Water Use Field Research and Baseline Assessment

U.S. EPA Wynkoop Building, Denver, Colorado

For

U.S. General Services Administration
Office of Federal High Performance Green Buildings

December 2012 – FINAL REPORT

by

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INTRODUCTION

The following report summarizes the results of the water efficiency evaluation of the U.S. Environmental Protection Agency (EPA) Wynkoop office building located at 1595 Wynkoop Street in Denver, Colorado. This 8-story building consists of a total of 420,000 gross square feet[1], of which the EPA occupies 218,000 rentable square feet. The EPA occupancy includes a large fitness center with showers, conference center, and library.

Contract Tasks

Koeller and Company was tasked in 2010 by Pacific Northwest National Laboratory (PNNL) under the American Recovery and Reinvestment Act (ARRA) to complete water measurement and analysis directed at assessing the compliance of the plumbing systems with prevailing standards, identifying the source of any water use anomalies, recommending actions to reduce water use, and providing data leading to the development of water use baselines for future projects of a similar nature. These evaluations required on-site inventory of the installed plumbing systems and measurements of water consumption in selected locations within the building. The General Services Administration commissioned subsequent work in 2012.

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[1] Of the total of 420,000 gross square feet, approximately 100,000 are dedicated to two levels of subterranean parking and 18,000 to ground floor retail. The U.S. EPA occupies 218,000 net rentable square feet.

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SUMMARY & CONCLUSIONS

1. Physical inspections of the plumbing fixtures and fittings installed in the building disclosed only one minor non-compliance issue with lavatory faucets that was immediately corrected by building staff.
2. An analysis of total domestic water demands in the Wynkoop building during 2010 and 2011 showed water use to be very close to those calculated/estimated as part of the original LEED application (once the LEED values were adjusted to reflect actual building occupancy and faucet flow rates). Actual domestic water use of approximately 5.34 gallons per capita per day (gcd) in 2010 and 5.25 gcd in 2011 tracked closely with the LEED projected demand of 5.44 gcd.
3. The projected LEED water use (plumbing systems) for the Wynkoop building originally showed a 49 percent reduction from the LEED template baseline. However, after adjusting for the faucet calculation within the LEED template formula[2], the estimate was revised to a 40 percent projection, still sufficient to earn the LEED Innovation Design point.
4. Monitoring building water consumption indicated no evidence of leakage in the plumbing system. It is possible, however, that some small level of leakage may exist in the building – i.e., leakage with a flow rate too low to be recorded by the monitoring equipment.
5. Water use on the 7th floor was sub-metered and data logged. The collected data indicated that building occupants were generally not using the 'reduced' flush option on the dual-flush toilets on that floor. The dual-flush flush valves installed on the building's toilets are designed to provide a 'full' 1.6-gallon flush to remove solid waste when the handle is pushed down and a 'reduced' 1.1-gallon flush to remove liquid waste when the handle is pulled up. Those handles were installed correctly.
6. As a result of item 5, the toilet flush handles on the 7th floor were replaced with handles of the opposite design, i.e., where pushing down on the handle produced a 'reduced' flush and pulling up produced a 'full' flush. Prior to replacement, several samples of these new flush handles were laboratory tested by Veritec Consulting, Inc. to verify that the units provided the correct reduced flush volume when pushed down and the full volume when pulled up. Once replaced, building maintenance staff received no complaints regarding the new "opposite" flush handles and believed that most occupants were unaware that the change was made.
7. The overall volume of water saved by replacing the flush handles, however, was not accurately quantified, primarily because of the variability in personnel occupancy on that floor[3], but also because of the accuracy of the monitoring equipment that was used[4].
8. Following completion of the study in 2011, the remaining flush valve handles in the building were similarly replaced with the new flush handles.

