1 Introduction

We all need clean water to survive, yet is increasingly becoming scarce on the planet. While architects and engineers have gotten much better at how to reach Net Zero Energy (NZE) with buildings, Net Zero Water (NZW) remains more of a mystery. The critical issue with "water neutral" as it stands is the term, and related terms, are ambiguous. Different private firms, towns, or water utilities define it differently; as a result, the phrase is in danger of losing any meaning it might have, and becoming little more than a way to market products. This report intends to define the "Net Zero Water" term for our semester project and explains in depth the tasks completed and in progress, for 30% concept design submission, to achieve NZW system for Mehran University of Engineering and Technology.

The first section of the report discusses the design criteria and detailed calculation to estimate the water budget and amount of water reuse for the Jatoi hostel building, MUET Jamshoro. All the input data to calculate water budget was readily available through our contacts. Few assumptions were imperative to take for the calculations, and those are (a) rainfall data of Hyderabad was used as there is no gage station in Jamshoro city, (b) fixture rates are not taken from the regional authority, it is based upon Capital Development Authority, Islamabad. This task is completed. For the part related to water reuse, for this submission, it has yet not been completed. The main hurdles for this task are to find regulations in Pakistan for rainwater harvesting and gray/black water reuse.

The second section of the report explains the sustainability rating system for this project. We are implementing "Living Building Challenge, Water Petal." The intent of the Water Petal is to realign how people use water and to redefine "waste" in the built environment so that water is respected as a precious resource. The water petal encompasses the Net Positive Water Imperative which defines that site water utilization and discharge must work in amicability with site hydrology and its environment. 100% of the site's water needs should be provided by caught precipitation or closed loop system with treatment process as needed to maintain water quality that will be used for indoor or outdoor activities. The calculations for net zero water has been completed for the conceptual design stage and it will be modified till the detailed design phase.

The third section of the report discusses the cost analysis (BOQs) for plumbing work, water treatment plant and rainwater harvesting. This is the initial estimate, and it will get refined in the next submission. Life-cycle cost is not calculated yet, which will be provided in the late submission.

2 Site Description

This report sets out the basis for conceptual design and schematic for water and wastewater infrastructure of Jatoi Hostel in Mehran University of Engineering and Technology (MUET), Jamshoro. The project is located about 18 kilometers from Hyderabad. The hostel building has approximately 20,000 sq.ft of covered area and 25,000 sq.ft of landscape area in its territory. Climatic conditions are arid; days are hot and dry while nights are cooler. The majority portion of precipitation happens in monsoon season (June to August) with an average rainfall of 3.36”. However, in recent years, there have been several rainfall events that have exceeded the average rainfall in the region. The historical precipitation data for the study region have been provided in Appendix. The only source of freshwater for the study area is from Karachi Canal that is roughly 3km away, and ground water is not favorable for indoor and outdoor usage. The existing stormwater infrastructure is conventional, consisting of the downspout at the roof, which collects rainwater and discharges it into existing municipal drainage system.

2.1 Site Maps

Known location of primary water source overlaid on the aerial photo concerning site area is shown below. The map also provides an overview of open space availability that can be used for gray/black water reuse for irrigation purposes.

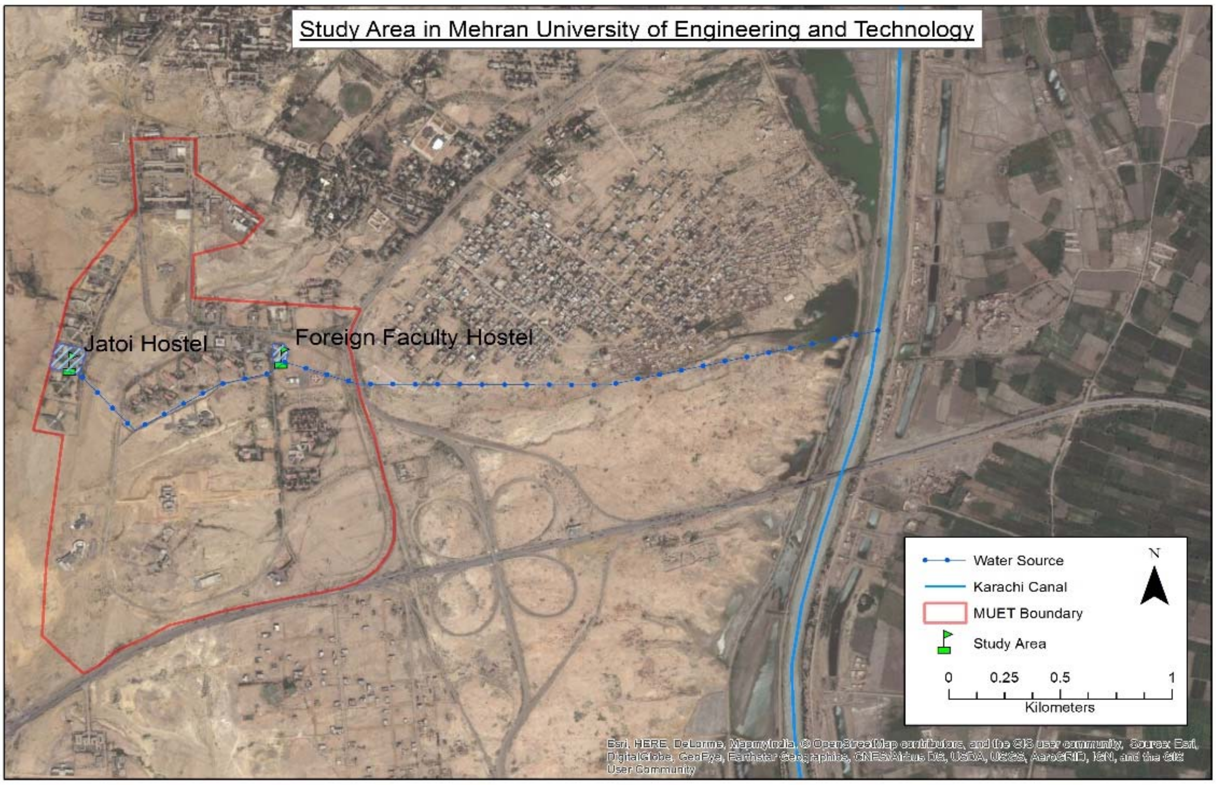


Figure 1. Study area location map

3 Data Requirements

The initial data requirements for this project was to get the total numbers of a resident at the hostel building. This information was gathered with the help of a formal resident and current exchange student from MUET at U of U, named Azizullah Ghafar. He was the primary source for reconfirming the total number of students from hostel administration. The next step was to get the type of fixtures and their flow rates for accurate estimation of the water budget. This information was collected from Capital Development Authority (CDA), Islamabad and local builders. Lastly, the rainfall data was collected from Pakistan Metrological Department by the help of a Dr. Rasul Bux Mehr (Faculty Member at MUET). Due to unavailability of rain gauge station at the project site, nearby city's (Hyderabad) precipitation data was used for all the calculation purposes.

