline Flush Fixture Case
70	Baseline	BflushRCRes	Number	Item from Table 1.1 - Baseline Flush Fixture Case
72	Baseline	BflushRCInc	Number	Item from Table 1.1 - Baseline Flush Fixture Case
71	Baseline	BflushRCOth	Number	Item from Table 1.1 - Baseline Flush Fixture Case
74	Baseline	BflushAnnUse	Number	Annual Baseline Flush Fixture Water Usage
163	Baseline	BflowOtherType	Text	Item from Table 1.2 - Baseline Flow Fixture Case
164	Baseline	BflowRARef	Text	Item from Table 1.2 - Baseline Flow Fixture Case
165	Baseline	BflowRAType	Text	Item from Table 1.2 - Baseline Flow Fixture Case

166	Baseline	BflowRAGPM	Number	Item from Table 1.2 - Baseline Flow Fixture Case
167	Baseline	BflowRADur	Number	Item from Table 1.2 - Baseline Flow Fixture Case
168	Baseline	BflowRAFTE	Number	Item from Table 1.2 - Baseline Flow Fixture Case
169	Baseline	BflowRASV	Number	Item from Table 1.2 - Baseline Flow Fixture Case
170	Baseline	BflowRARC	Number	Item from Table 1.2 - Baseline Flow Fixture Case
171	Baseline	BflowRARes	Number	Item from Table 1.2 - Baseline Flow Fixture Case
173	Baseline	BflowRAInc	Number	Item from Table 1.2 - Baseline Flow Fixture Case
172	Baseline	BflowRAOth	Number	Item from Table 1.2 - Baseline Flow Fixture Case
174	Baseline	BflowRBRef	Text	Item from Table 1.2 - Baseline Flow Fixture Case
175	Baseline	BflowRBType	Text	Item from Table 1.2 - Baseline Flow Fixture Case
176	Baseline	BflowRBGPM	Number	Item from Table 1.2 - Baseline Flow Fixture Case
177	Baseline	BflowRBDur	Number	Item from Table 1.2 - Baseline Flow Fixture Case
178	Baseline	BflowRBFTE	Number	Item from Table 1.2 - Baseline Flow Fixture Case
179	Baseline	BflowRBSV	Number	Item from Table 1.2 - Baseline Flow Fixture Case
180	Baseline	BflowRBRC	Number	Item from Table 1.2 - Baseline Flow Fixture Case
181	Baseline	BflowRBRes	Number	Item from Table 1.2 - Baseline Flow Fixture Case
183	Baseline	BflowRBInc	Number	Item from Table 1.2 - Baseline Flow Fixture Case
182	Baseline	BflowRBOth	Number	Item from Table 1.2 - Baseline Flow Fixture Case
184	Baseline	BflowRCRef	Text	Item from Table 1.2 - Baseline Flow Fixture Case
185	Baseline	BflowRCType	Text	Item from Table 1.2 - Baseline Flow Fixture Case
186	Baseline	BflowRCGPM	Number	Item from Table 1.2 - Baseline Flow Fixture Case
187	Baseline	BflowRCDur	Number	Item from Table 1.2 - Baseline Flow Fixture Case
188	Baseline	BflowRCFTE	Number	Item from Table 1.2 - Baseline Flow Fixture Case
189	Baseline	BflowRCSV	Number	Item from Table 1.2 - Baseline Flow Fixture Case
190	Baseline	BflowRCRC	Number	Item from Table 1.2 - Baseline Flow Fixture Case
191	Baseline	BflowRCRes	Number	Item from Table 1.2 - Baseline Flow Fixture Case
193	Baseline	BflowRCInc	Number	Item from Table 1.2 - Baseline Flow Fixture Case
192	Baseline	BflowRCOth	Number	Item from Table 1.2 - Baseline Flow Fixture Case
194	Baseline	BflowRDRef	Text	Item from Table 1.2 - Baseline Flow Fixture Case
195	Baseline	BflowRDType	Text	Item from Table 1.2 - Baseline Flow Fixture Case
196	Baseline	BflowRDGPM	Number	Item from Table 1.2 - Baseline Flow Fixture Case
197	Baseline	BflowRDDur	Number	Item from Table 1.2 - Baseline Flow Fixture Case
198	Baseline	BflowRDFTE	Number	Item from Table 1.2 - Baseline Flow Fixture Case
199	Baseline	BflowRDSV	Number	Item from Table 1.2 - Baseline Flow Fixture Case
200	Baseline	BflowRDRC	Number	Item from Table 1.2 - Baseline Flow Fixture Case
201	Baseline	BflowRDRes	Number	Item from Table 1.2 - Baseline Flow Fixture Case
203	Baseline	BflowRDInc	Number	Item from Table 1.2 - Baseline Flow Fixture Case
202	Baseline	BflowRDOth	Number	Item from Table 1.2 - Baseline Flow Fixture Case
204	Baseline	BflowRERef	Text	Item from Table 1.2 - Baseline Flow Fixture Case
205	Baseline	BflowREType	Text	Item from Table 1.2 - Baseline Flow Fixture Case

206	Baseline	BflowREGPM	Number	Item from Table 1.2 - Baseline Flow Fixture Case
207	Baseline	BflowREDur	Number	Item from Table 1.2 - Baseline Flow Fixture Case
208	Baseline	BflowREFTE	Number	Item from Table 1.2 - Baseline Flow Fixture Case
209	Baseline	BflowRESV	Number	Item from Table 1.2 - Baseline Flow Fixture Case
210	Baseline	BflowRERC	Number	Item from Table 1.2 - Baseline Flow Fixture Case
211	Baseline	BflowRERes	Number	Item from Table 1.2 - Baseline Flow Fixture Case
213	Baseline	BflowREInc	Number	Item from Table 1.2 - Baseline Flow Fixture Case
212	Baseline	BflowREOth	Number	Item from Table 1.2 - Baseline Flow Fixture Case
214	Baseline	BflowAnnUse	Number	Annual Baseline Flow Fixture Water Usage
215	Baseline	BaseAnnTotUse	Number	Total annual baseline water usage
75	Design	DflushROtherType	Text	Item from Table 2.1 - Design Flush Fixture Case
76	Design	DflushRARef	Number	Item from Table 2.1 - Design Flush Fixture Case
78	Design	DflushRAGen	Text	Item from Table 2.1 - Design Flush Fixture Case
79	Design	DflushRAFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
80	Design	DflushRAFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
81	Design	DflushRAGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
82	Design	DflushRACentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
83	Design	DflushRAFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
84	Design	DflushRASV	Number	Item from Table 2.1 - Design Flush Fixture Case
85	Design	DflushRARC	Number	Item from Table 2.1 - Design Flush Fixture Case
86	Design	DflushRARes	Number	Item from Table 2.1 - Design Flush Fixture Case
87	Design	DflushRAOth	Number	Item from Table 2.1 - Design Flush Fixture Case
88	Design	DflushRBRef	Number	Item from Table 2.1 - Design Flush Fixture Case
90	Design	DflushRBGen	Text	Item from Table 2.1 - Design Flush Fixture Case
91	Design	DflushRBFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
92	Design	DflushRBFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
93	Design	DflushRBGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
94	Design	DflushRBCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
95	Design	DflushRBFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
96	Design	DflushRBSV	Number	Item from Table 2.1 - Design Flush Fixture Case
97	Design	DflushRBRC	Number	Item from Table 2.1 - Design Flush Fixture Case
98	Design	DflushRBRes	Number	Item from Table 2.1 - Design Flush Fixture Case
99	Design	DflushRBOth	Number	Item from Table 2.1 - Design Flush Fixture Case
100	Design	DflushRCRef	Number	Item from Table 2.1 - Design Flush Fixture Case
102	Design	DflushRCGen	Text	Item from Table 2.1 - Design Flush Fixture Case
103	Design	DflushRCFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
104	Design	DflushRCFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
105	Design	DflushRCGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
106	Design	DflushRCCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
107	Design	DflushRCFTE	Number	Item from Table 2.1 - Design Flush Fixture Case