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[2] LEED 2009, WE Credit 3, provides a baseline for conventional lavatory faucets of 0.5 gpm, or, in the case of metering faucets, a maximum volume of 0.25 gallons.
[3] Walk-thru's and headcounts taken at various times by EPA staff resulted in occupancy estimates ranging from as low as 92 to as high as 141 on the 7th floor.
[4] Unlike turbine or positive displacement meters, the accuracy of ultra-sonic meters can be affected by how they programed and installed, as well as by the condition of the piping on which they are installed.

RECOMMENDATIONS

We recommend these follow-on actions with respect specifically to Wynkoop:

- Building management to continue tracking the main building water meter and the various sub-meters to segregate and track domestic demands in the building on a month-by-month basis.

- Building management to periodically calculate the equivalent full-time occupancy of the building and, based on calculated domestic water demands, track per capita domestic water demands in the building. Take necessary action should an unexpected increase in per capita water demands be identified.

LESSONS LEARNED

Calculating per capita domestic water demands in any building requires an accurate determination of the volume of water provided for domestic purposes and the number of persons being served by this volume. Projections of building domestic water use[5] (including projections for LEED) are based upon several assumptions, including fixture flush/flow rates and building occupancy. Unfortunately, it is frequently difficult to accurately define values for these two characteristics in advance of construction and occupancy. Important factors to be considered are as follows:

Building Occupancy

Some buildings, such as the Wynkoop building, have highly variable occupancy rates. Not only can building occupancy change from year-to-year as new projects ramp up or existing projects shut down, but they can also change from month-to-month (e.g., employee vacations, holiday breaks, etc.), and even from day-to-day (e.g., some employees may routinely take Mondays or Fridays off). What's more, some employees occasionally work off-site, or work overtime or on weekends, and some buildings have varying levels of visitors. All of these factors complicate the accurate determination of 'full-time equivalent' building occupancy values.

Segregating Water Consumption Values

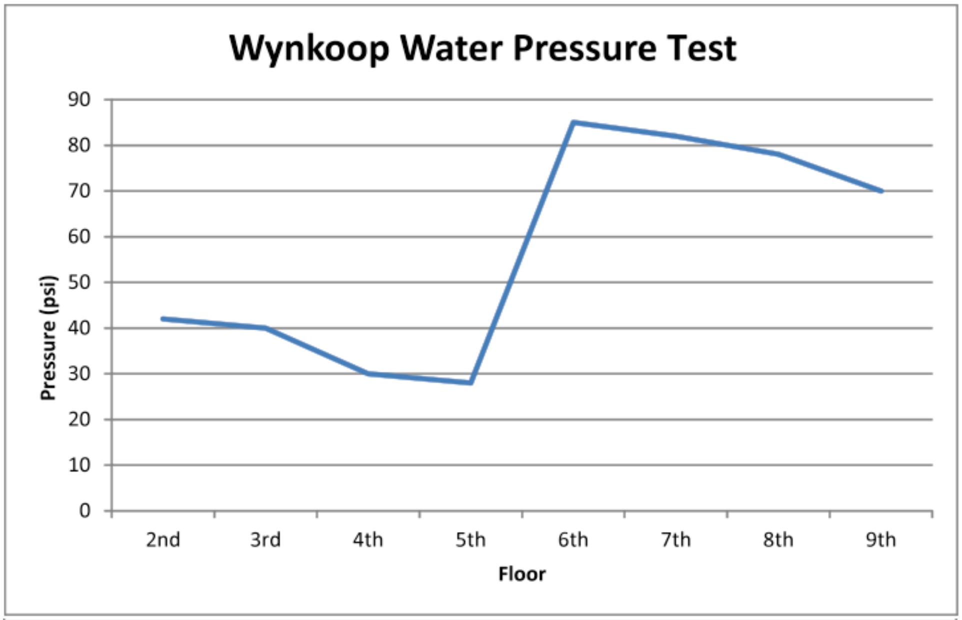
It is also common for a building to consume water for non-domestic purposes. For instance, water can be used in a building for cooling tower make-up, boiler make-up, trap priming, landscape irrigation, process water use, general cleaning, humidification, etc. These types of water demands could be segregated from domestic demands either through the use of separate domestic and non-domestic supply piping *or* by an array of sub-meters installed on every non-domestic demand. However, this is almost never the case. While the use of sub-meters to delineate between domestic and non-domestic water demands is beneficial, no water meter is 100 percent accurate and, therefore, as the number of sub-meters in a facility increases, the cumulative level of accuracy is diminished.