3.1 Applicable Authorities & Approvals

The requirements of the relevant local authority shall be adhered to where no applicable standards or guidelines are provided then local standards, international standards, and best practice shall be adopted.

Should conflicts arise during the design out of discrepancies between codes, standards and other documents, the more stringent requirement shall apply. Local authority requirements will usually prevail to ensure compliance and ease of obtaining approvals. Where differing or conflicting standards are used, a unified approach shall be adopted to avoid errors or discrepancies arising from differences in approach, methodology or criteria.

3.2 Services Layout Drawings

The proposed water and wastewater network layout in hostel building has been provided for ground floor which is assumed to be replicated in rest of the building. For conceptual design stage, a typical layout is provided will be modified as the project moves to the detailed design stage. The drawings are attached in Appendix.

3.3 Regulations and Codes

Due to unavailability of local codes and regulations related to our project, mostly international standards and regulation will be applied to carry out all the work. For plumbing work, "International Plumbing Code" (IPC) will be followed. A copy of IPC is attached as Appendix. For rainwater harvesting, "Ontario Guidelines for Residential Rainwater Harvesting Systems" will be used as regulatory guidelines. The copy of this code is also attached in Appendix. Finally, for gray water reuse, "Guidelines for the Reuse of Gray Water" by Prepared by Hawaii State Department of Health Wastewater Branch.

4 Model/Calculations

4.1 Water Budget

Water budget calculations are done by using two different tools. First is excel based and the second is python coded (Jupiter interface based) tool. Both tools are required to input a total number of resident, rooftop and landscape area. These tools estimate total indoor and outdoor water demand for the project site. The guidance document by which water budget was determined is attached in Appendix.

5 Evaluation Measure

5.1 Living Building Challenge

The Living Building Challenge is an endeavor to significantly increase present expectations from a worldview of doing less harm to one in which we see our part as steward and co-maker of a genuine Living Future. The Challenge characterizes the most exceptional measure of manageability in the assembled condition conceivable today and acts to quickly reduce the crevice between current breaking points and the end-amusement positive arrangements. Living Building Challenge gives a structure to plan, development and the advantageous relationship amongst individuals and all parts of the group.

5.1.1 Water Petal

The expectation of the Water Petal is to realign how individuals utilize water and to reclassify "squander" in the fabricated condition with the goal that water is regarded as a valuable asset. Shortage of consumable water is rapidly turning into a significant issue the same number of nations around the globe confronted extreme deficiencies and traded off water quality. Indeed, even locales that have kept away from the dominant part of these issues to date because of a chronicled nearness of plentiful crisp water are at hazard: the effects of environmental change, profoundly unsustainable water utilize designs, and the proceeded with the drawdown of real aquifers forecast huge issues ahead.

5.1.2 Net Positive Zero

Living Buildings must demonstrate that they have achieved Net Positive Water. As a result, Living Buildings harvest, use, and treat all the water that they require without burdening aging municipal infrastructure. In other words, Living Buildings are regenerative; in that, they generate sufficient benefits to the building's site, to the project's community, and to the environment at large to offset any negative impacts that the project may incur.

5.2 Site Info

Location – Jamshoro Sindh

Living Transect – L3 Campus Zone

This transect is comprised of relatively low-density mixed-use development

Typology – Building

Occupant Type – Men's Hostel

5.3 Net Positive Water Imperative

Mehran University of Engineering and Technology is located in the arid region of Sindh. Local average annual precipitation is 3.36 inches with significant portion spread in months of July and August. In this arid environment, Net Zero Water Imperative is a challenging task to achieve. The table below gives an overview of net zero water imperative for the undertaken case study;

Water demand calculations were performed for the building based on building occupancies, scheduled uses and design fixture flow rates to determine the daily water supply for the building. The design of this building includes several water-saving plumbing devices such as composting toilets, low-flow lavatories, low-flow kitchen sinks and a low-flow shower. All landscaping is native to the region and does not require permanent irrigation.

5.3.1 Systems Used

Rainwater Harvesting: Since achieving Net Zero Water is difficult enough in an arid climate without adding losses from FFDs (known to be relatively water inefficient in practice), the team requested and achieved approval for a design that replaced FFDs with gravel filters at the bottom of each downspout. The gravel filter consists of a 1 square foot by 20 inches deep box filled with three layers of gravel separated by screens that can be accessed and cleaned if needed.

After passing through the gravel filters, harvested rainwater is conveyed via underground plumbing to a centrally located cistern beneath the main garage. The 3,000-gallon cistern was built into the foundation of the garage with its roof functioning as the floor for the garage. Harvested rainwater flows first into an entry chamber where any sedimentation can settle to the bottom.

Collected rainwater passes through two additional filters before it is delivered as water suitable for human consumption. First, microfiltration removes all remaining suspended solids and finally, an ultraviolet (UV) disinfection unit ensures the water is sanitary and free of pathogens.

Greywater and Blackwater Reuse:

In this project, we are discussing the water use for a three storied boy's hostel of Mehran University of Engineering and Technology. Some of the major use of water is a bath, dishwasher, toilet, water faucet, drinking water, laundry, etc.

We are trying to achieve net zero water consumption for the hostel. That means we are proposing a system where all the water being used inside the system will be recycled in such a way that it will be again ready for the regeneration.

