# Sensor-Operated Plumbing Fixtures

# Do They Save Water?

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# 1.0 Introduction

Over the years, there has been much debate among water efficiency professionals, manufacturers, green building advocates, and others regarding the water savings associated with using sensor-activated valves[1] in restrooms. This includes the three main categories of such valves found in commercial restroom facilities, i.e., flush valves for both urinals and toilets (water closets), and flow control valves for faucets. While it is commonly accepted that these "touchless" valves are more hygienic than manually-operated valves, there remains some question as to whether or not they are more water-efficient.

Many have experienced first-hand the "phantom flushes" that sometimes occur with sensor-operated toilet and urinal flush valves. A "phantom flush" is an activation of the flush valve at times other than when required. Phantom flushes of urinals and toilets usually occur when (1) persons walk past a bank of urinals and the sensor identifies movement and activates the flush or (2) when the movement of a person within a water closet compartment (toilet stall) triggers the sensor and activates the flush. Because it is not possible for manually-operated valves to "phantom flush", many water efficiency professionals believe that sensor-activated toilet and urinal flush valves are less efficient than manually-operated valves[2].

Some sensor-operated flush valves for urinals claim to provide water savings vs. manually-operated valves by employing a "smart technology" that prevents the valve from operating after every user during periods of high use (e.g., at half-time during a football game)[3]. Furthermore, the marketing materials of many manufacturers make claims of significant water savings related to the installation of sensor-operated faucets. To date, however, we (the authors) are aware of no independent studies that support such claims.

# 2.0 Purpose

The purpose of this project was to evaluate the effectiveness of sensor-operated valves to save water. The project included completing a comprehensive pre- and post-auditing program involving physical inspections, sub-metering, data logging, maintenance staff surveys, etc. The project evaluated changes in water demands when manually-operated toilet, urinal, and faucet valves were replaced with sensor-operated fixtures in an office tower environment. The study was conducted over a 23-month period beginning February 2007 and concluding January 2009.

# 3.0 Background

Hillsborough County, Florida, takes a proactive approach to improving water efficiencies within its water service area. In 2005, Hillsborough County agreed to sponsor a study to evaluate the potential for water savings associated with replacing manual valves with sensor-operated fixtures. The County executed a funding agreement with the California Urban Water

[1] Also known as "hands free" valves; includes infrared and other types of motion sensors; does not include manual valves activated by the user.
[2] Assuming that both types of valves are operating at the same flush volume.
[3] Though some may questions the extent of the savings claims noting that men do not necessarily flush manual urinal valves after every use either.

Conservation Council in November 2005, after which key elements of the study were further defined.

In 2006, an on-site survey was conducted of candidate properties within the County for the purpose of identifying one or more buildings meeting the following criteria:

- Manual faucets and manual flush valves currently installed in restrooms
- Accessible utility chaseways that would facilitate the installation of sub-metering and data logging equipments on water supply piping to faucets, toilets, and urinals
- Management willingness to participate in this type of study[4], including availability of personnel to remove and install fixtures and meters
- Consistent in-building populations over the study period

Following physical inspections and interviews with building managers, the LakePoint Two property at 3111 West Dr. Martin Luther King Blvd., Tampa (photo to right), was found to be ideally suited for participation in this project. The LakePointe Two building is an 8-story, 223,000 $ft^2$ (net rentable) office building located in the 1.1 million $ft^2$ Tampa Bay Park. The building had readily accessible water supply piping and all toilet/urinal/faucet valves were manually operated. Furthermore, building management was willing to allow the installation of sub-metering and monitoring equipment, and to allow a member of the project team to visit the site on a weekly basis to download the information from the data logging equipment.

The project was implemented on the seventh floor of the LakePointe Two building. The mens' and ladies' washrooms on this floor are situated immediately beside each other. The piping that supplies water to these washrooms is accessible in a janitor's closet located directly beside the mens' room. The water supply piping is hung from ceiling brackets in the janitor's closet.