Building Water Pressure Issues

In multi-story buildings, such as Wynkoop, service pressure to the individual floors and the fixtures on those floors can vary significantly. For example, as noted in Figure 1 below[6], water pressure ranged from a low of less than 30 psi (5th floor, uppermost floor serviced by municipal water pressure) to as high as 85 psi (6th floor, lowermost floor serviced by in-building booster pump system). Varying pressures such as these can have a significant impact upon flush and flow rates of installed fixtures and fixture fittings. For example, in some cases, toilet fixtures will not perform adequately at the low pressures (e.g., below 30 psi). Other products, such as showers and appliances, may not function satisfactorily at extremely high pressures (e.g., above 80 psi).

[5] Toilet and urinal flushing, faucet use, and showering.
[6] From U.S. Department of Energy, 2012. *Wynkoop Building Performance Measurement: Water*, by Pacific Northwest National Laboratory.

Figure 1. Wynkoop Supply Water Pressure by Floor



In view of the above, consider the following guidelines for future building or project water use studies:

Building Occupancy

Where employees and visitors are required to 'log-in' or otherwise note their entry and departure from the building, use that documentation as the starting point for establishing full-time equivalent occupancy levels. Recognize the variability of occupancy data as noted above.

Submetering

- Meter type: Where possible, sub-metering should be conducted using either permanent turbine or positive displacement meters if a high level of accuracy is required.
- Meter location: Where possible, meters should be installed as per the manufacturer's instructions, e.g., with adequate lengths of 'straight pipe' upstream and downstream of meter.
- Meter size: Meters should be properly sized for in-situ flow rates.
- Meter readings: Meter readings should be recorded to the highest level of accuracy provided by the meter. The date and time for each meter reading should be recorded, as well as the name of the person taking the reading. To the extent possible, all meter reads for a given project or site should be taken by the same individual.
- Utilize the results of this study to support the requirement that LEED-certified buildings be equipped with sub-meters, enabling domestic water demands to be delineated from other building water demands and tracked through a real-time management system designed to quickly identify water consumption anomalies.

Building Water Pressure

Measure supply water pressure at the fixtures and fittings on each floor to aid in identifying the possible source of plumbing performance issues.

SCOPE AND METHODOLOGY

1.0 Background

The following report summarizes the results of the water efficiency evaluation of the 8-story U.S. Environmental Protection Agency (EPA) Wynkoop office building located at 1595 Wynkoop Street in Denver, Colorado.

The purpose of this water efficiency evaluation was twofold:

1. To determine the building's actual water demand (related to building occupancy) and compare this value to the water demand estimate calculated as part of the building's LEED application, and
2. To identify whether any practical options were available to achieve an even greater level of water use efficiency.

2.0 Comparison of LEED Calculated Demands with Actual Demands

<u>2.1 Original water consumption estimates</u>

It should be noted that LEED calculations are completed during building design and, therefore, must use assumed values for total building occupancy, ratio of men to women, the flow rates and flush volumes of the building's plumbing fixtures, and the frequency of plumbing fixture use.

The Wynkoop project was assessed in 2007 by Architectural Energy Corporation (AEC)[7] against the USGBC's LEED[8] New Construction (NC) criteria and found to have earned three (3) points for water efficient plumbing fixtures and fittings as follows: one (1) point each for meeting 20 percent and 30 percent water use reduction thresholds and one (1) point for Innovative Design by having achieved a 49 percent reduction threshold from a calculated baseline.

