WATER PERFORMANCE IN NEW ZEALAND OFFICE BUILDINGS

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ABSTRACT

There is no formal information on overall water use in New Zealand commercial office buildings, or on how much water a building might be expected to use for a given purpose. Over the past three years this study has undertaken multiple investigations of daily water usage and patterns, as well as overall building water audits to help resolve this gap in New Zealand commercial building literature.

Water use indices (performance benchmarks) are established based on performance data from ninety-three commercial office buildings within Auckland and Wellington. Statistical analysis shows that there is a significant difference between the two cities; therefore individual benchmarks were required. The final results show that the median (typical) water usage for office buildings, based on net lettable floor area, is 0.76 m^3/m^2/year for Auckland and 1.03 m^3/m^2/year for Wellington. The reason for this difference between the two cities is hypothesised to be the higher Auckland water tariff giving incentives for reducing both water and wastewater.

The main areas for potential savings of water, and therefore expenditure, were found to be in the restrooms. The effect of Water Efficiency Labelling Scheme (WELS) rated appliances and/or higher efficiency flushing/outlet mechanisms showed a 'noticeable' reduction in water use, where these were implemented in buildings. The study also found that buildings harvesting rainwater did not reduce internal water demand, but rather reduced the demand on the local mains supply by using an alternate supply.

KEYWORDS

Office Buildings, Water Efficiency, Water Performance, Benchmarks, Water Use Index.

1 INTRODUCTION

In New Zealand there is a shortage of both practical and technical information available with regard to water consumption in commercial buildings. Water efficiency methods cannot be proposed without the primary determination of how purchased water is actually being consumed. There are a few international examples of water consumption studies; however these studies may not be relevant for New Zealand buildings due to climatic, technical, and/or behavioural differences.

The overall aim of this study is to investigate and to understand water consumption in existing commercial office buildings in New Zealand. Office buildings in New Zealand account for between 20% and 40% of commercial building floor area, and therefore represent a significant proportion of commercial building stock (Isaacs et al, 2010). Water is predominantly monitored, and charged for, in commercial office buildings by the metered volume used, and this therefore enables an avenue for the understanding of water use in these buildings.

This paper presents the final dataset, and analysis of this data, to form New Zealand's baseline of water performance in commercial office buildings. This will be done by determining appropriate normalisation drivers, statistically analysing any variance in the datasets, and making comparisons with both observational results, and international standards, benchmarks, and rating tools. From here, and in the hope of promoting and enhancing water efficiency and conservation awareness, a water efficiency rating tool has been developed and is soon to be implemented in a trial mode.

The statistical and pragmatic approach to this research has demonstrated the feasibility of the methodologies, and replicability for further building types. Both the water and building industries, as well as sustainability advisors, can now put a baseline figure on water performance in office buildings, and then attempt to design and/or implement efficiency measures to meet this target.

2 FIELD DATA COLLECTION

The research reported is based on investigations of ninety-three office buildings within Auckland and Wellington centres. Buildings were selected on the criteria of the majority (>80%) of the Net Lettable floor Area (NLA) being specified as office spaces, and their physical address being located within a pre-determined city boundary. Thus, a non-random sample was formulated.

The field data collection involved three main steps once consent was gained from the relevant building owner or manager: survey information; water billing history; and site visits. The survey information was requested in the form of a 'questionnaire' type sheet which was emailed to the building manager or owner at the same time as the initial consent request. By doing this, the process was transparent to the participants. The information sheet highlighted possible key drivers for water use, building characteristics, as well as building operation and occupancy details.

For consent, the building manager or owner completed a written consent form authorising access to their water billing history (up to five years worth of revenue readings) through their local billing utility. In Wellington the water meters are read bi-monthly, and in Auckland they are read monthly. Other regions' meter reading frequency differs from monthly to annually, and tariff structures can also vary.

The site visits were the final step. This consisted of accessing all areas of the buildings which contained water using appliances (restrooms; kitchens; showers; heating, ventilating, air-conditioning (HVAC) plant; boiler; irrigation area & controls), the water meter, and water storage. This was to take note of number, type, and condition of each appliance, and to try to fully understand what is happening in the buildings.

Table 1: Range of Information from Field Data Collection.

Key Driver	Lowest	Median	Maximum
Year Built	1917	1982	2009
Full Time Equivalent Occupants	13	210	2,820
Hours of Operation	0	42	65
Number of Storeys	3	14	42
Annual Water Consumption (m^3)	520	6,952	32,671
Net Lettable Area (m^2)	1,636	8,951	39,490
Footprint Area (m^2)	145	762	3,213
Number of Domestic Amenities	51	193	699

The collected data were then entered into a spreadsheet, together with historic billing data, ready for analysis. Table 1 above highlights the range found in the buildings in the study sample.