A plumbing company was hired to install a water meter on the supply piping[5] and a datalogger was connected to the water meter during the entire monitoring period. Because it was necessary to take weekly water meter readings as part of the project, the water supply piping was re-routed such that the water meter could be installed below eye level, on a small table against the back wall of the janitor's closet (see photos on next page).

A datalogger (Brainard Meter-Master 100) was installed on the meter and Tampa Bay Water Conservation staff periodically read the meter and downloaded the information from the data logger on a bi-weekly basis.

[4] Involving maintenance staff time, disruption of restroom availability.
[5] Hot water wasn't monitored as part of this study as it is only associated with faucet use and, therefore, makes up only a very small percentage of the entire water demand.



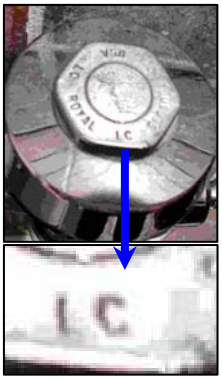
*The above photographs show existing supply piping, piping modifications, and the new water meter.*

## 4.0 Phasing

To help quantify any change to washroom water demands related to the introduction of sensor-operated plumbing fixtures, the project was expected to be completed in 4 phases:

**Phase 1**: pre-monitoring (i.e., washrooms demands with existing manually operated fixtures),
**Phase 2**: period after manual faucets replaced by sensor-operated fixtures,
**Phase 3**: period after manual urinal flush valves replaced by sensor-operated valves, and
**Phase 4**: period after manual toilet flush valves replaced by sensor-operated valves.

## 5.0 Unexpected Findings




The initial pre-monitoring was conducted between January 5 and February 22, 2007. A review of the data identified that the existing manual toilet flush valves were flushing with significantly more than 1.6 gallons of water. Site staff confirmed that "low consumption" valves were installed on the toilets (see photo to right – the "LC" indicates a Low Consumption valve). Site staff next removed the flush valve caps to verify whether or not low consumption diaphragms were installed. It was discovered that all of the toilet flush valves on this floor of the building were incorrectly fitted with 3.5-gallon per flush (gpf) diaphragms. Building maintenance staff replaced all of the 3.5-gpf diaphragms with 1.6-gpf models and the pre-monitoring was repeated.

Because of scheduling difficulties, the second round of pre-monitoring was conducted from February 2007 until January 2008 – almost a full year. Figure 1 on the following page illustrates the average daily water demands of the washrooms both prior to and subsequent to the replacement of the 3.5-gpf diaphragms with 1.6-gpf models. As illustrated in Figure 1, a significant volume of water was saved simply by installing the proper diaphragms.

## 6.0 Phase 1: Pre-Monitoring

As stated earlier, pre-monitoring of the existing fixtures (after the 1.6-G diaphragms were installed) was conducted from February 2007 until January 2008. The average daily water demands during this period was 654 gallons per day.