Based upon the engineering calculations by AEC in accordance with USGBC LEED template formulae, total annual water consumption by indoor plumbing at Wynkoop was estimated as:

Baseline water use	3,372,168 gallons
Projected water use	<u>1,719,738 gallons</u>
Design reduction from baseline	1,652,430 gallons (49%)

The values above were based on the following assumptions:

- Baseline Case – Weekday Demands
    - Men flush toilet (1.6-gallons per flush, gpf) once and urinal (1.0-gpf) twice per day.
    - Women flush toilet (1.6-gpf) three times per day.
    - Men and women use lavatory sink (2.5-gallons per minute, gpm) three times per day for 15 seconds each time.
    - Men and women use kitchen sink (2.5-gpm[9]) two times per day for 15 seconds each time.

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[7] 2007, Architectural Energy Corporation. Memo to USGBC, LEED Review Committee, *"ID Credit 1.2 – Wec3 Exceedance, Water Use Reduction"*

[8] U.S. Green Building Council, Leadership in Energy and Environmental Design program

[9] The baseline flow rate for kitchen faucets used by AEC for the LEED calculation was incorrectly set at 2.5-gpm, whereas the national standard and Federal law set the maximum at 2.2-gpm. This error had little impact upon the LEED water use assessment.

- 25 percent of the staff take a shower (2.5-gpm) on-site each day for five minutes
- Janitor sink (2.5-gpm) is used eight times per day for 15 seconds each time.

- Projected Case – Weekday Demands
  - Men flush toilet (1.6-gpf) once and use non-water urinal twice per day.
  - Women use full flush of dual-flush toilet (1.6–gpf) twice and use reduced flush (1.1-gpf) twice per day.
  - Men and women use lavatory sink (0.5-gpm) three times each day for 15 seconds each time.
  - Men and women use kitchen sink (0.5-gpm) two times each day for 15 seconds each time.
  - 25 percent of the staff take a shower (1.6-gpm) on-site each day for five minutes.
  - Janitor sink (2.0-gpm) is used eight times per day for 15 seconds each time.

2.2 Adjustment for Actual Building Occupancy (i.e., reduced headcount)

The LEED calculation of water use was based upon a building occupancy of 1,240 persons (full-time equivalent), divided equally between males and females. Actual average population for the 24-month period from April 2009 through March 2011 was estimated to be only 765 persons, including EPA employees, contractors, visitors, and others. Of these, 54.6 percent were female (418 persons) and 45.4 percent were male (347 persons).[10] Recalculating the LEED indoor water estimate based upon the actual (reduced) occupancy numbers yields a reduced annual projection:

Adjusted baseline water use	2,093,520 gallons
Project water use	1,082,900 gallons
Design reduction from baseline	1,010,620 gallons (48%)

2.3 Adjustment for lavatory faucets

The LEED formulas used to calculate the base demands for this building erroneously used a LEED baseline flow rate of 2.5 gallons per minute for lavatory faucets[11]. Correcting the lavatory faucet flow rate baseline maximum to 0.5 gpm results in the following values:

Final adjusted baseline water use	1,795,300 gallons
Project water use	1,082,900 gallons
Design reduction from baseline	712,400 gallons (40%)

A target demand of 1,082,900 gallons per year equates to an average workday demand of 4,165 gallons (based on 260 workdays per year), or an average demand of 5.44 gallons per capita per workday based on a building occupancy (full-time equivalent) of 765 persons.