3 UNDERSTANDING CONSUMPTION

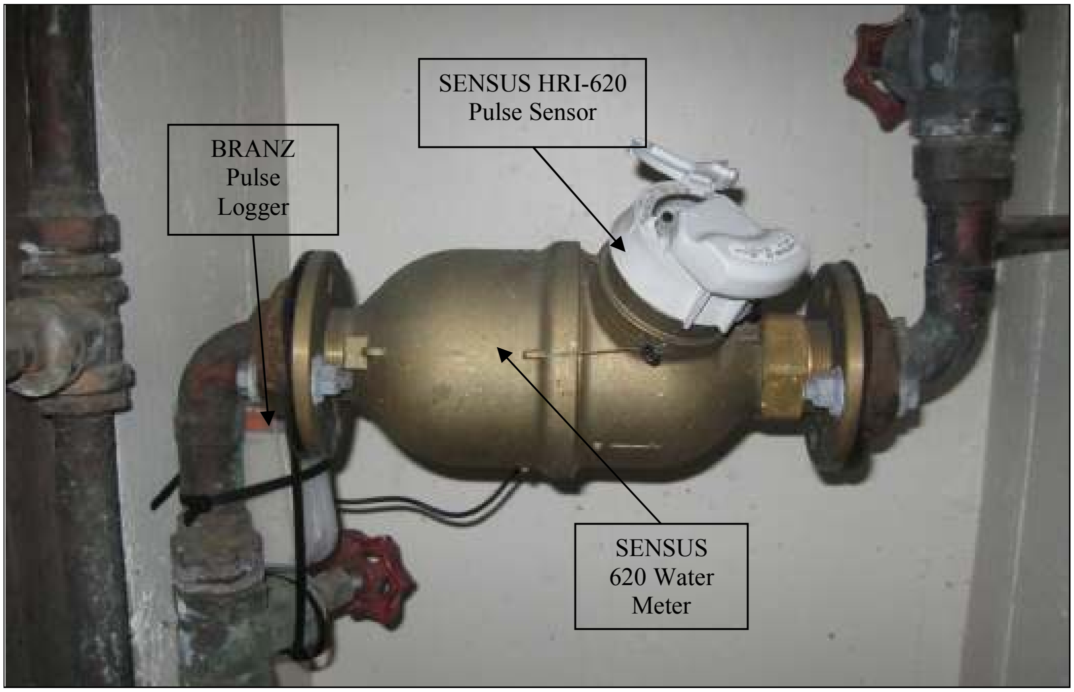
In order to accurately rate the efficient use of a resource, the current 'real-time' use of that resource must firstly be understood (Chetty et al, 2006). In addition to the field data collection above, monitoring equipment has been installed on a smaller sub-sample of buildings to allow time-of-use patterns to be understood, and potentially enabling an end-use breakdown to be determined.

3.1 TIME-OF-USE DATA

Four buildings in Wellington were fitted with monitoring devices, including compatible pulse sensors and BRANZ USB data loggers. Pulse sensors and data loggers were provided by the Building Energy End-Use Study (BEES), at BRANZ.

In a large number of the studied buildings, the location of the main water meter was unknown. Once found, the existing water meter was matched with the appropriate compatible pulse sensor, which restricted the buildings to a select few, based on the pulse sensor's availability – thus non-random selection.

Figure 1: Typical Pulse Sensor & Data Logger Installation.



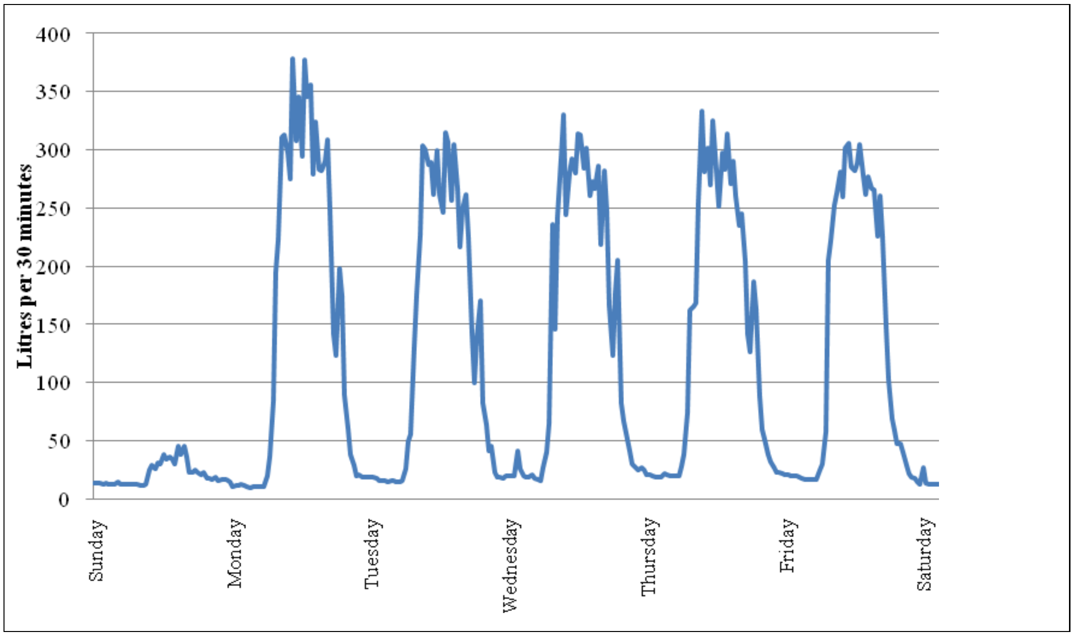
Each installation, for example as shown in Figure 1, involved fitting the sensor to the face of the water meter ensuring connectivity, and connecting the data logger, and securing to minimise accidental hazard or annoyance.

3.1.1 DAILY & WEEKLY PROFILES

Once the monitoring equipment was installed, it was set to record consumption at ten second intervals for the first five weeks, and then was switched to record at ten minute intervals for the remainder of the monitoring period. Data from the initial ten second recording intervals were used as a trial for end-use disaggregation (Section 3.2.2), and as the ten-minute recording intervals still provided enough detail for daily, weekly, and seasonal analysis, the data were more manageable.