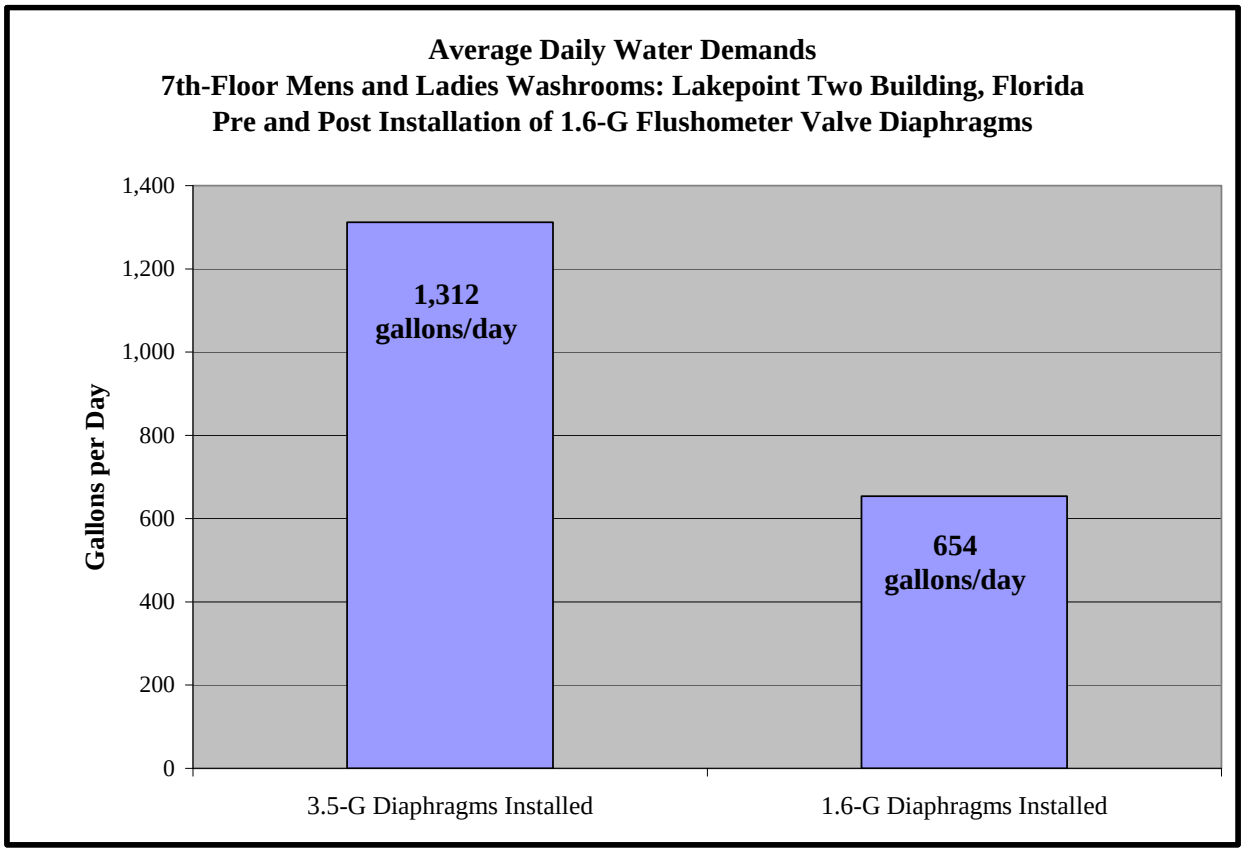



**Figure 1**

## 7.0 Phase 2: Installation of Sensor-operated Faucets

The existing faucets in the mens' and ladies' washrooms were two handle, single spout models, with larger handles and a gooseneck spout on the sinks located in the handicap stalls (see photos on following page). These were replaced with new sensor-operated faucets on January 29, 2008. The new faucets were graciously donated to the project by Sloan Valve Company[6].

The average flow rate of the manual faucets was measured as 1.32 gallons per minute (with the valve fully open) and the average flow rate of the sensor faucets was slightly less at 1.21 gallons per minute (valve fully open). Water demands were monitored for the 127-day period from the date of installation until June 4, 2008. The average daily water demand of the washrooms during this period was 856 gallons per day – an increase of 202 gallons or 30% per day. Figure 2 on the

[6] The exact make and model of the sensor-operated fixtures used in this study is not important as the intent of this study was to evaluate sensor-operated fixtures in general, not a specific make or model of fixture.

following page illustrates the change in water demands when the sensor-operated fixtures were installed. Note that only a portion of the pre and post data is included in Figure 2 to make the chart easier to read.