There are two types of wastewater being generated from the hostel. One is the gray water that is being produced from the bath, kitchen, dishwasher, laundry, etc. and the other one is the black water being generated from the toilet after flushing. So we are proposing the separation of two types of waste water and two types of purification. The main reason behind this is cost and time reduction in the total water purification system. Primary water purification is not significantly costly, but the generation of drinking quality water through RO water purification system is particularly expensive. So we are separating the water type and separating the water purification strategy to make sure quality water and cost reduction

Two steps of purification: If we take a closer look then we can see that only the water being used in the kitchen faucet will need to receive final purification to make sure the drinking water quality. The main reason behind this is only this water will be exposed to our digestive system.

Workflow for Grey water and Blackwater collection and regeneration:

Water from kitchen faucet

Will use a separate pipe to reach the treatment plant

Will use a separate primary and secondary treatment (RO) system to get ready for the reuse in the kitchen faucet

Other gray water generation points

Will use a separate pipe to reach the treatment plant

Receive the primary treatment and get ready to be reused in the system

Water from toilet flush

Will use an entirely different pipeline to reach the onsite wastewater treatment plant

After receiving just the primary treatment water will be reused in the toilet flush and urinals.

6 Results

The table below shows the results obtained from water budget calculations which take into account rainwater harvesting and potential gray water reuse for domestic and outdoor purposes.

Table 1. Water budget calculation results per annum

Annual water use	3,046,719 gal
Harvested onsite	67,554 gal
Water cistern size	3,000 gal
Collection strategies	Rainwater for domestic use
Systems fed	Canal - interior domestic use
Graywater	2,661,838 gal
Systems fed	Irrigation of landscaped area
Blackwater	N/A
Systems fed	Composting toilets (Proposal)
Estimated total water use, per capita	3,478 gallons (actual)
Stimulated/Designed	N/A
Design tool(s) & calculation method(s)	Water estimations

7 Cost Estimate

Table 2. Initial cost estimate

DESCRIPTION	QUANTITY	TOTAL COST
SCHEDULE A - MOBILIZATION & SITE PREPARATION		
Equipment Mobilization	LS*	$3,500.00
Labor Mobilization	LS	$2,500.00
Site Marking & Safety Signs	LS	$1,000.00
TOTAL SCHEDULE A		**$7,000.00**
SCHEDULE B - PLUMBING WORKS		
Excavation and backfilling for all Pipes Works	LS	$5,000.00
PPR Water supply pipes	LS	$8,000.00
UPVC Sewrage pipes	LS	$9,500.00

DESCRIPTION	QUANTITY	TOTAL COST
All pipe specials such as bends, junctions, elbows, tees, etc.	LS	$2,250.00
Valves and flow meters	LS	$6,000.00
Testing & commissioning the entire installation	LS	$2,000.00
TOTAL SCHEDULE B		**$32,750.00**
SCHEDULE C - WATER TREATMENT PLANT		
Oil & Grease trap	EA*	$4,750.00
Equalization tank	EA	$15,000.00
Sand Filter & Activated Carbon filter	EA	$9,500.00
Chlorinator	EA	$7,500.00
Sludge holding tank	EA	$5,750.00
Filter press	EA	$4,000.00
Piping and Cabling	EA	$8,500.00
Final treated effluent tank	EA	$10,000.00
TOTAL SCHEDULE C		**$65,000.00**
SCHEDULE D - RAINWATER HARVESTING COMPONENTS		
3,000 Gallon Cistern	EA	$15,000.00
Sump with Transfer Pump	EA	$7,000.00
Gutter with Gutter Screens	LF	$6,500.00
Prefilter	EA	$1,250.00
Insulated Enclosure & Isolation Valve	EA	$750.00
Booster Pump with Controls	EA	$6,000.00
Bag Filter	EA	$100.00
2" Backflow Preventer, RPBA	EA	$650.00
Automated Valve	EA	$150.00
6" Storm Drain Pipe	LF*	$1,500.00
2" Pressurized Rainwater Pipe	LF	$2,375.00
TOTAL SCHEDULE D		**$41,275.00**
SCHEDULE E -FINISHING		
Clearing spaces and cleaning	LS	$3,000.00
TOTAL SCHEDULE E		**$3,000.00**
	TOTAL - ALL SCHEDULES	**$149,025**
	CONTINGENCY (20%)	**$29,805**
	Sales Tax @8.7%	**$2,593**
TOTAL ESTIMATE INCLUDING SALES TAX		**$181,423**

*LS is lump sum; EA is each and LF is labor force

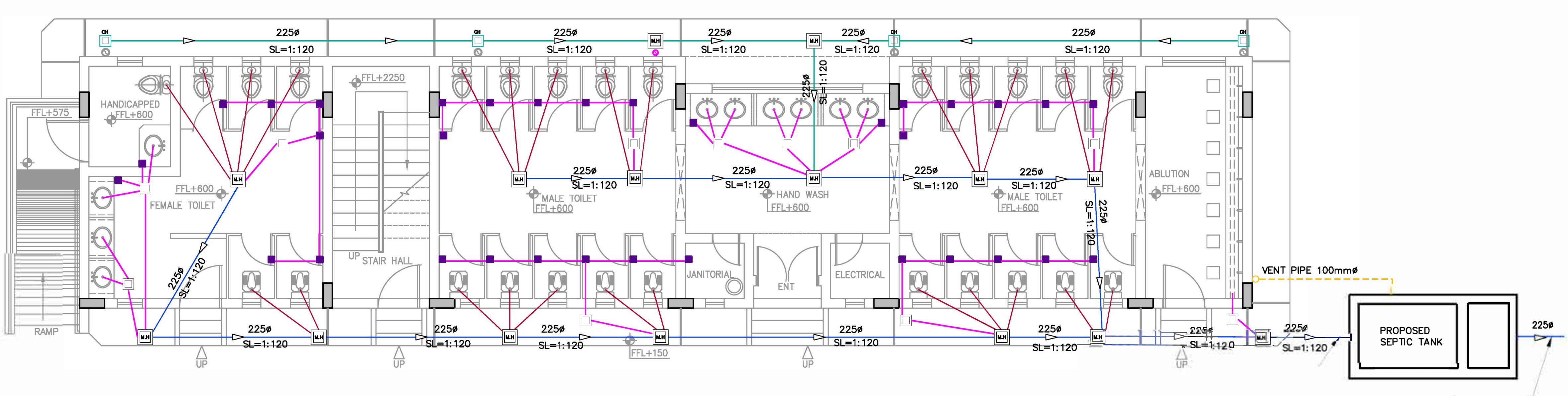
Appendices

Monthly Precipitation Data (mm)
Hyderabad Station
Source: Pakistan Metereological Department
http://www.pmd.gov.pk/