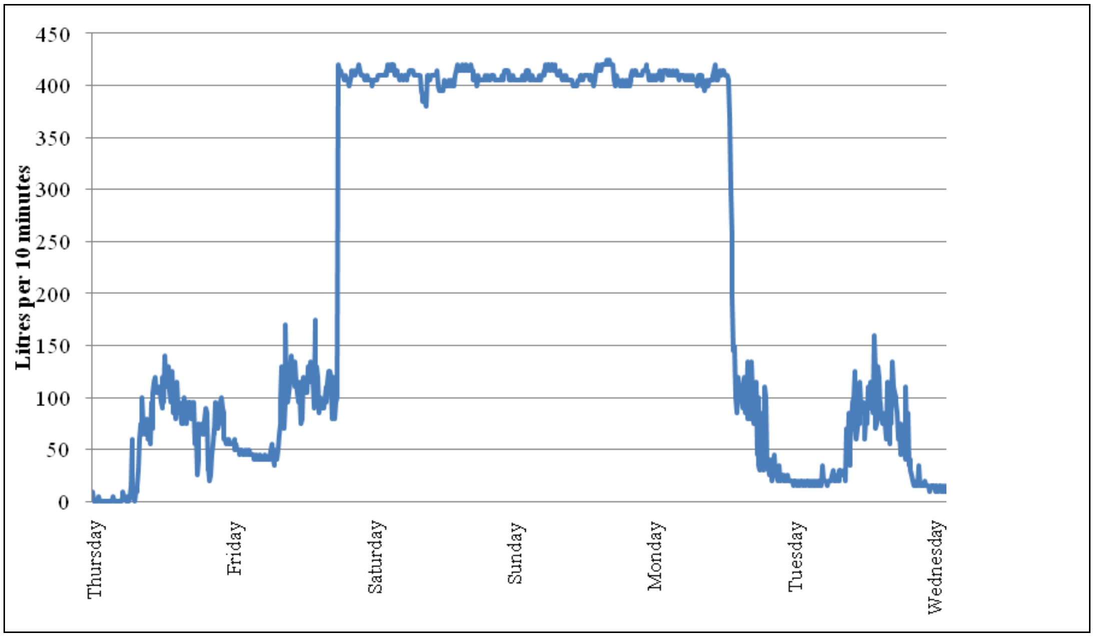
Below is an average week in one of the studied buildings, recorded from the time-of-use data, from Sunday through to Saturday.

Figure 2: Average Weekly Time-of-use Water Profile for a Monitored Building.



It is interesting to note the obvious week-day, week-night, and weekend profiles, also the fact that the night-time and weekend usage very rarely reduce completely to zero. This is hypothesised to be due to automated urinal flushing, and unidentified leakages or miscellaneous use within the buildings. The spike at the end of each working day is assumed to be from cleaning contractors.

Figure 3: Leak Identified in a Monitored Building (weekly time-of-use profile).



It should be detailed that this monitoring system allows for quick leak detection. For example, in another building a valve malfunction caused the tanks to empty, and to be refilled constantly for a period of three days, as seen in Figure 3. Please note the difference in scale from the average weekday profiles in Figure 2.

3.1.2 SEASONAL ANALYSIS

At the beginning of this study it was found that due to the frequency of water meter revenue readings, a seasonal analysis could not take place due to the inability to identify any seasonal related changes. This is illustrated in Figure 4 and Figure 5. Therefore, the time-of-use monitoring not only enables time-of-use analysis, but also allows the seasonal profile to be compared against regional demand for the same period.

Figure 4: Average Weekly Consumption in Buildings Monitored (column) & Auckland CBD 5-year average Weekly Demand (line).

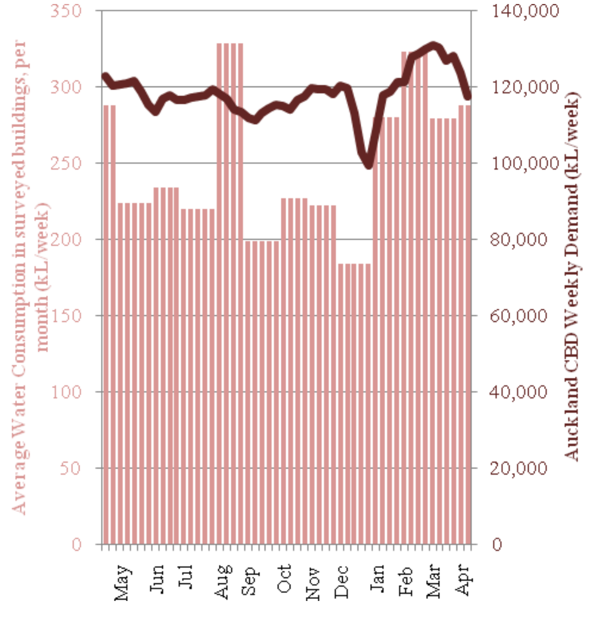
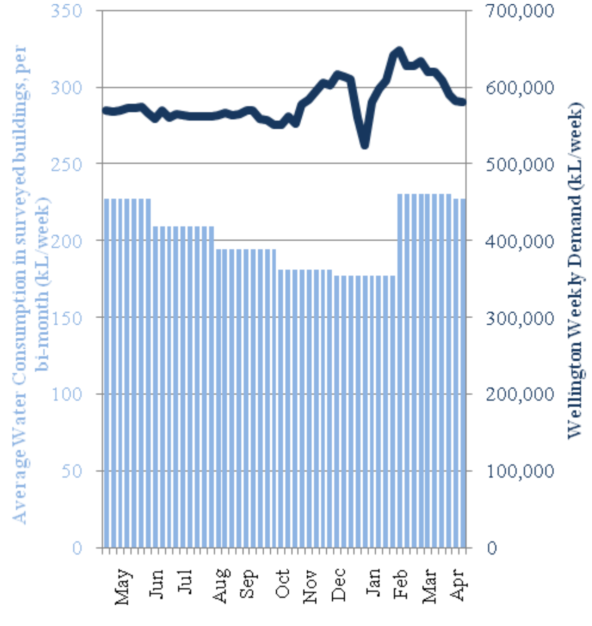