108	Design	DflushRCSV	Number	Item from Table 2.1 - Design Flush Fixture Case
109	Design	DflushRCRC	Number	Item from Table 2.1 - Design Flush Fixture Case
110	Design	DflushRCRes	Number	Item from Table 2.1 - Design Flush Fixture Case
111	Design	DflushRCOth	Number	Item from Table 2.1 - Design Flush Fixture Case
112	Design	DflushRDRef	Number	Item from Table 2.1 - Design Flush Fixture Case
114	Design	DflushRDGen	Text	Item from Table 2.1 - Design Flush Fixture Case
115	Design	DflushRDFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
116	Design	DflushRDFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
117	Design	DflushRDGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
118	Design	DflushRDCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
119	Design	DflushRDFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
120	Design	DflushRDSV	Number	Item from Table 2.1 - Design Flush Fixture Case
121	Design	DflushRDRC	Number	Item from Table 2.1 - Design Flush Fixture Case
122	Design	DflushRDRes	Number	Item from Table 2.1 - Design Flush Fixture Case
123	Design	DflushRDOth	Number	Item from Table 2.1 - Design Flush Fixture Case
124	Design	DflushRERef	Number	Item from Table 2.1 - Design Flush Fixture Case
126	Design	DflushREGen	Text	Item from Table 2.1 - Design Flush Fixture Case
127	Design	DflushREFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
128	Design	DflushREFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
129	Design	DflushREGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
130	Design	DflushRECentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
131	Design	DflushREFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
132	Design	DflushRESV	Number	Item from Table 2.1 - Design Flush Fixture Case
133	Design	DflushRERC	Number	Item from Table 2.1 - Design Flush Fixture Case
134	Design	DflushRERes	Number	Item from Table 2.1 - Design Flush Fixture Case
135	Design	DflushREOth	Number	Item from Table 2.1 - Design Flush Fixture Case
136	Design	DflushRFRef	Number	Item from Table 2.1 - Design Flush Fixture Case
138	Design	DflushRFGen	Text	Item from Table 2.1 - Design Flush Fixture Case
139	Design	DflushRFFixMan	Text	Item from Table 2.1 - Design Flush Fixture Case
140	Design	DflushRFFixMod	Text	Item from Table 2.1 - Design Flush Fixture Case
141	Design	DflushRFGPF	Number	Item from Table 2.1 - Design Flush Fixture Case
142	Design	DflushRFCentOcc	Number	Item from Table 2.1 - Design Flush Fixture Case
143	Design	DflushRFFTE	Number	Item from Table 2.1 - Design Flush Fixture Case
144	Design	DflushRFSV	Number	Item from Table 2.1 - Design Flush Fixture Case
145	Design	DflushRFRC	Number	Item from Table 2.1 - Design Flush Fixture Case
146	Design	DflushRFRes	Number	Item from Table 2.1 - Design Flush Fixture Case
147	Design	DflushRFOth	Number	Item from Table 2.1 - Design Flush Fixture Case
149	Design	DflushAnnUse	Number	Annual Design Case Flush Fixture Water Usage
148	Design	DflushErrors	Text	Item from Table 2.1 - Design Flush Fixture Case
216	Design	DflowOtherType	Text	Item from Table 2.2 - Design Flow Fixture Case

217	Design	DflowRARef	Number	Item from Table 2.2 - Design Flow Fixture Case
219	Design	DflowRAFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
220	Design	DflowRAFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
221	Design	DflowRAGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
222	Design	DflowRACentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
224	Design	DflowRAFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
225	Design	DflowRASV	Number	Item from Table 2.2 - Design Flow Fixture Case
226	Design	DflowRARC	Number	Item from Table 2.2 - Design Flow Fixture Case
227	Design	DflowRARes	Number	Item from Table 2.2 - Design Flow Fixture Case
228	Design	DflowRAOth	Number	Item from Table 2.2 - Design Flow Fixture Case
223	Design	DflowRADur	Number	Item from Table 2.2 - Design Flow Fixture Case
229	Design	DflowRBRef	Number	Item from Table 2.2 - Design Flow Fixture Case
231	Design	DflowRBFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
232	Design	DflowRBFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
233	Design	DflowRBGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
234	Design	DflowRBCentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
236	Design	DflowRBFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
237	Design	DflowRBSV	Number	Item from Table 2.2 - Design Flow Fixture Case
238	Design	DflowRBRC	Number	Item from Table 2.2 - Design Flow Fixture Case
239	Design	DflowRBRes	Number	Item from Table 2.2 - Design Flow Fixture Case
240	Design	DflowRBOth	Number	Item from Table 2.2 - Design Flow Fixture Case
235	Design	DflowRBDur	Number	Item from Table 2.2 - Design Flow Fixture Case
241	Design	DflowRCRef	Number	Item from Table 2.2 - Design Flow Fixture Case
243	Design	DflowRCFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
244	Design	DflowRCFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
245	Design	DflowRCGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
246	Design	DflowRCCentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
248	Design	DflowRCFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
249	Design	DflowRCSV	Number	Item from Table 2.2 - Design Flow Fixture Case
250	Design	DflowRCRC	Number	Item from Table 2.2 - Design Flow Fixture Case
251	Design	DflowRCRes	Number	Item from Table 2.2 - Design Flow Fixture Case
252	Design	DflowRCOth	Number	Item from Table 2.2 - Design Flow Fixture Case
247	Design	DflowRCDur	Number	Item from Table 2.2 - Design Flow Fixture Case
253	Design	DflowRDRef	Number	Item from Table 2.2 - Design Flow Fixture Case
255	Design	DflowRDFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
256	Design	DflowRDFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
257	Design	DflowRDGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
258	Design	DflowRDCentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
260	Design	DflowRDFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
261	Design	DflowRDSV	Number	Item from Table 2.2 - Design Flow Fixture Case