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual (mm)	Annual (in)
1981	0	12.7	26.8	0.3	0	0	51.4	25.8	0	0	0	0	117	4.61
1982	0.8	16.3	0.4	0.9	6.7	0	0	53.7	0	0	2	0	80.8	3.18
1983	0.1	10.5	0	33.9	0	0	46.4	205.1	3.7	0.7	0	0	300.4	11.83
1984	0	0	0	0.8	0	0	13.4	147	11.5	0	33.7	0	206.4	8.13
1985	0	0	0	30.7	0	0	24.7	61	0	0	0	0	116.4	4.58
1986	0	2.1	0.4	21	0	1.5	25.8	127.3	0	0	0	0	178.1	7.01
1987	0	0	14.2	0	1.6	0	0	0	0	0	0	0	15.8	0.62
1988	0	0	0	0	0	0	152.2	113.1	0	0	0	0	265.3	10.44
1989	3	TRACE	TRACE	TRACE	0	TRACE	197.7	0	0	0	0	0	200.7	7.90
1990	0	14.9	0	0	1.6	0	0	105.4	49	0	0	TRACE	170.9	6.73
1991	2	6.5	0	0	0	0	0	0	0	0	0	0	8.5	0.33
1992	10.6	0	TRACE	0	0	0	179.8	234.5	2.3	0	0	0	427.2	16.82
1993	2	10.2	TRACE	27	0	0	7.7	0	0	0	14	0	60.9	2.40
1994	1.4	1.3	0	26.7	0	0	46.6	284.6	126.5	0	0	TRACE	487.1	19.18
1995	2.6	6	0	0.3	0	0	78.6	0.8	TRACE	7.4	0	0	95.7	3.77
1996	0	0	0	TRACE	6.3	4	6.1	TRACE	0	0	0	TRACE	16.4	0.65
1997	5.9	0	15.3	6	1.6	1.2	0.8	9	0	16.2	1	0	57	2.24
1998	1	3.5	2.2	TRACE	0	0	8.6	TRACE	8.4	25.6	0	0	49.3	1.94
1999	TRACE	7	TRACE	0	51.1	TRACE	0.7	TRACE	0	11	9.6	0	79.4	3.13
2000	0	0.4	0	0	TRACE	0	8	46.6	0	0	0	0	55	2.17
2001	0	0	0.4	18.5	0	0	104.9	47.5	TRACE	TRACE	0	0	171.3	6.74
2002	0	2	0	0	0	4	0	TRACE	0	0	3	0	9	0.35
2003	TRACE	106	TRACE	0	0	13	209.2	77.4	0	0	0	0	405.6	15.97
2004	2	0	0	6.2	0	TRACE	0	16	TRACE	103.3	0	2	129.5	5.10
2005	2.2	2.6	0	3.4	15	0	10.6	15.4	3.2	0	0	0	52.4	2.06
2006	0	0	37	21.4	0	0.7	80.2	204.5	170	0	0	11.1	524.9	20.67
2007	0	3	33.5	0	0	34.3	7.5	130.4	0	0	0	33.2	241.9	9.52
2008	8.8	TRACE	1	14.5	0	0.7	8	103.8	0	0	0	19.8	156.6	6.17
2009	0.7	0.2	0.4	0.6	0	0.3	137.8	62.2	0	0	0	0	202.2	7.96
2010	0.4	0.4	0	0	0	76.5	29.5	85.9	18	0	3.4	0	214.1	8.43

* Trace mean rainfall less than 0.1mm

EXISTING SEWER AND STORM DRAINAGE NETWORK LAYOUT - JATOI HOSTEL



LEGEND:

FOUL PIPE	
FOUL PIPE FROM WATER CLOSET DIA 100mm	
WASTE WATER PIPE DIA 100mm	
DRAINAGE PIPE FOR RAIN WATER	
VENT PIPE DIA 100mm	
M.H	MANHOLE (500X500)
CH	DRAINAGE CHAMBER (300x300)
	GULLY TRAP (300X300)
	FLOOR TRAP (150X150)
	WASTE WATER DOWN PIPE DIA 100mm

CONCEPT DESIGN - NOT FINAL

GUIDELINES FOR THE REUSE OF GRAY WATER

Prepared by

Hawaii State Department of Health
Wastewater Branch
June 22, 2009

IPC®
INTERNATIONAL PLUMBING CODE®

Ontario Guidelines for Residential Rainwater Harvesting Systems

2010

HANDBOOK

In Ontario, Ontario's Building Code (OBC) and the Ontario Electrical Safety Code are the codes that are applicable to the design, construction and management of rainwater harvesting systems. This guidelines document and the accompanying handbook provide guidance for designing, constructing, and managing rainwater harvesting systems based on the minimum safety requirements established in these codes:

Ontario's Building Code:

http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_060350_e.htm

Ontario Electrical Safety Code Regulation:

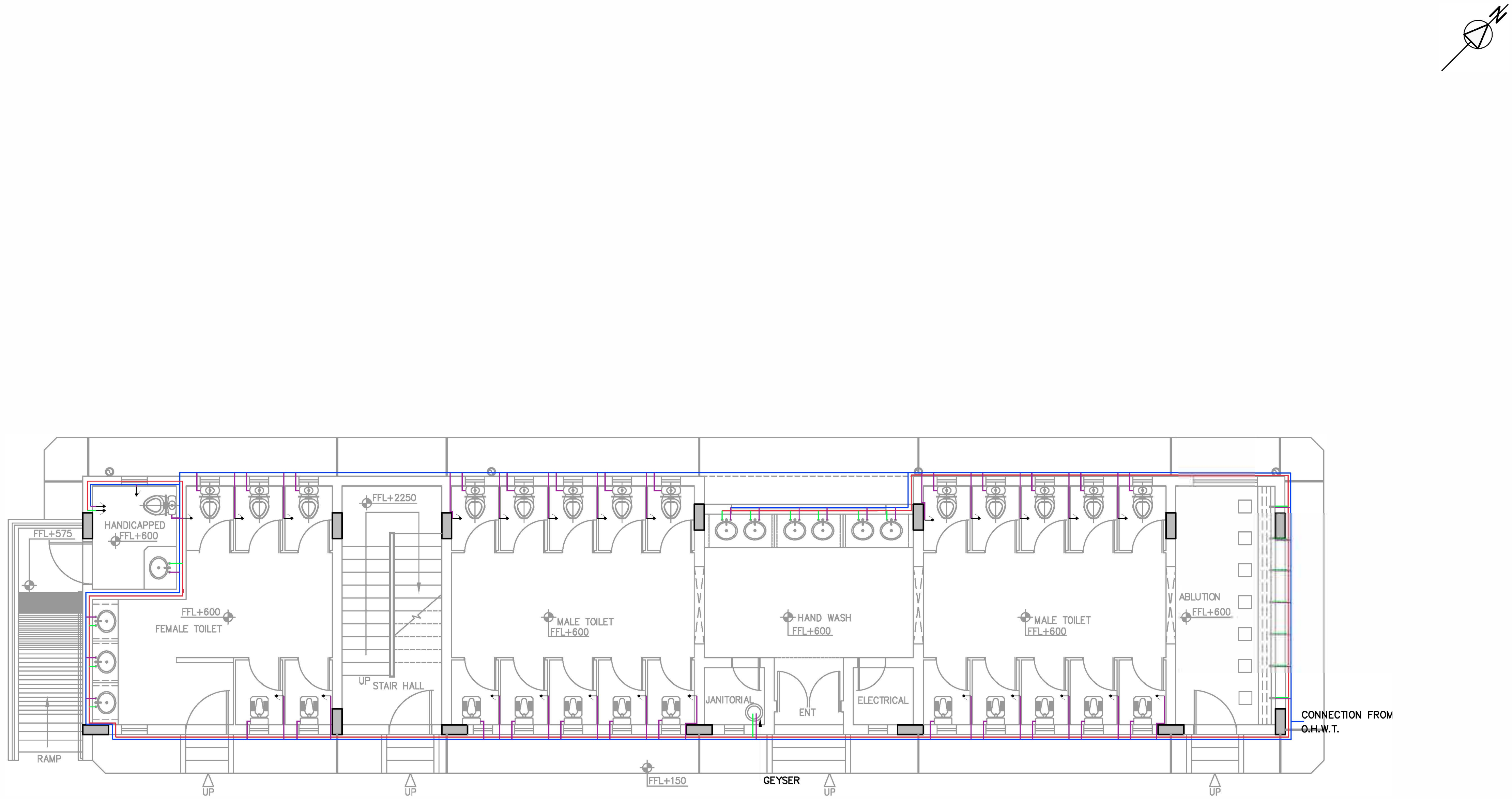
http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_990164_e.htm

This document is not intended to convey legal advice and is not a substitute for professional technical design. While care has been taken to ensure accuracy, the examples and explanations in this guide are given for the purposes of illustration only.

Readers must refer to the actual wording of the applicable law, including the Building Code Act, 1992, O. Reg. 350/06 (the Building Code), O. Reg. 164/99 (the Ontario Electrical Safety Code) and other applicable law. Persons seeking legal advice about the matters discussed in these guidelines should consult a solicitor.

The Author and Editors do not assume responsibility for errors or oversights resulting from the information contained herein.

First Edition, December 2010



CONCEPT DESIGN - NOT FINAL

2/3/2017

Guidance Document for Water Budget Calculation

Table of Contents

1. Purpose and Applicability

1.1. Purpose

The primary purpose of this document is to provide procedural and design guidelines for estimating water budget for human occupied buildings. Document enlists all the possible indoor and outdoor usage rates necessary to calculate total water demand for a building. The goal of the water budget is to show the home/facility owner how much water is used in the building.

1.2. Applicability

The enlisted guidelines can be applicable to various buildings for estimating water budget. Some example showing the applicability of this document are provided in Table 1.

Table 1. Guidance document applicability

Building Types	Applicability
General Office building	✓
Shopping Mall	✓
Hostels	✓
Warehouses	✓
Schools	✓
Nuclear Plants	×
Libraries	✓
Hospitals	×

2. General Guidelines

A suitable building (enlisted in Table-1.2) should be selected with following known basic parameters.

- Number of occupants in the building
- Flow rates and average daily use of the fixtures
- Type of Grass laid in the lawns
- Lawn Area
- Weather Conditions of the area

First, calculate indoor and outdoor water demands, then incorporate amount of rain water available for reuse in your calculation and then estimate net water budget for the building using table 6.4.

3. Indoor Water Budget Calculation

The indoor budget is calculated using three factors:

- Flowrates of the fixtures installed in the building
- The average daily usage rate of the fixtures
- The number of people in the household

Generally, flowrates can be found in the fixture description manual/literature or obtained from the builder. The average daily usage rates are estimated numbers of use of that fixture per day. And number of people occupying the building can be obtained from facility managing authorities.

Table-2 presents different types of indoor usages and their average rates. Formula used for calculating net indoor demand is also given below.

Indoor Water Demand per Capita (gpd/capita) = (Flow Rate x Duration x Ave Daily Use)

Indoor Water Demand (gpd) = Indoor Water Demand per Capita (gpd/capita) x No. of Occupants

Table 2. Indoor water demand calculation

Usage Types (Daily Use)	Flow Rate	Unit	Duration (4)	Unit	Ave Daily Use (4)	Indoor Water Demand (gpd/capita)
Showerhead (1)	2	gpm	8.2	min	0.65	10.66
Bathroom Faucet (2)	1.3	gpm	1.5	min	1.00	1.95
Bath (2)	25	gal/bath	1	bath	0.10	2.50
Washing Machine (3)	36.9	gal/cycle	1		0.31	11.44
Urinals	0.5	gpf	1	flush	1.74	0.87
Toilet (Water Closet) (1)	1.28	gpf	1	flush	4.75	6.08
Kitchen Faucet (1)	1.8	gpm	7.82	min	1.00	14.08
Drinking Use	0.5	gpd	1		1.00	0.50
Dishwasher (3)	11.15	gal/cycle	1		0.04	0.45
TOTAL						**48.52**

Notes:
(1) Flow rate based on maximum flow rate prescribed by 2011 SF Green Building Requirements (Table 13C.5.303.2.3).
(2) Flow rate from SFPUC 2011 Urban Water Management Plan (UWMP) Retail Demand Model for New Multi-Family Residential Water Use.
(3) Flow rate based on 2010 rate used in the 2010 UWMP Conservation Model.
(4) Flow rate from SFPUC 2010 Urban Water Management Plan (UWMP) Retail Demand Model for New Multi-Family Residential Water Use.
Ave Daily Use for faucets are represented by total average usage per person per day (min/person/day)

4. *Outdoor Water Budget Calculation*

The outdoor budget is calculated using three factors:

- Daily localized weather data
- Irrigated area
- Grass type factor

The calculation method given in this manual is for lawn (sunny turf) areas only. Soil type can also affect water demand. If no lawn is present and there is a maintained landscape, use water requirements provided by the nursery or landscape designer. This method presented here is SLIDE (Simplified Landscape Irrigation Demand Estimation) equation method, which will give a general indication of outdoor demand only.