Figure 5: Average Weekly Consumption in Buildings Monitored (column) & Wellington Region 5-year average Weekly Demand (line).



Please note the two Figures above have different vertical scales, due to the coverage of different land areas and numbers of buildings.

The summer months (January through March) display a trend of higher water consumption. It is hypothesised that this is due to the warmer summer climate, influencing possibly higher cooling loads or increased irrigation needs. However, for the buildings of interest, during the Christmas (summer) holiday period when the building is likely to be shut or with reduced staff numbers for up to three weeks, there is only a minimal correlating dip in water use. This is in contrast to the dip in the CBD or region demand lines. The reasons for this have yet to be explored, but on first view would appear to suggest that the office buildings' water demand is driven not by the presence or absence of occupants, but rather by the water using features of the building itself.

3.2 WATER END-USES

The end-uses of water for a commercial office building are typically found in restrooms, kitchenettes, HVAC plant, irrigation, and other uses (retail/food). In this study, the effect Water Efficiency Labelling Scheme (WELS) appliances rated to AS/NZS 6400: 2005 have on the overall building usage has been explored, as well as an example of end-use disaggregation in Australia to give context.

3.2.1 WATER EFFICIENCY LABELLING SCHEME (WELS)

The uptake of WELS rated appliances for commercial buildings does not appear large at this stage. However, discussions with building managers suggest that common areas (i.e. core stairwells containing restrooms, showers, cleaners facilities, and the like) are upgraded only every 15 or so years, which is longer that the current standard has been in place. As kitchens are typically located within tenancies as opposed to common areas, they are upgraded with each new tenant upgrade. Approximately 11% of the studied buildings employed some (or all) WELS rated appliances.

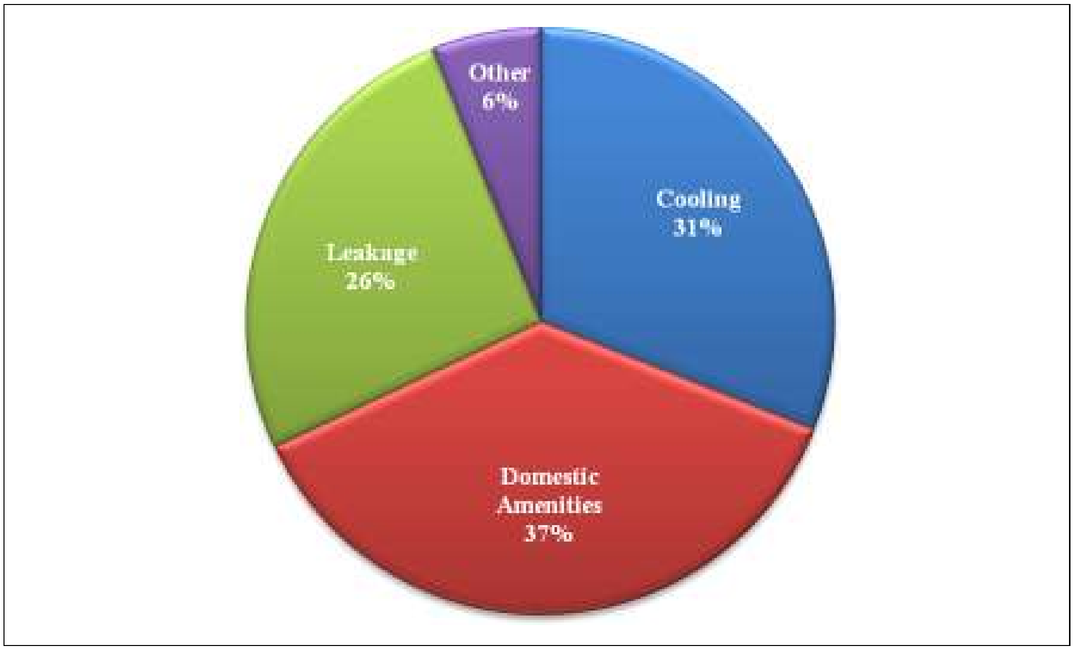
Consideration must be given when installing lower consumption appliances, especially in older buildings, to the drainage as-built specifications. The current drainage systems in place may not be able to carry away wastage in low-flow systems, as they have been designed for previous norms of flow rate capacity, i.e. pipe materials, pipe size, and fall gradients.

However, the buildings which did employ WELS or water efficient appliances claimed to have noticed a visible reduction in their water bills; while the buildings themselves all had a slightly better than average water use index (WUI) overall.