262	Design	DflowRDRC	Number	Item from Table 2.2 - Design Flow Fixture Case
263	Design	DflowRDRes	Number	Item from Table 2.2 - Design Flow Fixture Case
264	Design	DflowRDOth	Number	Item from Table 2.2 - Design Flow Fixture Case
259	Design	DflowRDDur	Number	Item from Table 2.2 - Design Flow Fixture Case
265	Design	DflowRERef	Number	Item from Table 2.2 - Design Flow Fixture Case
267	Design	DflowREFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
268	Design	DflowREFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
269	Design	DflowREGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
270	Design	DflowRECentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
272	Design	DflowREFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
273	Design	DflowRESV	Number	Item from Table 2.2 - Design Flow Fixture Case
274	Design	DflowRERC	Number	Item from Table 2.2 - Design Flow Fixture Case
275	Design	DflowRERes	Number	Item from Table 2.2 - Design Flow Fixture Case
276	Design	DflowREOth	Number	Item from Table 2.2 - Design Flow Fixture Case
271	Design	DflowREDur	Number	Item from Table 2.2 - Design Flow Fixture Case
277	Design	DflowRFRef	Number	Item from Table 2.2 - Design Flow Fixture Case
279	Design	DflowRFFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
280	Design	DflowRFFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
281	Design	DflowRFGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
282	Design	DflowRFCentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
284	Design	DflowRFFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
285	Design	DflowRFSV	Number	Item from Table 2.2 - Design Flow Fixture Case
286	Design	DflowRFRC	Number	Item from Table 2.2 - Design Flow Fixture Case
287	Design	DflowRFRes	Number	Item from Table 2.2 - Design Flow Fixture Case
288	Design	DflowRFOth	Number	Item from Table 2.2 - Design Flow Fixture Case
283	Design	DflowRFDur	Number	Item from Table 2.2 - Design Flow Fixture Case
289	Design	DflowRGRef	Number	Item from Table 2.2 - Design Flow Fixture Case
291	Design	DflowRGFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
292	Design	DflowRGFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case
293	Design	DflowRGGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
294	Design	DflowRGCentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
296	Design	DflowRGFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
297	Design	DflowRGSV	Number	Item from Table 2.2 - Design Flow Fixture Case
298	Design	DflowRGRC	Number	Item from Table 2.2 - Design Flow Fixture Case
299	Design	DflowRGRes	Number	Item from Table 2.2 - Design Flow Fixture Case
300	Design	DflowRGOth	Number	Item from Table 2.2 - Design Flow Fixture Case
295	Design	DflowRGDur	Number	Item from Table 2.2 - Design Flow Fixture Case
301	Design	DflowRHRef	Number	Item from Table 2.2 - Design Flow Fixture Case
303	Design	DflowRHFixMan	Text	Item from Table 2.2 - Design Flow Fixture Case
304	Design	DflowRHFixMod	Text	Item from Table 2.2 - Design Flow Fixture Case

305	Design	DflowRHGPM	Number	Item from Table 2.2 - Design Flow Fixture Case
306	Design	DflowRHCentOcc	Number	Item from Table 2.2 - Design Flow Fixture Case
308	Design	DflowRHFTE	Number	Item from Table 2.2 - Design Flow Fixture Case
309	Design	DflowRHSV	Number	Item from Table 2.2 - Design Flow Fixture Case
310	Design	DflowRHRC	Number	Item from Table 2.2 - Design Flow Fixture Case
311	Design	DflowRHRes	Number	Item from Table 2.2 - Design Flow Fixture Case
312	Design	DflowRHOth	Number	Item from Table 2.2 - Design Flow Fixture Case
307	Design	DflowRHDur	Number	Item from Table 2.2 - Design Flow Fixture Case
314	Design	DesAnnFlowUse	Number	Annual Design Case Flow Fixture Water Usage
315	Design	DesAnnTotUse	Number	Annual Design Case Flush and Flow Fixture Water Usage
313	Design	DesFlowErrors	Number	Item from Table 2.2 - Design Flow Fixture Case
150	Savings	NonPotASource	Text	Source of non-potable water
151	Savings	NonPotAQuant	Number	Quantity from non-potable source
152	Savings	NonPotBSource	Text	Source of non-potable water
153	Savings	NonPotBQuant	Number	Quantity from non-potable source
154	Savings	NonPotCSource	Text	Source of non-potable water
155	Savings	NonPotCQuant	Number	Quantity from non-potable source
156	Savings	NonPotDSource	Text	Source of non-potable water
157	Savings	NonPotDQuant	Number	Quantity from non-potable source
158	Savings	NonPotTotal	Number	Total quantity from non-potable sources
159	Savings	BaseAWC	Number	Baseline Case - Annual Water Consumption (gal)
160	Savings	DesAWC	Number	Design Case - Annual Water Consumption (gal)
161	Savings	TotalAWC	Number	Total Annual Non-Potable Water Consumption (gal)
162	Savings	TotalWaterSavings	Number	Total Water Savings (gal)
316	Narrative	Narrative1	Text	Narrative for compliance
317	Narrative	Narrative2	Text	Special circumstances narrative
318	Narrative	AltComp	Text	Alternative compliance approach is used
319	Narrative	AltCompPts	Number	Points documented for alternative compliance
321	General	CreditAttempted	Text	Credit attempted on form
322	General	PointsDocumented	Number	Number of points documented on form
320	General	ProjName	Text	Name of project
323	General	SubFirstName	Text	Submitter's first name
324	General	SubLastName	Text	Submitter's last name
325	General	SubDate	Text	Submission date
326	General	SubUsername	Text	Submitter's user name
327	General	SubPW	Text	Submitter's password
328	General	TemplateVer	Text	Page template version
329	General	FormVerID	Number	Form version ID
77	Design	DflushRAFixType	Text	Item from Table 2.1 - Design Flush Fixture Case

89	Design	DflushRBFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
101	Design	DflushRCFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
113	Design	DflushRDFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
125	Design	DflushREFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
137	Design	DflushRFFixType	Text	Item from Table 2.1 - Design Flush Fixture Case
218	Design	DflowRAFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
230	Design	DflowRBFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
242	Design	DflowRCFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
254	Design	DflowRDFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
266	Design	DflowREFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
278	Design	DflowRFFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
290	Design	DflowRGFixType	Text	Item from Table 2.2 - Design Flow Fixture Case
302	Design	DflowRHFixType	Text	Item from Table 2.2 - Design Flow Fixture Case