Existing Faucet – general area

Existing Faucet – handicap stall

Sensor-operated Faucet – general area


Sensor-operated Faucet – handicap stall

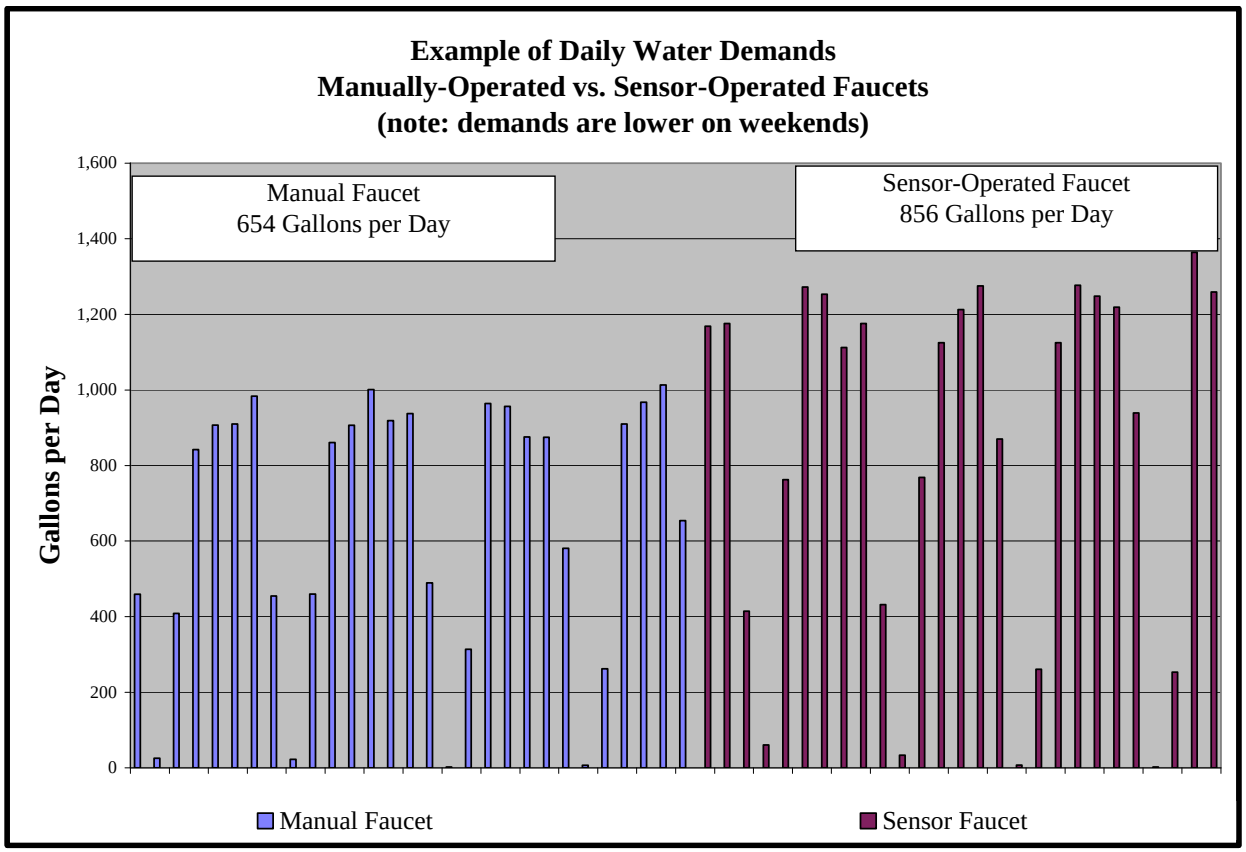



**Figure 2**

Site maintenance staff was asked several times between January and June 2008 if they experienced any performance or maintenance issues with the new sensor-operated faucets, or if they had received any complaints or comments from the office staff that worked on the seventh floor. Maintenance staff commented that they had not experienced any problems with the new faucets nor had they received any negative feedback from office staff – in fact, all feedback had been positive.

## 8.0 Phase 3: Installation of Sensor-operated Urinal Flush Valves

To ensure that any change in water demands was related to a change in the operating system utilized by the flush valve rather than in a change to the flush valve itself, it was decided that rather than replace the existing flush valves, the project would, instead, simply replace the existing manual flush handles on the urinals with battery-powered retrofit sensor-operated valves graciously provided by Zurn (AquaSense® E-Z Flush – see photos below).

The two manually-operated urinal flush valve handles were replaced with sensor-operated devices on June 4, 2008. No further changes were made to the plumbing fixtures until August 25, 2008 when the existing manually-operated toilet flush valve handles were likewise replaced with sensor-operated devices. As such, the water savings resulting from the installation of the sensor-operated urinal flush valves is based on the water demand data collected between June 4 and August 25, 2008. Note that this period of data collection coincides with the typical "summer vacation" period, i.e., it is likely that staff occupancy at the site during this period was lower than during other non-summer periods (this monitoring period was only included in the study because the project was behind schedule). Unfortunately, the project team was not able to obtain staff occupancy data for this period of time.