3.2.2 END-USE DISAGGREGATION

Due to the expense and time commitment of installing additional meters into the water lines, it was not possible to obtain an accurate end-use breakdown for each of the buildings in this study. It was also found that the water reticulation methods within each building can differ dramatically, and as-built drawings are not always accessible and/or available. This can make it difficult to place additional meters. The use of water storage tanks, which appear in most multi-storey buildings, essentially buffered the time-of-use data being provided from the main water meter, further limiting the possibility of an end-use breakdown.

Figure 6: New South Wales Example of how Purchased Water is Consumed (Source: Quinn et al, 2006).



The use of American end-use profile software by Aquacraft, Tracewizard (Aquacraft, 2011), was trialled on the first output of time-of-use data to determine if it could be used for commercial buildings. However, as the sensitivity of the software was designed for residential/small commercial use, this trial was unsuccessful. Therefore, only approximations can be made and comparisons made against the NSW example outlined above in Figure 6.

4 BENCHMARK DEVELOPMENT

Benchmarks are indicators of actual water performance, and in the context of this research they represent the performance of water consumption in commercial office buildings. The primary purpose of a benchmarking measure is to 'normalise' water use with respect to the size and type of the building, which makes possible a method of comparison relative to other buildings with a similar occupied use.

There are two main types of benchmarks commonly used: those used as 'a point of reference' also known as consumption benchmarks; and those that 'designate efficient levels of use' (Dziegielewski et al, 2000) also known as efficiency benchmarks. Both are significant, in that one indicates the standard level of consumption with regard to that region, and the latter leads to an understanding of the levels of water use efficiency within each building. At the present time, no formal water benchmarking system exists in New Zealand. This makes it impossible to compare buildings or regions, other than in terms of total annual consumption per category or per capita (Bint et al, 2010).

4.1 STATISTICAL & DRIVER ANALYSIS

For Wellington, the water consumption and billing data provided by the local billing utility gave bi-monthly meter readings for the previous five years to date, thus giving a base of approximately 31 data points per building, with an overall Wellington dataset of 1767 points. Similarly for Auckland, the local billing utility gave monthly meter readings for as far back as account creation. This gave a base of approximately 67 data points per building, or 2570 points for the overall Auckland dataset.

This information was tested to find the highest correlated key driver, using a multi-variate regression method, and then using variance testing to determine the significance of any differences.

4.1.1 DRIVER (NORMALISATION) SELECTION

The normalisation process is intended to allow an unbiased comparison between two buildings, or one building and the benchmark/target. The normalised consumption model is a measure of water performance against a driver, such as Net Lettable Area (NLA) or Full Time Equivalent Occupants (FTEO), number of amenities, and so on.

This data underwent statistical analysis to determine the most appropriate driver to be used. The coefficient of determination represents the percentage of variance in water consumption which can be explained by the variance in the key driver.

Table 2: Relationship between Water Consumption and Key Drivers

Key Driver	**Coefficient of Determination (r^2 or %)**
Age of Building	2%
Hours of Operation	9%
FTEO	44%
Number of Domestic Appliances	49%
Number of Storeys	53%
NLA	68%

NLA proved to be the most statistically and pragmatically appropriate driver to be used; 68% of the variation in water consumption can be explained by the variance in NLA. The benchmarks and individual Water Use Indices (WUI's) will be given as cubic metres of water per square metre of NLA, per year (m^3/m^2/year).

4.1.2 ANALYSIS OF VARIANCE

Another statistical technique called ANalysis Of VAriance (ANOVA), involved determining whether the overall sample should be separated for any reason, for example by location, presence (or absence) of cooling, or size.

The two datasets were tested for any statistically significant differences which could mean that two (or more) resultant benchmarks would stand independent of one another.

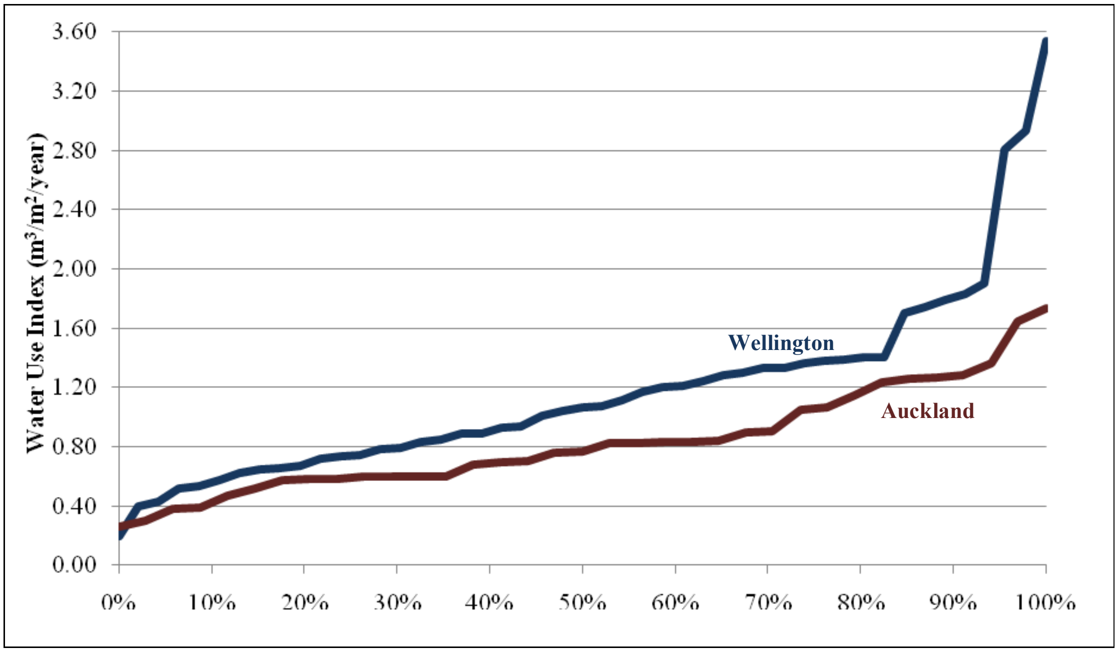
Table 3 outlines any differences and the significance (*p*-value) of those differences, where a *p*-value of < 0.05 demonstrates that a significant difference is occurring and benchmark separation should be established.