The basic SLIDE equation uses only the Plant Factors, given in Table 3 to adjust reference ET and follows simple calculations to produce an estimate of the water required by a landscape area for a given period. The basic SLIDE equation is:

Landscape Water Demand (gal.) = ETo × PF × LA × 0.623

where,

- ETo is inches of historical average or real-time reference evapotranspiration data in inches for the period of interest.
- PF is the Plant Factor from Table 3.
- LA is the landscape area, in square feet.
- 0.623 is the factor to convert inches of water to gallons; omit this factor if the estimated water demand is desired in inches.

Table 3. Plant factor values for outdoor water demand calculations

Plant Type	Plant Factor
Tree, Shrubs, Vines, Groundcovers (woody plants)	0.5
Herbaceous Perennials	0.5
Desert Adapted Plants	0.3
Annual Flowers & Bedding Plants	0.8
General Turfgrass Lawns, cool-season (tall fescue, Ky. bluegrass, rye, bent)	0.8
General Turfgrass Lawns, warm-season (bermuda, zoysia, St, Augustine, buffalo)	0.6
Home Fruit Crops, Deciduous	0.8
Home Fruit Crops, Evergreen	1
Home Vegetable Crops	1
Mixed Plantings	*PF of the planting is that of the plant type present with the highest PF*

5. Precipitation Calculation

These calculations are only necessary for buildings furnished to store and reuse rainwater. Following steps should be followed in order to estimate for rainwater harvesting for a building

- Calculate daily precipitation falling on the building
- Calculate the daily evaporation losses or initial abstraction and apply runoff co-efficient
- Calculate the net rainfall falling on the building
- Multiply the net rainfall with the roof area of the building to get net volume of water available

- Based on the design of harvesting technology, this amount can be used for indoor or outdoor reuse.

6. *Case Study (Boys Hostel at Mehran University of Engineering and Technology, Jamshoro)*

This section estimate step by step water budget for hostel facility at Boys Hostel at Mehran University of Engineering and Technology, Jamshoro.

6.1. Indoor Water Budget Calculations for MUET Hostel

- First, we will get total number of students living at the hostel facility i.e. 167 students.
- Then we need to check fixture flow rates, if rates are not compatible with table 2, we need to update this table.
- Finally, we will add number of students and multiply them with total consumption rates to get net water demand.

Table 4. Indoor water demand calculation for Jatoi Hostel, MUET Jamshoro

Fixture Type (Daily Use)	Flow Rate	Unit	Duration	Unit	Ave Daily Use	Water Demand (gpd/person)	No. of occupants/ Students	Net Indoor Demand (gpd)
Showerhead	2	gpm	8.2	min	0.65	10.66	200	1780
Bathroom Faucet	1.3	gpm	1.5	min	1	1.95	200	325
Bath	25	gal/bath	1	bath	0.1	2.50	200	417
Washing Machine	36.9	gal/cycle	1		0.31	11.44	200	1910
Urinals	0.5	gpf	1	flush	1.74	0.87	200	145
Toilet	1.28	gpf	1	flush	4.75	6.08	200	1015
Kitchen Faucet	1.8	gpm	7.82	min	1	14.08	200	2350
Drinking Use	0.5	gpd	1		1	0.50	200	83
Dishwasher	11.15	gal/cycle	1		0.04	0.45	200	74
TOTAL						**48.52**		**8,103**

- Graph of net indoor daily demand is attached in appendix II as Figure A1.
- From net indoor water demand per day, we can estimate monthly demand by multiplying number of days of that month. Similarly, we can easily convert monthly demand into annual demand.
- A bar chart showing net indoor monthly demand is attached in appendix II as Figure A2.

Table 5. Monthly indoor demand variation in Jatoi Hostel

Months	Net Indoor Monthly Demand (gpm)
January	251,193
February	226,884
March	251,193
April	243,090
May	251,193
June	243,090
July	251,193
August	251,193
September	243,090
October	251,193
November	243,090
December	251,193
TOTAL	**2,957,598**

6.2. Outdoor Water Budget Calculations for MUET Hostel

For outdoor water budget, we will use following equation.

Landscape Water Demand (gal.) = ETo × PF × LA × 0.623

where,

- ETo is inches of historical average evapotranspiration in inches for the period of interest. For this case, monthly average ET value are available and given in the table 6.2.
- PF is the Plant Factor from Table 3. In this case, PF = 0.6 for General Lawn Turf grass, warm season.
- LA is the landscape area, in square feet. In this case, LA = 25,000 sq. ft
- 0.623 is the factor to convert inches of water to gallons; omit this factor if the estimated water demand is desired in inches

Graph representing monthly outdoor demand is attached in appendix II as Figure A3.