Appendix S: LEED NCv2.2 WEc3 Cleaning Log

- Discovered 14 fields that did not translate.
  - Wrote program to open files, simulate manual data extraction.
  - ran program, extracted data
  - some forms did not translate properly
    - wrote code to identify
      - “Enter description here” for some fields
      - selected wrong fields
    - manually input those forms
  - replaced “Blank” with empty cells
- Appended missing fields to table
- Added count column to see if any fields failed to translate.
- SubPW
  - had none, but it is a password field and not needed or in any forms
- Checked for form versions. 4 found
  - Versions
    - 10000504
    - 10000400
    - 10001450
    - 10001495
  - No data field changes found
- Filled all empty numeric fields with 0
- Modified option Field values to equal option numbers (map 3)
- standardized fixture type and water source
  - wrote programs to
    - separate into types of fields (type/source)
    - identify all unique entries
  - assigned standardized values to all unique entries (stored in separate document for reference)
  - added corresponding fields for each field with potential conflict with program
  - filled corresponding fields with standard entry with program
- Found that _ projects do not have fixture types
  - projects
    - 10072376
      - in narrative
    - 10100368
      - in narrative
    - 10321016
      - only model given, type looked up

Appendix T: LEED NCv2.2 WEc3 Cleaning Code

```
Private Sub CommandButton1_Click()

Dim i, j As Integer

Application.ScreenUpdating = False
'432 records, 329 fields

For i = 2 To 330
    If Sheets("Raw").Cells(i, 4).Value = "Number" Then
        For j = 4 To 436
            Sheets("Clean").Cells(i, j).Value = Sheets("Raw").Cells(i, j + 1).Value
            If Sheets("Raw").Cells(i, j + 1).Value = "" Then
                Sheets("Clean").Cells(i, j).Value = 0
            End If
        Next
    Else
        For j = 4 To 436
            Sheets("Clean").Cells(i, j).Value = Sheets("Raw").Cells(i, j + 1).Value
        Next
    End If
Next

For j = 4 To 436
    Sheets("Clean").Cells(4, j).Value = Sheets("Clean").Cells(4, j).Value + 1
Next

End Sub
```

```
Private Sub CommandButton1_Click()

Dim i, j, ci, k As Integer
Dim colCount As Integer

k = Sheets("Standardization").Cells(2, 1).Value + 3
'Sheets("Standardization").Cells(2, 2).Value = k

i = 4
colCount = 3

Do While Sheets("Standardization").Cells(i, 1).Value <> ""
   'set up next round of columns
   Sheets("Standardization").Cells(3, colCount + 0).Value = "Copy"
   Sheets("Standardization").Cells(3, colCount + 1).Value = "Change to"
   Sheets("Standardization").Cells(2, colCount + 1).Value = Sheets("Standardization").Cells(i,
1).Value
   Sheets("Standardization").Cells(1, colCount + 1).Value = Sheets("Standardization").Cells(i,
2).Value

   'copy from clean data c4 to k
   ci = 2
   Do While Sheets("Clean").Cells(ci, 2).Value <> Sheets("Standardization").Cells(i, 1).Value
      ci = ci + 1
   Loop
   Sheets("Standardization").Cells(2, colCount + 1).Value = Sheets("Clean").Cells(ci, 2).Value
   Sheets("Standardization").Cells(2, colCount + 0).Value = Sheets("Clean").Cells(ci, 3).Value
   Sheets("Clean").Range(Sheets("Clean").Cells(ci, 4), Sheets("Clean").Cells(ci, k)).Copy
   Sheets("Standardization").Cells(4, colCount).PasteSpecial Transpose:=True

   'sort <<
   Sheets("Standardization").Range(Sheets("Standardization").Cells(4, colCount),
Sheets("Standardization").Cells(k, colCount)).Sort
key1:=Range(Sheets("Standardization").Cells(4, colCount), Sheets("Standardization").Cells(k,
colCount)), order1:=xlAscending, Header:=xlNo
   Sheets("Standardization").Range(Sheets("Standardization").Cells(4, colCount),
Sheets("Standardization").Cells(k, colCount)).RemoveDuplicates Columns:=1, Header:=xlNo
   '>>
   'copy then sort then remove duplicates
   Columns(colCount).Borders(xlEdgeLeft).LineStyle = xlContinuous

   'prep for next round
   i = i + 1
   colCount = colCount + 2
Loop
End Sub
```

```
Private Sub CommandButton1_Click()

Dim i, j, k, m, newRow As Integer
'Cells(i, 8).Value = Application.VLookup(Cells(i, 7).Value, Range(Cells(2, 1), Cells(11, 2)), 2,
False)

newRow = 331

'do while loop to check each class until empty
j = 1 'j is column with field numbers on Change Record sheet
Do While Sheets("Change Record").Cells(4, j).Value <> ""
   'do while loop for each field
   i = 4 'i is row of field in process
   Do While Sheets("Change Record").Cells(i, j).Value <> ""
      'find the column in cleanstandard
      k = 2 'k is row of field in CleanStandard
      Do While Sheets("CleanStandard").Cells(k, 2).Value <> ""
         If Sheets("CleanStandard").Cells(k, 2).Value = Sheets("Change Record").Cells(i,
j).Value Then
            'add replacement field
            Sheets("CleanStandard").Cells(newRow, 3).Value = Sheets("CleanStandard").Cells(k,
3).Value & "Cl"
            'add replacement values
            For m = 4 To 435 'm is column of record in CleanStandard
               'look up replacement
               If Sheets("CleanStandard").Cells(k, m).Value <> "" Then
                  Sheets("CleanStandard").Cells(newRow, m).Value =
Application.VLookup(Sheets("CleanStandard").Cells(k, m).Value, Sheets("Change
Record").Range(Sheets("Change Record").Cells(4, j + 1), Sheets("Change Record").Cells(1000,
j + 2)), 2, False)
                  'If Sheets("CleanStandard").Cells(newRow, m).Value = "#N/A" Then
                  '   Sheets("CleanStandard").Cells(newRow, m).Value = ""
                  'End If
               End If
            Next
            newRow = newRow + 1
            Exit Do
         End If
         k = k + 1
      Loop
      'for loop for each project
      i = i + 1
   Loop
   j = j + 3
Loop
End Sub
```

```
Private Sub CommandButton1_Click()

Dim h, i, j, k, m, Ccnt, Fcnt As Integer

'multiples

'classes
Ccnt = Sheets("Standardization").Cells(2, 2).Value
'fields
Fcnt = Sheets("Standardization").Cells(1, 2).Value

'prep for classes

For x = 1 To Ccnt 'x is the current class number
   Sheets("Classes").Cells(1, (1 + (3 * x))).Value = "Class"
   Sheets("Classes").Cells(1, (2 + (3 * x))).Value = x
   Sheets("Classes").Cells(3, (1 + (3 * x))).Value = "Fields with"
   Sheets("Classes").Cells(3, (2 + (3 * x))).Value = "Possibilities"
   Sheets("Classes").Cells(3, (3 + (3 * x))).Value = "Change to"

   'copy field numbers
   i = 4
   For y = 1 To Fcnt
      If Sheets("Standardization").Cells(3 + y, 2).Value = x Then
         Sheets("Classes").Cells(i, (1 + (3 * x))).Value = Sheets("Standardization").Cells(3 + y,
1).Value
         i = i + 1
      End If
   Next
   i = i - 4 'i is now the number of fields in the class

   'check
   Sheets("Classes").Cells(2, (1 + (3 * x))).Value = "i= " & i

   'copy possibilities

   'for each field in the class
   k = 4
   For h = 1 To i
      'for until we find the column with matching fid, then exit for
      For j = 4 To (Fcnt * 2 + 2)
         If Sheets("Standardization").Cells(2, j).Value = Sheets("Classes").Cells(h + 3, (1 + (3 *
x))).Value Then
            m = 4
            Do While Sheets("Standardization").Cells(m, j - 1).Value <> ""
               Sheets("Standardization").Cells(m, j).Value = "nabbed"
```

```
                If Sheets("Classes").Cells(k, (2 + (3 * x))).Value = "" Then
                    Sheets("Classes").Cells(k, (2 + (3 * x))).Value =
Sheets("Standardization").Cells(m, j - 1).Value
                Else
                    k = k + 1
                    Sheets("Classes").Cells(k, (2 + (3 * x))).Value =
Sheets("Standardization").Cells(m, j - 1).Value
                End If
                m = m + 1
                k = k + 1
            Loop
            'Exit For
        End If
    Next
    Sheets("Classes").Cells(2, (2 + (3 * x))).Value = "h= " & h
  Next

  'checks
  Sheets("Classes").Cells(5, 1).Value = "fcnt*2+2= " & (Fcnt * 2 + 2)
  Sheets("Classes").Cells(6, 1).Value = x
  Sheets("Classes").Cells(2, (3 + (3 * x))).Value = "k= " & k

  'when all class fields are done, sort and then remove duplicates
  Sheets("Classes").Range(Sheets("Classes").Cells(4, (2 + (3 * x))), Sheets("Classes").Cells(k,
(2 + (3 * x)))).Sort key1:=Range(Sheets("Classes").Cells(4, (2 + (3 * x))),
Sheets("Classes").Cells(k, (2 + (3 * x)))), order1:=xlAscending, Header:=xlNo
  Sheets("Classes").Range(Sheets("Classes").Cells(4, (2 + (3 * x))), Sheets("Classes").Cells(k,
(2 + (3 * x)))).RemoveDuplicates Columns:=1, Header:=xlNo

  'add lines
  Columns(1 + (3 * x)).Borders(xlEdgeLeft).LineStyle = xlContinuous
Next
End Sub
```

```
Private Sub CommandButton1_Click()

Dim i, j, k As Integer

i = 2
k = 0
Do While Cells(i, 1).Value <> ""

   If Right(Cells(i, 3).Value, 3) = "Inc" Then
      For j = 4 To 435
         If Cells(i, j).Value = 1 Then
         Cells(i, j).Value = "On"
         Cells(365, j).Value = "On"
         k = k + 1
         End If

      Next
   End If
   i = i + 1
Loop

Cells(365, 1).Value = k


End Sub
```