Table 3: Benchmark (Difference) Separation Significance

Variable	**Median Benchmark**		***p*-value (Significance)**
Size	<13,000m^2 0.89 m^3/m^2/year	>13,000m^2 0.83 m^3/m^2/year	0.07
Water Cooled HVAC	Water Cooled 1.05 m^3/m^2/year	Non-Water Cooled 0.82 m^3/m^2/year	0.79
Location	Auckland 0.76 m^3/m^2/year	Wellington 1.03 m^3/m^2/year	0.00

The study looked at size separation, with the strongest separation being found by splitting the cumulative floor area in half, but the significance does not warrant benchmark separation. The difference between buildings with and without water cooled HVAC (i.e. cooling towers) showed no statistical significance. Location (between Auckland and Wellington) demonstrated a statistically significant reason for benchmark separation, at the 95% confidence level. Figure 7 below shows the cumulative distribution of the two locations as separate datasets.

Figure 7: Cumulative Distribution of Buildings by Normalised Use (Auckland vs. Wellington).



Wellington office buildings also appear to have a number of high water users. There is no obvious reason why the top 5% of buildings in the Wellington sample should have such high normalised water use so further investigation is needed.

4.2 OBSERVATIONAL DIFFERENCE

As well as purely statistical measures, further investigation was conducted on more observational characteristics, including climatic, technical, and behavioural observations. Domestic amenities were also considered for their contribution towards the differences between regions, however they appeared about the same in terms of efficiency levels, flushing mechanisms, and general condition in both regions overall.

4.2.1 CLIMATIC

The National Institute of Atmosphere and Water Research (NIWA) climate database suggests that during the calendar year of 2010, the outside mean air temperature for Auckland was approximately 2.1°C warmer than

Wellington's for the same period. This similar, but minimal, difference can also be seen in Relative Humidity and Absolute Humidity, as outlined in Table 4.

Table 4: Climatic Differences between Auckland and Wellington

AVERAGE	**Auckland**	**Wellington**	**Difference**
Temperature	16.0 °C	13.9 °C	2.1 °C
Relative Humidity	85 %	80 %	5 %
Absolute Humidity	15.0 hPa	12.5 hPa	2.5 hPa

Climate normalisation adjustments generally assume that warmer climates use more water, based on the increased need for irrigation and/or heat rejection, as well as evaporative losses from exposed swimming pools and the like. However, in this case the reverse is happening, whereby the warmer climate (Auckland) has a lower benchmark for their office buildings. The lack of the expected outcome may also be influenced by the difference relative and absolute humidities between the two regions.

4.2.2 ECONOMIC TARIFFS

In terms of the service charges for providing water to a premises, those in Auckland pay a variable charge of NZD\$1.300/m^3 and in Wellington pay NZD\$1.715/m^3 for ingoing potable water (as at August 2011). For wastewater Auckland premises pay a variable charge of NZD\$4.056/m^3 for 75% of ingoing potable water, unless a greater loss can otherwise be proven before the water enters the sewerage system (e.g. from evaporative cooling). In Wellington the cost of wastewater is included in the annual land tax (rates).

Table 5 is an example of the tariff structure differences between Auckland and Wellington, based on a hypothetical building of NZD\$59,000,000 capital value using 28,000m^3/year of water.

Table 5: Tariff Differences in Auckland & Wellington, based on Hypothetical Building of NZD\$59,000,000 Capital Value and using 28,000m^3/year.

Auckland			***Charge:***	**Wellington**		
Visible on Invoice	**Total Charged**	**Tariff**		**Tariff**	**Total Charged**	**Visible on Invoice**
\$43	\$43	\$43	*Annual Service Fee*	\$100	\$100	\$100
\$36,400	\$36,400	\$1.300/m^3	*Ingoing Potable Water*	\$1.715/m^3	\$48,020	\$48,020
\$85,176	\$85,176	\$4.056/m^3 Based on 75% of Ingoing Potable Water	*Outgoing Wastewater*	0.00130171% Of Capital Value	\$76,801	\$ -
\$121,619	\$121,619		*TOTAL*		\$124,921	\$48,120

Visible tariff incentives, that is charges which appear on the water invoice, are thought to contribute to the overall lower normalized water use in Auckland. In terms of the visible water bill, Auckland building users pay 60% more than Wellington (\$121,619 vs. \$48,120). However, the actual cost of water to a comparable Wellington building where wastewater charges are a fixed annual charge hidden within council rates, is approximately 3% more than the Auckland cost.

4.2.3 BEHAVIOURAL

In Auckland efforts are put into proving that the outgoing wastewater is less than the ingoing potable water, and hence reducing the wastewater cost. This is normally achieved by installing sub-meters on cooling towers, and for industrial product manufacturing, etc, and monitoring these water-using systems for accuracy and leaks.