Table 6. Monthly outdoor water requirement for Jatoi Hostel

Months	Monthly Average ET Estimates (inches)	Plant Factor	Landscape Area (sq.ft)	Landscape/Outdoor Water Demand (gmpl)
January	0.31	0.6	25,000	2,897
February	0.49	0.6	25,000	4,579
March	1.17	0.6	25,000	10,934
April	2.21	0.6	25,000	20,652
May	3.58	0.6	25,000	33,455
June	4.05	0.6	25,000	37,847
July	4.45	0.6	25,000	41,585
August	3.8	0.6	25,000	35,511
September	2.47	0.6	25,000	23,082
October	1.37	0.6	25,000	12,803
November	0.57	0.6	25,000	5,327
December	0.3	0.6	25,000	2,804
Total Yearly Demand				**231,476**

6.3. Precipitation Calculations for MUET Hostel

For this part, it is assumed that hostel building has ability to temporary store rain water and then use it for outdoor demand only. The formula used in this scenario is

Net volume of water available (gal) = (Rainfall – losses) inches/12 feet * Runoff Coefficient*Roof area in sq.ft*7.48

- In our case, monthly rainfall data is available, as shown in second column of table 7
- Runoff co-efficient in our case is 0.95 (based on roof type)
- Building area in our case is 20,000 sq.ft

Table 7. Annual rainwater harvesting potential

Months	Monthly Average Precipitation (inches)	Runoff Co-efficient	Building Area (sq.ft)	Net Available Rain Water (gal)
January	0.02	0.95	20,000	189
February	0.02	0.95	20,000	189
March	0.00	0.95	20,000	0
April	0.00	0.95	20,000	0
May	0.00	0.95	20,000	0
June	2.81	0.95	20,000	33,303
July	0.59	0.95	20,000	7,011
August	1.50	0.95	20,000	17,812
September	0.66	0.95	20,000	7,817
October	0.00	0.95	20,000	0
November	0.10	0.95	20,000	1,232
December	0.00	0.95	20,000	0
Total Yearly Demand				**67,554**

In above table, months where monthly average losses are greater than monthly average precipitation values, net effective precipitation is taken as zero.

6.4. Overall Water Demand for MUET Hostel

The overall summary of monthly water demand for MUET hostel is given in the below table. A combo graph representing water budget summary is also given in the appendix II section as figure A4.

Net Water Demand = Indoor Demand + Outdoor Demand – Available Rain Water

Table 8. Net water demand calculation for Jatoi Hostel

Months	Net Indoor Monthly Demand (gal)	Landscape Water Demand (gal)	Available Rain Water for reuse (gal)	Net Water Demand (gal)
January	251,193	2,897	189	253,901
February	226,884	4,579	189	231,274
March	251,193	10,934	0	262,127
April	243,090	20,652	0	263,743
May	251,193	33,455	0	284,648
June	243,090	37,847	33,303	247,634
July	251,193	41,585	7,011	285,767
August	251,193	35,511	17,812	268,892
September	243,090	23,082	7,817	258,356
October	251,193	12,803	0	263,996
November	243,090	5,327	1,232	247,185
December	251,193	2,804	0	253,997
Yearly Demand	**2,957,598**	**231,476**	**67,554**	**3,121,519**