While the average water demands between June 4 and August 25 declined by approximately 5.5% vs. the period from January 29 until June 4, 2008 (856 gallons per day before installation of sensor-operated urinal flush valves and 807 gallons after installation), it is expected that most of this savings is related to lower occupancy rates during the post monitoring period rather than a decrease in urinal-related water demands. As can be seen in Figure 3 on the next page, the peak daily demand rate is similar during both the pre and post sensor-operated urinal monitoring period (the average of the days with demands greater than 1,000 gallons vary by only 1% between pre- and post-monitoring).

As stated earlier, sensor-operated urinals would not be expected to reduce water demands except, perhaps, when they operate in "stadium mode" and only flush after multiple uses. While some men may occasionally fail to flush a manually-operated urinal, sensor-operated fixtures are

designed to flush with every use[7] (plus there may be the occasional occurrence of phantom flushing with sensor-operated fixtures).

Once again, site maintenance staff was asked if they were aware of any performance or maintenance issues with the new sensor-operated urinal flush valve and, again, they reported that all feedback had been positive.

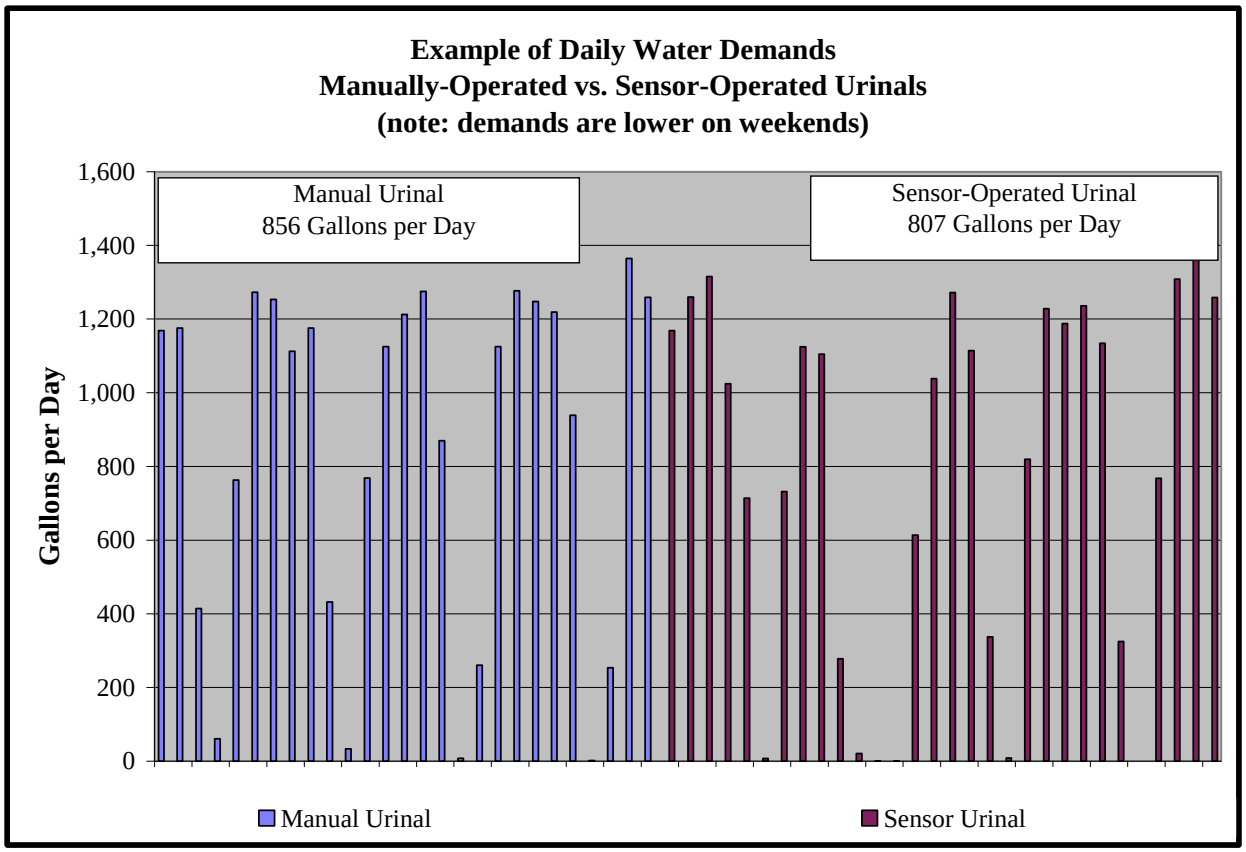



**Figure 3**

[7] Except in "stadium mode".

## 9.0 Phase 4: Installation of Sensor-operated Toilet Flush Valves

Similar to the urinals, only the flush handle was changed for the toilets to ensure that any change in water demands was related exclusively to the conversion to sensor-operating valves. The existing manual flush handles on the toilets (two in the mens' washroom and six in the womens' washrooms) were replaced with a battery-powered retrofit sensor-operated valve similar to that used on the urinals (the Zurn AquaSense® E-Z Flush).