After this investigation, it is suggested that the tariff structures for Auckland is more visually incentivising than that of Wellington, and this has influenced a higher awareness and focus on water use and water efficiency within the building/facilities management sector.

4.3 RESULTANT BENCHMARKS

From the statistical and observational results above, the benchmarks can now be finalised. To enable comparability with other international reports, the resultant benchmarks will be given as 'Excessive Use' (75% of sample), 'Typical' (50%), and 'Best Case' (25%) ratings. However, as Bannister et al (2005) identify, there are a number of rules that must be applied when designing benchmarks for a population. These are:

1- 80% of the sample population should be encompassed;

2- The median value should represent the typical value (not the mean);

3- The best score should 'represent a level of efficiency essentially beyond normal technological solutions, but attainable through innovation'; and

4- The rated bands of efficiency should be equal step and linear.

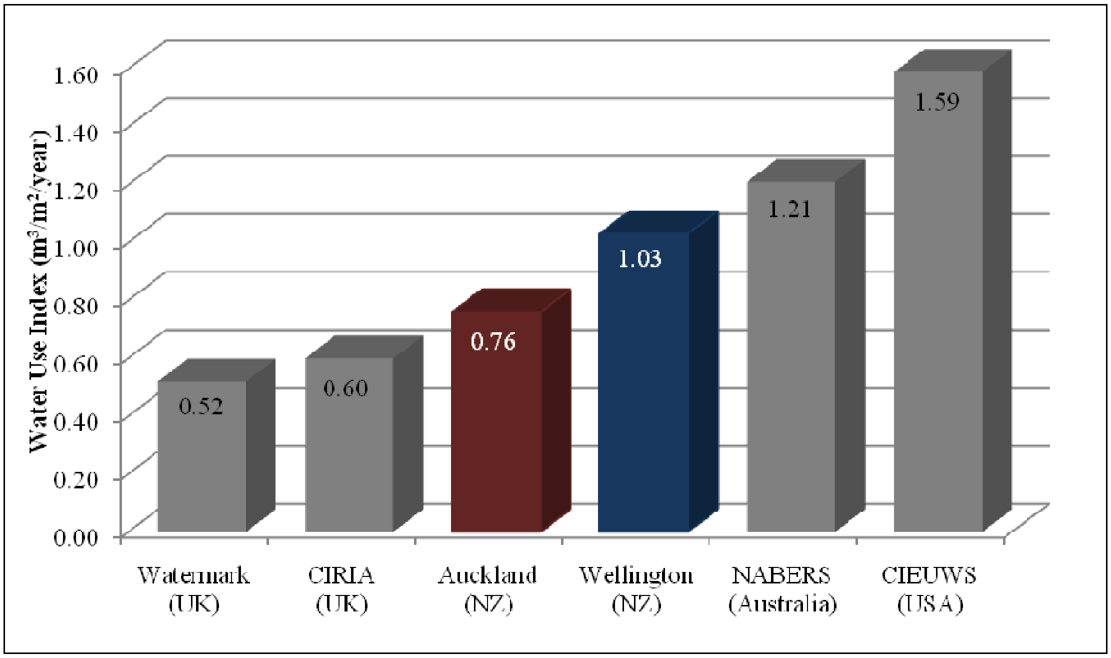
Where any discrepancies occur between the rules, Rule 2 and Rule 4 take precedence over Rule 1 and Rule 3 (Bannister et al, 2005). These rules have been used to form the efficiency benchmarks given in Table 6.

Table 6: Resultant Benchmarks for New Zealand

Auckland	**Benchmark (m^3/m^2/year)**	**Wellington**
0.57	Best Case	0.73
0.76	Typical	1.03
0.97	Excessive Use	1.33

The resultant benchmarks were then compared with similar benchmarks, literature, and rating tools from the United Kingdom (CIRIA (Waggett et al, 2000), Watermark (Kitchen et al, 2000)), Australia (NABERS (Bannister et al, 2005)), and America (CIEUWS (Dziegielewski et al, 2000)).

Figure 8: International Comparison of Typical (Median) Benchmarks.



When compared internationally, these benchmarks put both Auckland and Wellington somewhere between the United Kingdom (CIRIA median is 0.60 m^3/m2/year) and Australia (NABERS median is 1.21 m^3/m^2/year) study results.

4.3.1 RAINWATER HARVESTING

The two 'green' buildings included in this study demonstrated typical WUI's when considering the combination of rainwater harvested on-site and the mains supplied water. However, it was also found that, on average, approximately a quarter of the water demand was supplied by the harvested rainwater.

The harvested rainwater is predominantly used for toilet flushing and irrigation. It should be highlighted that, for an Auckland building, as ingoing potable water demand is reduced, so is the cost. However, outgoing wastewater stays the same (due to the combination of rainwater and ingoing potable water), but the cost is reduced because, as outlined in Table 5, the Auckland wastewater tariff is based on 75% of ingoing potable water and does not account for buildings harvesting their own rainwater.

The end-uses (i.e. appliances and fittings) of these green initiative buildings appeared to be of a higher standard than the majority of the sample, however, they did not employ water cooled HVAC, and were all reasonably new in age. The end result was that the WUI's for these buildings were all at a 'typical' benchmark level when counting the water use as the combination of mains supplied water and harvested rainwater.