Appendix U: Survey Recruitment Letter

This is the recruitment sent by email, and also posted by the researchers to LinkedIn.

Subject:

Invitation to participate in a survey about experiences with green water-related technologies in and around buildings

Body:

Greetings! You are invited to participate in a survey about your experiences with "green" water technologies in and around buildings. Please click on the following link to participate.

Survey

The survey is part of a study being conducted by Virginia Tech, the Water Research Foundation, and the US Green Building Council. The purpose of the survey is to identify and understand **unanticipated consequences of "green" water technologies and practices on water use in and around buildings**. The results will be used to synthesize experiences of building stakeholders to date, proactively identify common problems if they exist, and identify issues for future research. Results of the study will be made publicly available on the USGBC web site.

Completing the survey should take approximately 20-30 minutes of your time. After some introductory questions about you and your professional role, you will be asked about your experiences, either as a professional or as a layperson, with the different types of water-related technologies present in your buildings. For each technology with which you've had exceptional experiences, either good or bad, you will have an opportunity to tell us more about those experiences and what worked or didn't work well about each technology.

Survey

Thank you in advance for contributing your experiences to our study. If you have any questions about the survey or would like further information, please contact:

Dr. Annie R. Pearce, Associate Professor
Virginia Tech Myers-Lawson School of Construction
apearce@vt.edu
(540) 818-7732

Dr. Chris Pyke, Director of Research
U.S. Green Building Council
cpyke@usgbc.org
(202) 445-0041

Water Research Foundation℠

U.S. GREEN BUILDING COUNCIL USGBC®

Appendix V: Survey Recruitment Short Messages

The survey was advertised through posts on the LEEDUser Forum, the US Green Building Council Technical Advisory Groups, Yammer community, and Research Advisory Committee, a blurb on the US Green Building Council e-newsletter, and through emails to US Green Building Council Chapter members.

The US Green Building Council imposed a length limit on these to either ~50 words or Twitter length. Therefore, details are at the start of the survey after the link.