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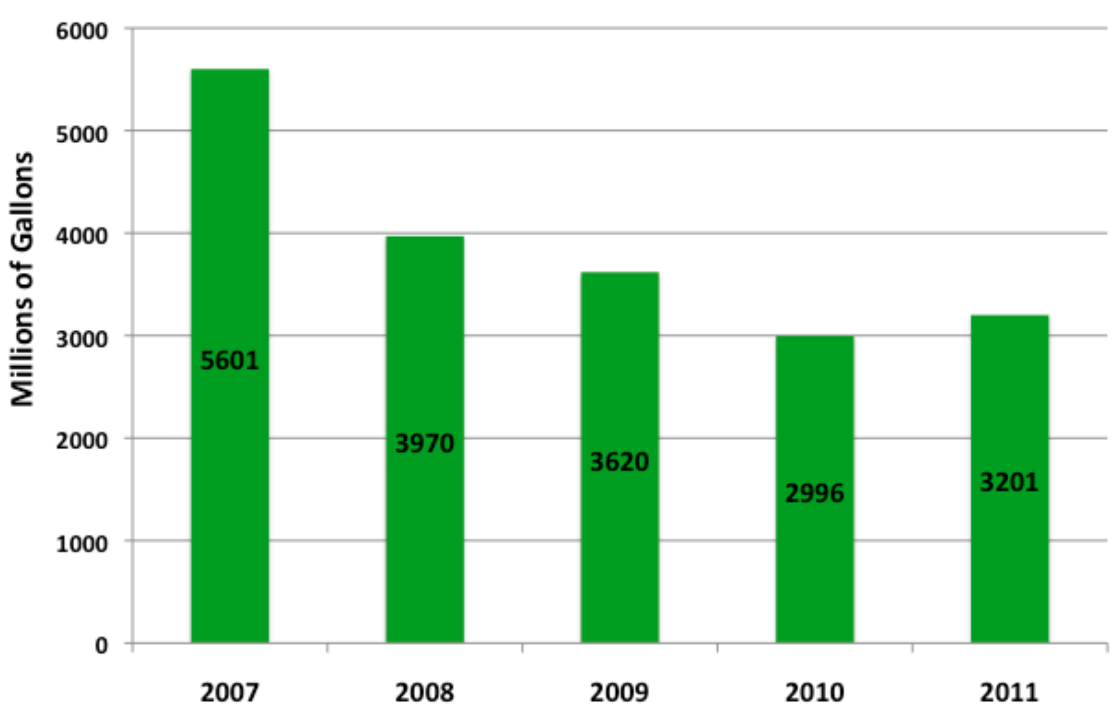
[10] 2011, Daniels, William. Email of March 17 to Bill Gauley. *"LEED submittals for water efficiency credits*"

[11] The lavatory faucet flows derived by AEC used a baseline of 2.5 gpm, rather than the stated 2.2 gpm maximum mandated by Federal law (EPAct 1992, as interpreted by the Department of Energy, set the maximum flow rate at 2.2 gpm at 60 pounds per square inch of supply pressure). However, even if LEED used an EPAct 1992 baseline lavatory faucet flow of 2.2 gpm within their calculation template, it was recognized in 2009 by the USGBC that this, too, was incorrect. Since the mid-1990s the American National Standard (ASME-ANSI A11218.1 for plumbing supply fittings) and the U.S. model codes (International Plumbing Code and Uniform Plumbing Code), both of which referenced that standard, specified a maximum flow rate of 0.5 gpm for non-residential lavatory faucets. As such, LEED 2009 corrected their error and LEED documentation now incorporates the correct baseline of 0.5 gpm for non-residential faucets.

2.4 Historical Total Building Water Use

Total building water use (Figure 2), including both domestic[12] and non-domestic demands[13] declined steadily since initial building occupancy in 2007 (5.6 million gallons per year) until 2010 (3.0 million gallons per year). Demands in 2011 were similar to those in 2010 (3.2 million gallons). Building managers report that much of the initial water demand reduction was due to changes made to the building's steam system, where the need for tempering water at the drain was reduced. Identifying the specific sources of other changes in total building water demands was not within the scope of this study.

Figure 2. ANNUAL POTABLE WATER CONSUMPTION AT WYNKOOP



2.5 Domestic Water Use (related to building occupancy)

In addition to the building's main utility water meters, the Wynkoop site is equipped with 12 sub-meters that allow domestic water use to be delineated from non-domestic water use.

The building's total *domestic* water use in 2010 was 1.06 million gallons, or about 35 percent of total building water demand. As also noted in Table 1, the total *domestic* use in 2011 was nearly the same at 1.04 million gallons, or about 32 percent of total building water use.