The manually-operated toilet flush valve handles were replaced with sensor-operated devices on August 25, 2008. A water meter reading taken on September 3 (only 9 days later) indicated that demands had increased substantially. Maintenance staff checked the operation of the flush valves but concluded that they appeared to be operating properly and stated that there had been complaints from staff on the seventh floor regarding the operation of the valves.

Although the data logging portion of the monitoring was concluded on September 3, 2008 (see Figure 4 on next page), a final meter reading was recorded on January 23, 2009 - a total of 151 days after the sensor-operated flush valve handles were installed on the toilets. The average water demand during this extended period was 1,243 gallons per day vs. less than 900 gallons per day before the installation of the sensor-operated toilet flush handles.

While the conversion from manually-operated toilet flush valves to sensor-operated valves was not expected to result in a decrease in water demands (in both cases the toilets should be flushed after each use, plus the potential for phantom flushes associated with the sensor-operated valves), the extent of the increase in demands was significant.

It seems likely that the increase in demand should be attributed to the conversion of both urinals and toilets to sensor-operated fixtures valves[8]. It is clear that water demands of the two washrooms on the seventh floor of the property increased from an average of 856 gallons per day before the sensor-operated urinal and toilet flush valves were installed to 1,243 gallons per day after they were installed – an increase of 45%.

In January 2009, the site maintenance staff was asked one final time if they were aware of any performance or maintenance issues with the new sensor-operated fixtures. Similar to previous responses, they reported that all feedback had been positive.

[8] It is expected that the decrease in demands after conversion of the urinals resulted from a reduction in occupancy during the summer rather than to the installation of the sensor valves.