The ~50 word post:

The Water Research Foundation and Virginia Tech have partnered for a study on the unanticipated consequences of green water technologies and practices on water use in buildings. The first step in this study is a brief internet survey asking about the experiences of users and professionals. Please follow the link below to details and the survey. <link>

The Twitter length post:

Hello! Please take this brief survey about your experiences with green water tech in buildings, you could win a prize! Details and survey here: <link>

Appendix W: Survey

(Note: The formatted survey is at https://virginiatech.qualtrics.com/SE/?SID=SV_3UYVO75JpYMbeVn)

1 The purpose of this survey is to identify and understand unanticipated consequences of "green" water technologies and practices on water use in buildings. The results will be used to synthesize experiences of building stakeholders to date, proactively identify common problems if they exist, and identify issues for future research. Results of the study will be made publicly available on the USGBC's web site. For purposes of this study, "green" water technologies and practices refers to any building system influencing potable hot and cold water, wastewater, and stormwater on site, that can either 1) lower water use, 2) reduce energy consumption associated with hot or cold water systems, and/or 3) reduce dependence on water infrastructure outside the building. These systems include any water conserving fixtures, toilets and designs; rainwater or reclaimed wastewater systems for non-potable use; grey water recovery and reuse; on-site wastewater treatment; and other systems. Completing the survey should take approximately 20-30 minutes of your time. After some introductory questions about you and your professional role, you will be asked about your experiences, either as a professional or as a layperson, with the different types of water-related technologies present in your buildings. For each technology with which you've had exceptional consumer experiences, either good or bad, you will have an opportunity to tell us more about those experiences and what worked or didn't work well about each technology. Thank you for your contribution of knowledge! You may discontinue participation at any time without penalty. In the survey, you will be given the opportunity to be entered into a drawing to win a copy of Dr. Pearce's new book, Sustainable Buildings and Infrastructure. If you have any questions about the survey or would like further information, please contact: Dr. Annie R. Pearce, Associate Professor Virginia Tech Myers-Lawson School of Construction apearce@vt.edu (540) 818-7732 Dr. Chris Pyke, Director of Research U.S. Green Building Council cpyke@usgbc.org (202) 445-0041

2 Are you involved in building operations or maintenance?

- ❍ Yes (1)
- ❍ No (2)

3 Have you ever been involved in the design, construction or operation of a building utilizing green water technologies?

- ❍ Yes (1)
- ❍ No (2)

4 Have you ever been an occupant of a building utilizing green water technologies?

- ❍ Yes (1)
- ❍ No (2)

5 What is your predominant professional role?

- ❍ Accountant (1)
- ❍ Architect (2)
- ❍ Building Maintenance (3)
- ❍ Building Management (4)
- ❍ Construction (5)
- ❍ Commissioning (6)
- ❍ Consultant (7)
- ❍ Education (8)
- ❍ Energy (9)
- ❍ Engineer (10)
- ❍ Financial (11)
- ❍ Government (12)
- ❍ Inspector (13)
- ❍ Insurance (14)
- ❍ Interior Design (15)
- ❍ Landscape (16)
- ❍ Owner (17)
- ❍ Planning (18)
- ❍ Product Manufacture/Distribution (19)
- ❍ Utility (20)
- ❍ Other (21)

6 What is your job title?

177 If you would like to be entered into a drawing to win a copy of Sustainable Buildings and Infrastructure: Paths to the Future, please enter your name, phone, and/or email address. If you win the drawing, we will contact you to obtain mailing information. Your contact information will be deleted at the conclusion of the study and will not be sold, shared, or included in any reports.

178 Contact Information

Name (1)

Phone (2)

Email (3)

177 Thank you for participating! Would you be interested in participating in a brief phone interview about your experiences? Your name and contact information will not be included in any reports and will be held in confidence.

- ❍ Yes (1)
- ❍ No (2)

179 How would you prefer to be contacted?

- ❍ Phone (1)
- ❍ Email (2)

180 Thank you for your contribution of knowledge! If you have any questions about the survey or would like further information, please contact:Dr. Annie R. Pearce, Associate ProfessorVirginia Tech Myers-Lawson School of Constructionapearce@vt.edu(540) 818-7732Dr. Chris Pyke, Director of ResearchU.S. Green Building Councilcpyke@usgbc.org(202) 445-0041

6 Please check any of the following problems you have experienced for water-related systems in green buildings, including systems dealing with potable water, wastewater, and stormwater on site:

- ❑ One or more water-related systems have had to be replaced before the end of their design life. (1)
- ❑ There have been user complaints about water taste, odors, or coloration. (2)
- ❑ There have been user complaints about water temperature. (3)
- ❑ There have been complaints about insufficient hot water. (4)
- ❑ A significant number of building users drink bottled water instead of tap water. (5)
- ❑ There have been leaks or clogging of pipes. (6)
- ❑ There have been capacity problems, including inability to handle water demand or undesired accumulation/diversion of wastewater/stormwater. (7)
- ❑ Building occupants have perceived illness (or other health concerns) as being related to green water systems. (8)
- ❑ Water tests show contamination. (9)
- ❑ Other (describe below) (10)

7 OPTIONAL: Please elaborate on items identified in the previous question.

8 Please describe the experiences that you personally have had with the following Toilet and Urinal technologies. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Water Conserving Toilets (1)	❑	❑	❑	❑	❑	❑
Waterless Toilets (2)	❑	❑	❑	❑	❑	❑
Waterless Urinals (3)	❑	❑	❑	❑	❑	❑
Alternative Flushometer Valves (4)	❑	❑	❑	❑	❑	❑

9 What dissatisfying types of water conserving toilet technologies did you use?

10 What problems did you experience with these dissatisfying water conserving toilet technologies?

11 How were these problems with the dissatisfying water conserving toilet technologies resolved?

12 What type of water conserving toilet did you use that exceeded your expectations?

13 In what way did water conserving toilets exceed your expectations?

14 What dissatisfying types of waterless toilet technologies did you use?

15 What problems did you experience with these dissatisfying waterless toilet technologies?

16 How were these problems with the dissatisfying waterless toilet technologies resolved?

17 What type of waterless toilet did you use that exceeded your expectations?

18 In what way did water conserving toilets exceed your expectations?

19 What dissatisfying types of waterless urinal technologies did you use?

20 What problems did you experience with these dissatisfying waterless urinal technologies?

21 How were these problems with the dissatisfying waterless urinal technologies resolved?

22 What type of waterless urinal did you use that exceeded your expectations?

23 In what way did this water conserving urinal exceed your expectations?

24 What dissatisfying types of alternative flushometer valve technologies did you use?

25 What problems did you experience with these dissatisfying alternative flushometer valve technologies?

26 How were these problems with the dissatisfying alternative flushometer valve technologies resolved?

27 What type of alternative flushometer valve did you use that exceeded your expectations?

28 In what way did the alternative flushometer valve exceed your expectations?

Q181 (1/9)

29 Please describe the experiences that you personally have had with the following Shower and Faucet Fixture technologies. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Low Flow Fixtures (1)	❑	❑	❑	❑	❑	❑
Alternative Controls (2)	❑	❑	❑	❑	❑	❑
Self-Powering (3)	❑	❑	❑	❑	❑	❑