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[12] Demands related to building occupant use of various plumbing fixtures.
[13] Demands related to cooling tower make-up, steam make-up, irrigation of green roofs and perimeter trees, water treatment, tempering valve, and commercial tenant water use.

Table 1. Annual Water Use (gallons)

Year	Total building	Domestic	*Domestic, % of total*
2010	2,996,305	1,061,947	*35%*
2011	3,201,348	1,044,884	*32%*

The 2010 domestic demand equates to an average workday demand of 4,084 gallons (based on 260 workdays per year), an average per capita demand of 5.34 gallons per day (based on an full-time equivalent occupancy rate of 765 persons), or about 1.8 percent lower than the LEED target design of 5.44 gallons per day.

The 2011 domestic demand (1,044,884 gallons) equates to an average workday demand of 4,019 gallons, an average per capita demand of 5.25 gallons per day (also based on an full-time equivalent occupancy rate of 765 persons), or about 3.5 percent lower than the LEED target design of 5.44 gallons per day.

2.6 Historical Building Occupancy

Since opening in 2007, personnel occupancy by the EPA and support activities[14] has remained relatively constant, increasing slightly from an estimated 734 persons in 2007 to an estimated 765 persons in 2010 and 2011[15].

Determining an exact 'full time equivalent' occupancy rate for this site is complicated by the fact that some EPA employees work on a flex shift versus an 8-hour per day, 5-day per week schedule. For example, some employees work to a 9/80 schedule, which allows them to work a full 80 hours over a two-week period, but doing so within 9 rather than 10 days. Furthermore, some Wynkoop employees are allowed to work from their homes on a periodic or continuing basis, and others are frequently in the field working on assignments that are either temporary (a few hours or days) or semi-permanent (a week or more). All of these arrangements contribute to a large degree of uncertainty regarding calculations of per capita water demands within the Wynkoop building.

2.7 LEED 'Calculated' vs. Actual Water Use

Reviewing actual water use for plumbing fixtures and fittings and comparing those figures with the 'calculated' values from LEED resulted in the following:

Table 2. 2010 Projected vs. Actual Domestic Water Demands

Demands	**Annual demand, gallons[16]**	**gcd[17]**	**Variance with LEED, gcd**
LEED Calculated	1,082,900	5.44	
2010 Actual	1,061,947	5.34	-0.10
2011 Actual	1,044,884	5.25	-0.19

Even though LEED calculated values are based on assumed values for the ratio of men to women and the frequency of plumbing fixture use, and 'actual' water use values are based on a best estimate of the full-time equivalent building occupancy, *actual* 2010 and 2011 demands follow closely with the LEED *calculated* demands.

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[14] Full-time equivalent of EPA employees, visitors, contractors, and others, as reported by the EPA
[15] Note: EPA staff estimates that building occupancy in 2012 had reduced to 705 persons.
[16] Domestic use only
[17] Based on 260 day work year and estimated full-time equivalent occupancy rate of 765 persons/day

3.0 Identification of Practical Water Efficiency Options

Detailed water demand monitoring was completed as part of this study to identify the potential to further reduce domestic water demands through the implementation of one or more water efficiency measures.

3.1 Water Demand Monitoring

As stated earlier, the Wynkoop building contains 12 water sub-meters that enable the domestic water demands to be segregated from non-domestic use on a building-wide basis. However, there are no sub-meters installed within the building to directly measure domestic demands on a floor-by-floor basis. The existing sub-meters provide no insight regarding specific characteristics of the domestic water demand – specifically characteristics such as toilet flush volumes, number of flushes per day, and shower and faucet demands.

3.2 Whole Building Leakage

An ultrasonic meter, complete with data logger, was installed on the main water supply piping to the building to provide data regarding the building's diurnal water demand patterns, weekend vs. weekday demand volumes, and whether there was any indication of leakage in the entire building. At numerous times throughout the monitoring period the building water demand reached zero gallons per minute and, as such, no evidence of leakage was observed. It is possible, however, that some small level of leakage may exist in the building - leakage with a flow rate too low to be recorded by the monitoring equipment.