5 IMPLEMENTATION & COMMUNICATION OF RESULTS

In order to validate the necessity of these results, the research was taken, trialled, and judged against a set of criteria both by industry target-users and by further examination. The criteria initially set included accuracy, usability, effective communication, and functionality.

5.1 EFFECTIVE COMMUNICATION

One of the most important parts of implementing research work is being able to communicate effectively the results to the target users (Onwuegbuzie et al, 2008). As cited by Onwuegbuzie et al (2008) "the way we think about what and how and why we are generating data must be addressed in a large way so that countless decisions can be made to move the ball forward in terms of real lives...". If the data cannot be communicated, then the uptake, awareness, and individual implementation of the benchmarked results may be of no value (Bint et al, 2011).

Therefore, effective communication was set as a high level criterion to be achieved, as to increase the potential market uptake. This was achieved by reporting results in a common language through the development of a water efficiency rating calculator/tool.

5.2 WATER EFFICIENCY RATING TOOL

In order for building managers, owners, water providers and local authorities to understand what all of this (benchmarking results) means, it must be communicated in a 'common' language. To achieve this, a water efficiency rating tool (WERT) has been developed, and will be in pilot trial mode near the end of 2011. It aims to allow the sometimes complex algorithms to be interpreted by anyone using the tool, in a simple informative and strategic manner.

There are three parts of the proposed WERT: a simple, easy to use level; a detailed level; and an implementation financial decision aid level.

The simple level WERT was developed using the performance based data outlined above. It calculates a building's water performance and provides a WUI against the benchmark values for its physical location/region. The simple level WERT compares the building results to the study, rating it excessive use, typical, or best case.

Under the detailed level, the end-use disaggregation can be approximated based on research outlining the water usage rates for specific appliances (Stewart, 1995; Vickers, 2001) and the actual installed fixtures and fittings. This is then compared to the results from international research (Quinn et al, 2006).

The detailed level enables priority areas to be identified, e.g. toilets that may be using a high proportion of the indoor water use, etc., and this enables the user to focus on reducing these priority areas as their first step of action.

The financial cost-benefit advisor provides information on how best these priority areas, and other less important areas, can have their water consumption reduced.

Owning and running a building is business. Therefore, to enable end-users to better understand the benefits of the building becoming more water efficient, the results have been provided in terms of financial viability. The results offered can be selected from Net Present Value (NPV), Internal Rate of Return (IRR), or Payback Period (PP).

By converting the savings opportunities into a financial term means that it is now in a common language, which can be used to communicate the results to a broader audience, and provides a financial decision aid. Depending on the business' budget and priority areas, an efficiency package is suggested which can be changed to the most suitable for that building, while reflecting suitable budgetary inputs in the preferred financial term. However, it must be reinforced that additional consultation is needed to identify specific drainage complexities that occur in each building.

The WERT can also generate a printed report for use elsewhere in the business, e.g. for discussions with plumbers or finance controllers.

The portfolio of properties for businesses with more than one building can also be stored within the tool for later comparison and adjustment.

5.3 MARKET VALIDATION WORKSHOPS

To gauge the effectiveness of the study results and the tool from an industry perspective, two workshops were conducted (one each in Auckland and Wellington), prior to the release of the WERT. Personnel from five industry categories (local authority, water service provider, building management, research institution, and consultants/advisors) were invited.

The core of the workshop involved firstly providing feedback on the study to date, then getting the participants to really identify the challenges and struggles that they are facing with regard to water use and/or water efficiency, providing a discussion around how best can we find a solution, and what is needed for the most effective solution. The remainder of the workshop was the demonstration of the WERT, gaining feedback on its features, advantages and benefits, while also highlighting ambiguous or disliked areas.

The most common point that arose in both workshops was the lack of end-user education, i.e. building tenants, and lack of incentive in Wellington to reduce consumption. However, the 24 participants in attendance over the two workshops covered a broad range of responses. The workshops incorporated individual feedback via questionnaires, and will be followed up with individual contact as appropriate. It was also found that the range of industry personnel, who would not normally be brought together in such a workshop, also benefitted from the table discussions that occurred outlining industry challenges in specific areas.

6 CONCLUSIONS

From this study, it has been established that the data collected from some ninety-three commercial office buildings in Auckland and Wellington has provided the grounds for the establishment of water use benchmarks.

It is concluded that NLA is the most statistically and pragmatically appropriated normalisation factor to be used for water performance benchmarking in New Zealand based on this study. The baseline (median or typical) WUI for the two regions studied were $0.76m^3/m^2$/year for Auckland and $1.03m^3/m^2$/year for Wellington – placing New Zealand neatly between Australia and the United Kingdom in terms of normalised water use.

The reasoning for the regional separation may not always be due to climatically influenced differences, as in the case of this study, water tariff levels appear to play a significant role beyond the scope of climate adjusted formulae. It was found that Auckland visibly pay more than Wellington, by 60% due to their tariff structure. However, the actual cost of water is 3% more in Wellington than in Auckland, based on an example calculation.

Effective communication has been identified as a key implementation criterion. This has been carried through into a WERT, which has been developed based on the performance data acquired under this study. From the workshops, it was identified that allowing the user to determine high priority areas in their buildings, and being able to see the cost-benefit of possible improvements using a common financial term, was a successful decision aid process for businesses.

End-user (i.e. building tenants) awareness and education was highlighted during the workshops as something that is lacking in the industry. As water efficiency becomes more established within the building industry, and as tariff structures and cost recovery strategies change this is something that is hoped to improve in the near future.

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