30 What dissatisfying types of low flow faucet or shower technologies did you use?

31 What problems did you experience with these dissatisfying low flow faucet or shower fixture technologies?

32 How were these problems with the dissatisfying low flow faucet or shower fixture technologies resolved?

33 What type of low flow faucet or shower fixture did you use that exceeded your expectations?

34 In what way did low flow faucet or shower fixtures exceed your expectations?

35 What dissatisfying types of alternative fixture control technologies did you use?

36 What problems did you experience with these dissatisfying alternative fixture control technologies?

37 How were these problems with the dissatisfying alternative fixture control technologies resolved?

38 What type of alternative fixture control did you use that exceeded your expectations?

39 In what way did alternative fixture controls exceed your expectations?

40 What dissatisfying types of self-powering faucet technologies did you use?

41 What problems did you experience with these dissatisfying self-powering faucet technologies?

42 How were these problems with the dissatisfying self-powering faucet technologies resolved?

43 What type of self-powering faucet did you use that exceeded your expectations?

44 In what way did this self-powering faucet exceed your expectations?

Q182 (2/9)

45 Please describe the experiences that you personally have had the following Plumbing technologies. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Alternative Piping (1)	❑	❑	❑	❑	❑	❑
Manifold Distribution (2)	❑	❑	❑	❑	❑	❑
Cured-in-Place Pipe Lining (3)	❑	❑	❑	❑	❑	❑
High Performance Epoxies (4)	❑	❑	❑	❑	❑	❑

46 What dissatisfying types of alternative piping technologies did you use?

47 What problems did you experience with these dissatisfying alternative piping technologies?

48 How were these problems with the dissatisfying alternative piping technologies resolved?

49 What type of alternative piping did you use that exceeded your expectations?

50 In what way did alternative piping exceed your expectations?

51 What dissatisfying types of manifold distribution technologies did you use?

52 What problems did you experience with these dissatisfying manifold distribution technologies?

53 How were these problems with the dissatisfying manifold distribution technologies resolved?

54 What type of manifold distribution did you use that exceeded your expectations?

55 In what way did manifold distribution exceed your expectations?

56 What dissatisfying types of cured-in-place pipe lining technologies did you use?

57 What problems did you experience with these dissatisfying cured-in-place pipe lining technologies?

58 How were these problems with the dissatisfying cured-in-place pipe lining technologies resolved?

59 What type of cured-in-place pipe lining did you use that exceeded your expectations?

60 In what way did this cured-in-place pipe lining exceed your expectations?

61 What dissatisfying types of high performance epoxy technologies did you use?

62 What problems did you experience with these dissatisfying high performance epoxy technologies?

63 How were these problems with the dissatisfying high performance epoxy technologies resolved?

64 What type of high performance epoxy did you use that exceeded your expectations?

65 In what way did the high performance epoxy exceed your expectations?

Q183 (3/9)

66 Please describe the experiences that you personally have had with the following Water Heating technologies. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Recirculation (1)	❑	❑	❑	❑	❑	❑
On-Demand (2)	❑	❑	❑	❑	❑	❑
Solar (3)	❑	❑	❑	❑	❑	❑
Heat Recovery (4)	❑	❑	❑	❑	❑	❑

67 What dissatisfying types of hot water recirculation technologies did you use?

68 What problems did you experience with these dissatisfying hot water recirculation technologies?

69 How were these problems with the dissatisfying hot water recirculation technologies resolved?

70 What type of hot water recirculation did you use that exceeded your expectations?

71 In what way did hot water recirculation exceed your expectations?

72 What dissatisfying types of on-demand hot water technologies did you use?

73 What problems did you experience with these dissatisfying on-demand hot water technologies?

74 How were these problems with the dissatisfying on-demand hot water technologies resolved?

75 What type of on-demand hot water did you use that exceeded your expectations?

76 In what way did on-demand hot water exceed your expectations?

77 What dissatisfying types of solar water heating technologies did you use?

78 What problems did you experience with these dissatisfying solar water heating technologies?

79 How were these problems with the dissatisfying solar water heating technologies resolved?

80 What type of solar water heating did you use that exceeded your expectations?

81 In what way did this solar water heating exceed your expectations?

82 What dissatisfying types of heat recovery technologies did you use?

83 What problems did you experience with these dissatisfying heat recovery technologies?

84 How were these problems with the dissatisfying heat recovery technologies resolved?

85 What type of heat recovery did you use that exceeded your expectations?

86 In what way did the heat recovery exceed your expectations?

Q186 (4/9)

87 Please describe the experiences that you personally have had with the following Appliances. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Water-Efficient Dishwashers (1)	❑	❑	❑	❑	❑	❑
Water-Efficient Clotheswashers (2)	❑	❑	❑	❑	❑	❑
Water-Efficient Icemakers (3)	❑	❑	❑	❑	❑	❑

88 What dissatisfying types of water-efficient dishwashers did you use?

89 What problems did you experience with these dissatisfying water-efficient dishwashers?

90 How were these problems with the dissatisfying water-efficient dishwashers resolved?

91 What type of water-efficient dishwashers did you use that exceeded your expectations?

92 In what way did water-efficient dishwashers exceed your expectations?

93 What dissatisfying types of water-efficient clotheswashers did you use?

94 What problems did you experience with these dissatisfying water-efficient clotheswashers?

95 How were these problems with the dissatisfying water-efficient clotheswashers resolved?

96 What type of water-efficient clotheswashers did you use that exceeded your expectations?

97 In what way did water-efficient clotheswashers exceed your expectations?

98 What dissatisfying types of water-efficient icemakers did you use?

99 What problems did you experience with these dissatisfying water-efficient icemakers?

100 How were these problems with the dissatisfying water-efficient icemakers resolved?

101 What type of water-efficient icemakers did you use that exceeded your expectations?

102 In what way did water-efficient icemakers exceed your expectations?

Q187 (5/9)

103 Please describe the experiences that you personally have had with the following Alternative Water Source technologies. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Rainwater Harvesting (1)	❑	❑	❑	❑	❑	❑
Greywater Reuse (2)	❑	❑	❑	❑	❑	❑
Blackwater Reuse (3)	❑	❑	❑	❑	❑	❑
Process Water Recycling/Reuse (4)	❑	❑	❑	❑	❑	❑
Condensate Recovery (5)	❑	❑	❑	❑	❑	❑
Municipal Nonpotable (6)	❑	❑	❑	❑	❑	❑