3.3 Monitoring 7th Floor Water Demand

While virtually all of the water-using fixtures and appliances in the building were inspected, specific water demand data was collected for the 7th floor (a "typical" office floor in the building) during March 2011 by removing a small section of drywall and installing an ultra-sonic sub-meter and data logger on the water supply to that floor. The data collected was used to determine:

- the total water demands of the floor (which, along with the 7th floor occupancy number, was used to determine an average gallons per capita per day value),
- flush volume characteristics (average flush volume, use of reduced flush option on dual flush fixtures), and
- whether there was any indication of leakage on the 7th floor (there was none).

Building staff estimated that there are typically 68 men and 73 women working on this floor - a total of 141 persons, though this number does vary from day-to-day and even from hour-to-hour[18]. The ultrasonic water meter (with data logger) was installed on the cold water supply piping to washrooms[19]. Flow rate data was collected on a second-by-second basis for several days. The collected data was analyzed to determine the mean and median volumes of water use 'events'. A water use event in this context may be a single toilet flush or lavatory use, or it may be several overlapping or coincidental water demands that could not be segregated. There was an average of 202 water use events per day during these three days with an average volume of 2.1 gallons per event.

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[18] In fact, on the afternoon of July 13, 2011, for example, EPA staff performed a walk-thru and counted only 92 persons on the floor.

[19] The only hot water demand on this floor is related to lavatory use – a minor demand that was not monitored.

The building is equipped with the Zurn AquaVantage dual-flush flush valves that are designed to discharge 1.1 gallons when pulled 'up' (to remove liquid waste) vs. 1.6 gallons when pushed 'down' (to remove solid waste). Almost all of the events on the 7th floor had flush volumes greater than 1.1 gallons. This result indicates that the building occupants were not lifting the flush handle and selecting the reduced flush volume as often as anticipated.

3.4 Dual-flush toilet fixtures

Based on the design of the dual-flush flush valves installed in the facility and the LEED assumptions, the collected water demand data would be expected to demonstrate water use volumes centered at approximately 1.1-gpf and 1.6-gpf to reflect the full and reduced flush volumes offered by the toilets. However, very few recorded water use events had flush volumes of 1.1-gpf or less, indicating that either the dual-flush valves were not operating properly or that building occupants were only infrequently selecting the reduced flush volume option[20]. As stated earlier, the LEED water demand calculations assume that women will activate two reduced flushes per day. Therefore, a failure to fully utilize the reduced flush option will result in greater-than-expected water demands.

The most likely cause for the infrequent use of the reduced flush option was thought to be related to the way the dual-flush flush handle is operated, i.e., the user pushes 'down' on the handle to activate the full flush and pulls 'up' on the handle to activate the reduced flush. The 'normal' method of activating a toilet flush (for both commercial and residential toilets) is to push down on the flush actuator. Using the 'pull up' option to activate a reduced flush would require the user to be fully aware of that flush option *and* to commit to making extra effort to select it.

3.5 Replacement of 7th Floor Dual-flush Toilet Flush Handles

Building management and the project manager agreed to replace the existing dual-flush handles with a different model of handle that worked in the opposite manner – the default 'down' position would produce a reduced flush and a 'up' position would activate a full flush[21]. A suitable aftermarket replacement dual-flush flush handle[22] was identified and laboratory tested by Veritec Consulting Inc. of Mississauga, Ontario, Canada. The laboratory testing verified that the new dual-flush handles provided a reduced flush volume when pushed 'down' and delivered the correct volume of water for each of the two flush options. The building manager arranged for installation of the new flush handles on all 7th floor washroom flushometer toilets.