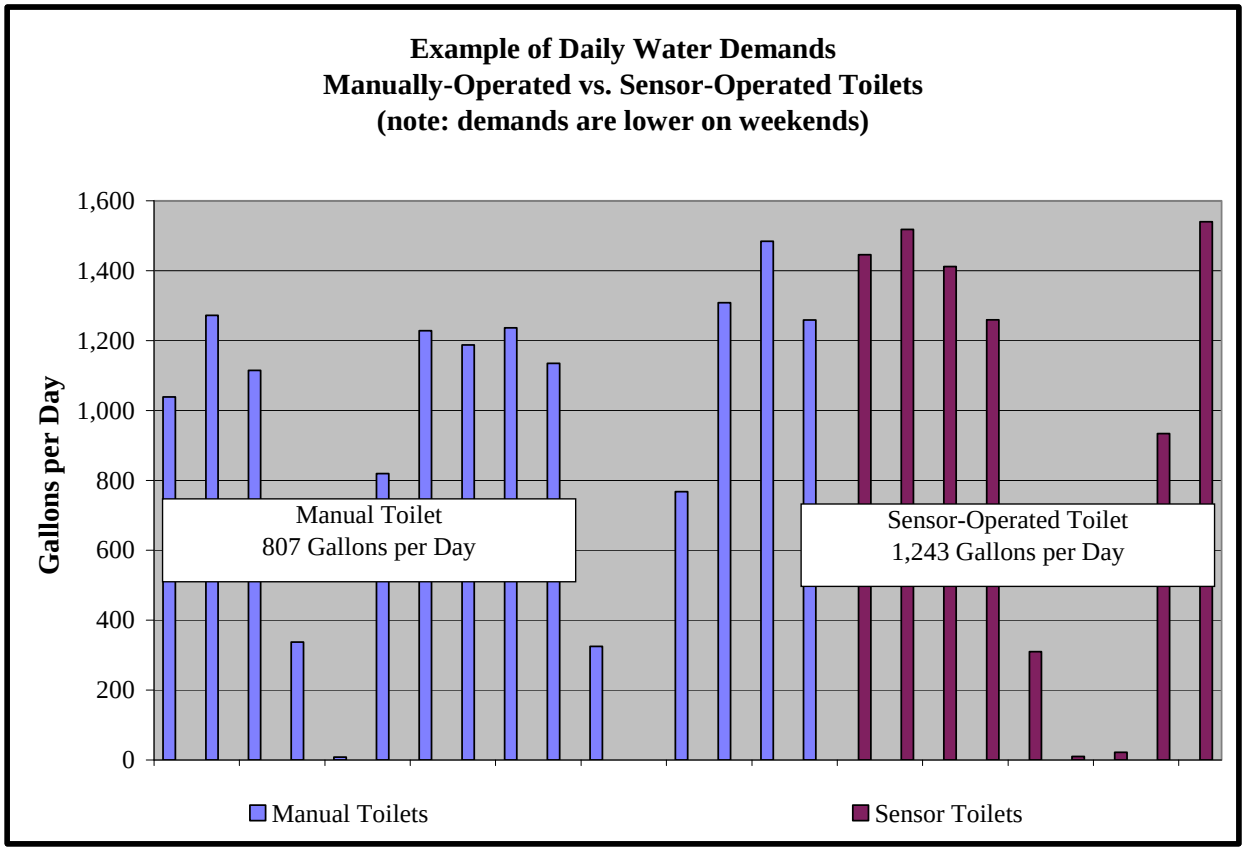



**Figure 4**

## 10.0 Summary of Demands

| Fixture | Pre-Demands gpd | Post-Demands gpd | % Difference | Gpd Difference |
|---|---|---|---|---|
| **Manual fixtures including 1.6 gpf toilets** | **654** | **-** | **-** | **-** |
| **Sensor-Operated Faucet** | **654** | **856** | **+30.1%** | **+202** |
| **Sensor-Operated Urinal** | **856** | **807** | **-5.7%** | **-49** |
| **Sensor-Operated Toilet** | **807** | **1,243** | **+54.0%** | **+436** |
| **Overall** | **654** | **1,243** | **+90.1%** | **+589** |

## 11.0 Conclusions

While the results achieved in this relatively small-scale project may not necessarily be indicative of results that might be achieved in other projects, they clearly indicate a ***significant increase*** in water demands when manually-operated plumbing fixtures on the seventh floor were converted to sensor-operated models. The total average daily demand of the mens' and ladies' washrooms almost doubled from 654 to 1,243 gallons per day when all faucets, urinals, and toilets were converted to sensor-operated units.

## 12.0 Recommendations

- While the use of sensor-operated toilet and urinal valves would not be expected to reduce water demands[9], it is not impossible that some sensor-operated faucet technology may save water - or at least not result in a significant increase in water demands. Further study of newer sensor-operated faucet technology might be warranted.
- Consumers and water supply agencies should be wary of unsubstantiated water savings claims related to the use of sensor-operated plumbing fixtures.
- All non-residential faucets – manually-operated and sensor-operated - should be equipped with faucets or aerators that flow at no more than 0.5 gpm (1.9 Lpm), consistent with the two major model plumbing codes[10] used in the U.S.

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[9] The only exception might be when sensor-operated urinal flush valves are operating in "stadium" mode.
[10] Uniform Plumbing Code and International Plumbing Code.