104 What dissatisfying types of rainwater harvesting technologies did you use?

105 What problems did you experience with these dissatisfying rainwater harvesting technologies?

106 How were these problems with the dissatisfying rainwater harvesting technologies resolved?

107 What type of rainwater harvesting did you use that exceeded your expectations?

108 In what way did rainwater harvesting exceed your expectations?

109 What dissatisfying types of greywater reuse technologies did you use?

110 What problems did you experience with these dissatisfying greywater reuse technologies?

111 How were these problems with the dissatisfying greywater reuse technologies resolved?

112 What type of greywater reuse did you use that exceeded your expectations?

113 In what way did greywater reuse exceed your expectations?

114 What dissatisfying types of blackwater reuse technologies did you use?

115 What problems did you experience with these dissatisfying blackwater reuse technologies?

116 How were these problems with the dissatisfying blackwater reuse technologies resolved?

117 What type of blackwater reuse did you use that exceeded your expectations?

118 In what way did blackwater reuse exceed your expectations?

119 What dissatisfying types of process water reuse technologies did you use?

120 What problems did you experience with these dissatisfying process water reuse technologies?

121 How were these problems with the dissatisfying process water reuse technologies resolved?

122 What type of process water reuse did you use that exceeded your expectations?

123 In what way did process water reuse exceed your expectations?

124 What dissatisfying types of condensate recovery technologies did you use?

125 What problems did you experience with these dissatisfying condensate recovery technologies?

126 How were these problems with the dissatisfying condensate recovery technologies resolved?

127 What type of condensate recovery did you use that exceeded your expectations?

128 In what way did condensate recovery exceed your expectations?

129 What dissatisfying types of municipal nonpotable technologies did you use?

130 What problems did you experience with these dissatisfying municipal nonpotable technologies?

131 How were these problems with the dissatisfying municipal nonpotable technologies resolved?

132 What type of municipal nonpotable did you use that exceeded your expectations?

133 In what way did municipal nonpotable exceed your expectations?

Q188 (6/9)

134 Please describe the experiences that you personally have had with the following Landscaping Techniques. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
High Efficiency Irrigation (1)	❑	❑	❑	❑	❑	❑
Water Conserving Plant Selection (2)	❑	❑	❑	❑	❑	❑
Green Stormwater Retention and Infiltration (3)	❑	❑	❑	❑	❑	❑
Grey Stormwater Retention and Infiltration (4)	❑	❑	❑	❑	❑	❑

135 What dissatisfying types of high efficiency irrigation did you use?

136 What problems did you experience with this dissatisfying high efficiency irrigation?

137 How were these problems with the dissatisfying high efficiency irrigation resolved?

138 What type of high efficiency irrigation did you use that exceeded your expectations?

139 In what way did high efficiency irrigation exceed your expectations?

140 What dissatisfying types of water conserving plant selection did you use?

141 What problems did you experience with these dissatisfying water conserving plant selection?

142 How were these problems with the dissatisfying water conserving plant selection?

143 What type of water conserving plant selection did you use that exceeded your expectations?

144 In what way did water conserving plant selection exceed your expectations?

145 What dissatisfying types of green retention and infiltration did you use?

146 What problems did you experience with these dissatisfying green retention and infiltration?

147 How were these problems with the dissatisfying green retention and infiltration resolved?

148 What type of green retention and infiltration did you use that exceeded your expectations?

149 In what way did green retention and infiltration exceed your expectations?

Q193 What dissatisfying types of grey retention and infiltration did you use?

Q194 What problems did you experience with these dissatisfying grey retention and infiltration?

Q195 How were these problems with the dissatisfying grey retention and infiltration resolved?

Q196 What type of grey retention and infiltration did you use that exceeded your expectations?

Q197 In what way did grey retention and infiltration exceed your expectations?

Q189 (7/9)

150 Please describe your personal experiences with the following Performance Monitoring Techniques. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Water Audits (1)	❑	❑	❑	❑	❑	❑
Sub-Metering (2)	❑	❑	❑	❑	❑	❑

151 What dissatisfying types of water audits did you use?

152 What problems did you experience with this dissatisfying water audits?

153 How were these problems with the dissatisfying water audits resolved?

154 What type of water audits did you use that exceeded your expectations?

155 In what way did water audits exceed your expectations?

156 What dissatisfying types of sub-metering did you use?

157 What problems did you experience with this dissatisfying sub-metering?

158 How were these problems with the dissatisfying sub-metering resolved?

159 What type of sub-metering did you use that exceeded your expectations?

160 In what way did sub-metering exceed your expectations?

Q185 (8/9)

161 Please describe the experiences that you personally have had with the following User Education Techniques. You may select more than one satisfaction level for multiple experiences. Hold the cursor over technologies for more detail.

	No Experience (1)	Extremely Dissatisfying (2)	Somewhat Dissatisfying (3)	Indifferent (4)	Satisfying (5)	Far Exceeded Expectations (6)
Feedback on Water Use (1)	❑	❑	❑	❑	❑	❑
Signage and Educational Materials (2)	❑	❑	❑	❑	❑	❑
Behavioral Policies and Incentives (3)	❑	❑	❑	❑	❑	❑

162 What dissatisfying types of feedback on water use did you use?

163 What problems did you experience with this dissatisfying feedback on water use?

164 How were these problems with the dissatisfying feedback on water use resolved?

165 What type of feedback on water use did you use that exceeded your expectations?

166 In what way did feedback on water use exceed your expectations?

167 What dissatisfying types of signage and educational materials did you use?

168 What problems did you experience with this dissatisfying signage and educational materials?

169 How were these problems with the dissatisfying signage and educational materials resolved?

170 What type of signage and educational materials did you use that exceeded your expectations?

171 In what way did signage and educational materials exceed your expectations?

172 What dissatisfying types of behavioral policies and incentives did you use?

173 What problems did you experience with this dissatisfying behavioral policies and incentives?

174 How were these problems with the dissatisfying behavioral policies and incentives resolved?

175 What type of behavioral policies and incentives did you use that exceeded your expectations?

176 In what way did behavioral policies and incentives exceed your expectations?

Q184 (9/9)

Appendix X: Survey IRB Approval Letter

VirginiaTech

Office of Research Compliance
Institutational Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, VA 24060
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: August 29, 2012

TO: Annie R Pearce, Marc A Edwards, Benjamin Daniel Chambers, William J Rhoads

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

PROTOCOL TITLE: Green Building Design: Water Quality and Utility Management Considerations

IRB NUMBER: **12-623**

Effective August 29, 2012, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 7**
Protocol Approval Date:	**August 29, 2012**
Protocol Expiration Date:	**August 28, 2013**
Continuing Review Due Date*:	**August 14, 2013**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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Appendix Y: Survey IRB Approval Renewal Letter

VirginiaTech

Office of Research Compliance
Institutational Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: August 12, 2013

TO: Annie R Pearce, Marc A Edwards, Benjamin Daniel Chambers, William J Rhoads

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)

PROTOCOL TITLE: Green Building Design: Water Quality and Utility Management Considerations

IRB NUMBER: **12-623**

Effective August 12, 2013, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Continuing Review request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 7**
Protocol Approval Date:	**August 29, 2013**
Protocol Expiration Date:	**August 28, 2014**
Continuing Review Due Date*:	**August 14, 2014**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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