A short period of time was allowed 7th floor occupants to become familiar with the new flush handles and then the ultrasonic meter and data logger were re-installed on the water supply piping. Unfortunately, problems were experienced with the ultrasonic meter during post monitoring and the resulting data could not be used to verify an overall reduction in 7th floor water demands. While water savings could not be verified using the sub-metering data, facility personnel noted that the toilets on the seventh floor appeared to flush better after the new

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[20] Anecdotally, it has been reported from other sources over the past three years that lifting "up" on the flush handle to activate a reduced flush is inconvenient and, as such, this option is seldom used. Facility managers and water efficiency professionals have asserted that until a reduced flush is activated by pushing 'down' on the handle (the normal user custom when activating a flush valve), water savings from these types of dual-flush valves will be minimal.

[21] Two options were identified to reduce the water demand related to toilet flushing: (a) remove the existing dual-flush bowl/flush valve fixtures in their entirety and replace them with single-flush high efficiency toilets (HETs) that flush with 1.28 gallons or less, OR (b) remove only the existing flush handles and replace them with dual-flush handles that require users to push 'down' to activate the 'reduced' flush option. Because of the cost associated option (a), building staff decided to initially explore the less expensive option of replacing the existing dual-flush handles.

[22] Manufactured by Advanced Modern Technologies Corporation – AMTC, Woodland Hills, California.

valves were installed and, perhaps more importantly, the number of complaints received regarding toilet plugging problems and other flushing issues was significantly reduced (to virtually zero) after the new valves were installed. In fact, facility personnel received no comments at all from the 7th floor occupants regarding the flush handle replacements, indicating that the occupants may not have even been aware of the change-out.

3.6 Replacement of Dual-flush Toilet Flush Handles in Entire Building

Based on the positive results achieved on the 7th floor, the existing flush handles in the remainder of the building were replaced with the new "opposite operation" flush handles. There have been no complaints regarding flushing performance and, again, it appears tenants are unaware of the change-out.

Subsequent to the entire building flush handle change-out, water demand monitoring was completed by PNNL to verify the savings. Unfortunately, the PNNL monitoring was unable to quantify the water savings on a building-wide basis for the following reasons:

- As stated earlier, determining an exact 'full-time equivalent' occupancy rate for the Wynkoop building is complicated by the fact that some building employees work on a flex shift, some are allowed to work from their homes on a periodic or continuing basis, and others frequently work out of the building on field assignments. All of these conditions contribute to some degree of uncertainty regarding calculations of per capita water demands.
- The volume of savings related to the installation of the new flush valve handles is relatively small compared to the water demands of the entire building. As such, it is difficult to quantify the level of savings related specifically to the flush handle change-out when there may be other changes in building water demands related to commercial tenant demands, irrigation demands, cooling tower make-up, etc.
- The domestic water demand is calculated by subtracting the demands recorded by the 12 sub-meters from the total building demand. The accuracy of the domestic demand calculation is, therefore, affected by the cumulative accuracy of the sub-meters and the recorded sub-meter readings (both the reading value and the date/time of the reading).

3.7 Restoration of Metering Faucets to Original Design Flow Rate

A physical inspection of the plumbing fixtures and fittings installed in the building disclosed only one non-compliance situation. A site visit to the building in September 2010 noted that lavatory faucets were set to flow at approximately 1.5 gpm for 30 seconds, whereas the LEED project design case (and the prevailing national plumbing standard) sets the maximum at 0.5 gpm for a conventional lavatory faucet (public setting) and 0.25 gallons per cycle for a metering faucet. As metering faucets, the calculated water volume per cycle exceeded the Federal and LEED volumetric maximum of 0.25 gallons per cycle[23]. Building management responded immediately to correct the situation by replacing the faucet aerators with 0.5 gpm aerators[24]. Once that was completed with the metering time set to no more than 30 seconds, the faucets became compliant metering faucets as defined in Table 1 of ANSI standard ASME A112.18.1/CSA B125.1 and LEED.

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[23] At 1.5 gpm for a 30 second cycle, total volume was calculated as 0.75 gallons.

[24] Metering faucets flowing at 1.5 gpm would have been acceptable and compliant provided the programmed cycle time (shut-off) was 10 seconds or less. However, given a cycle time of 30 seconds, the faucets were not found to qualify as metering faucets under the standard until the flow rate was reduced back to 0.5 gpm.