Appendix II

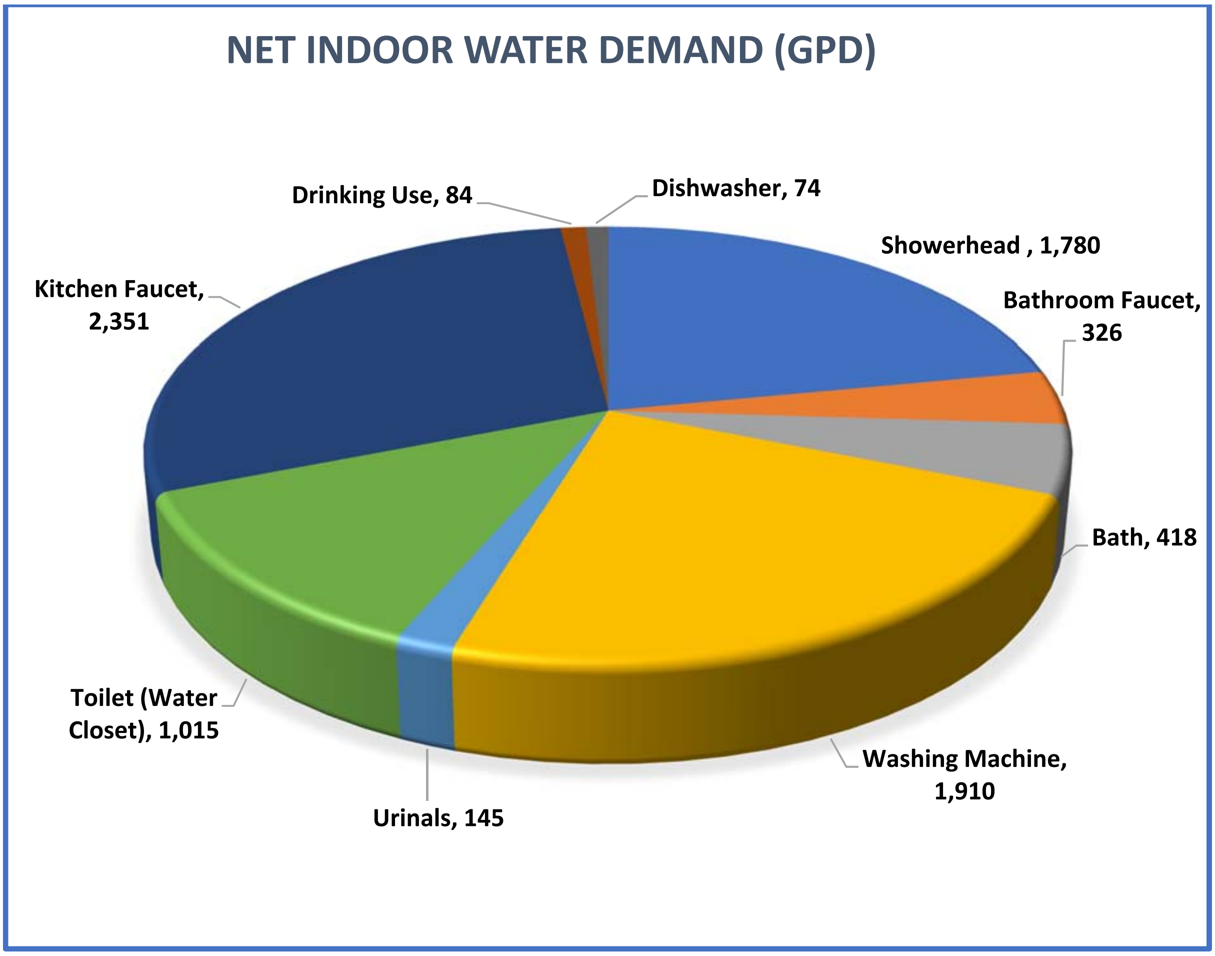


Figure A1. Net indoor water demand for various uses

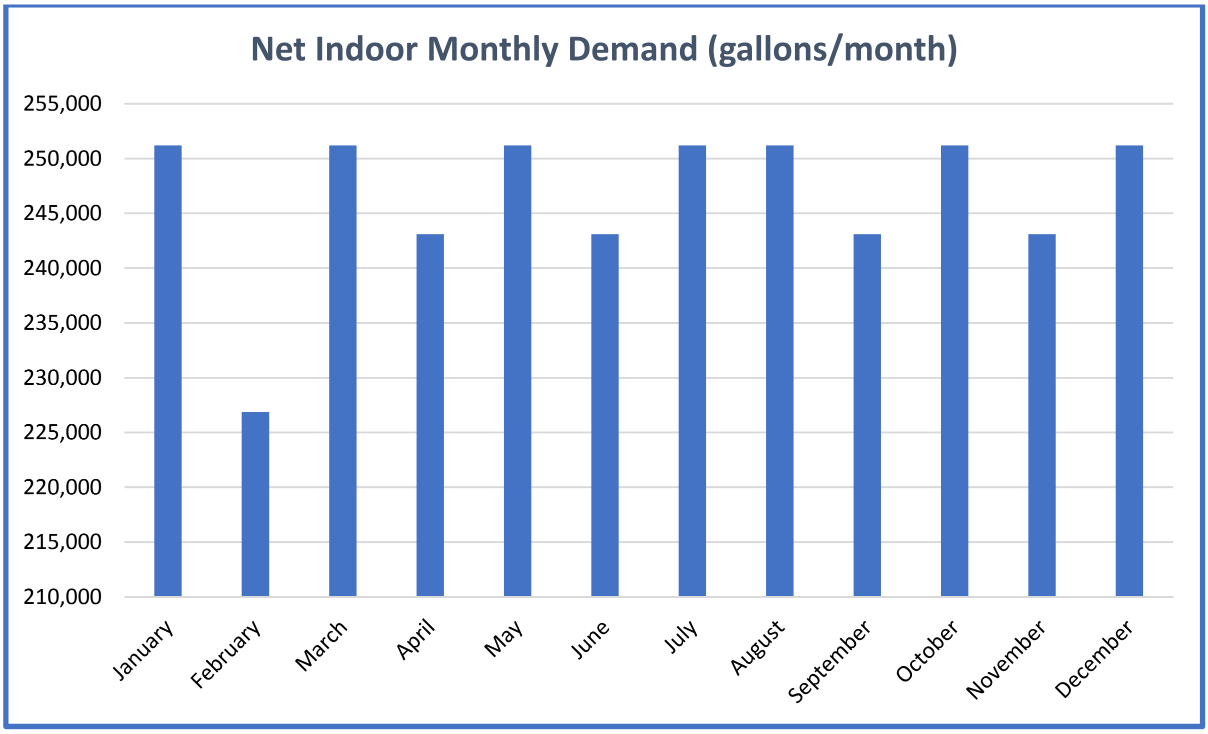


Figure A2. Monthly indoor water demand variation

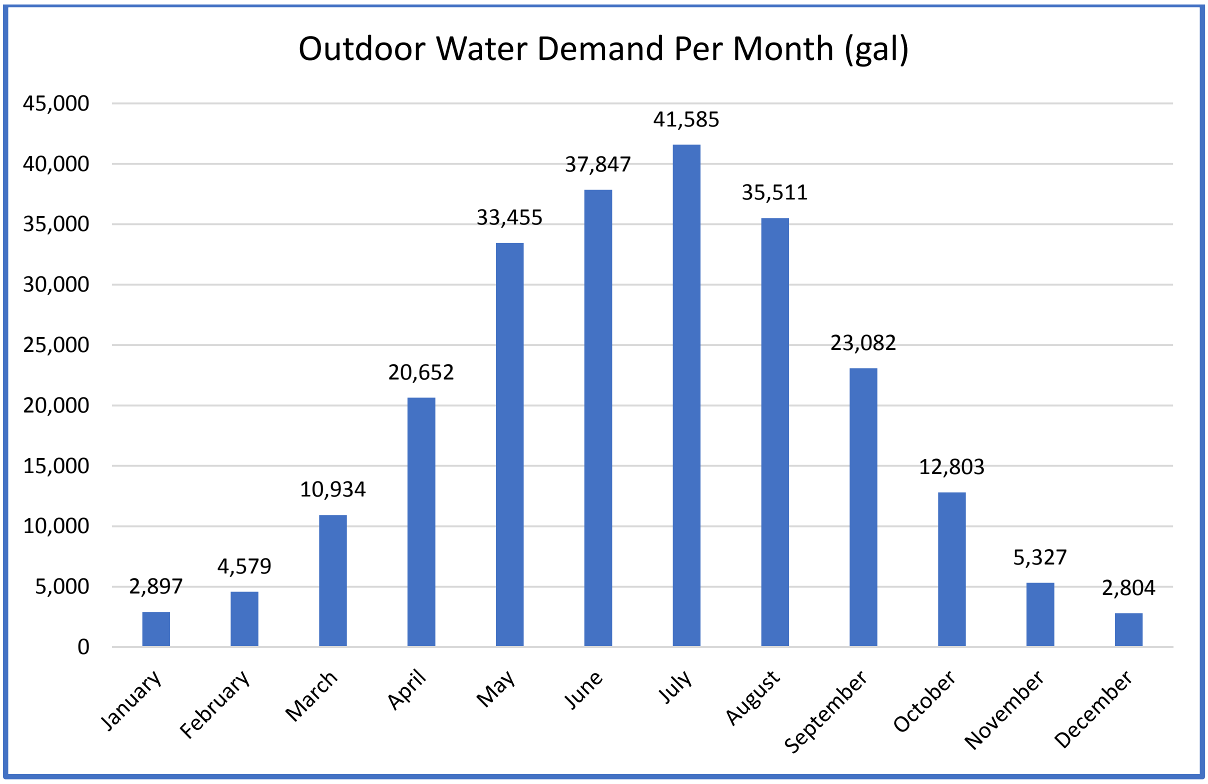


Figure A3. Monthly outdoor water demand variation

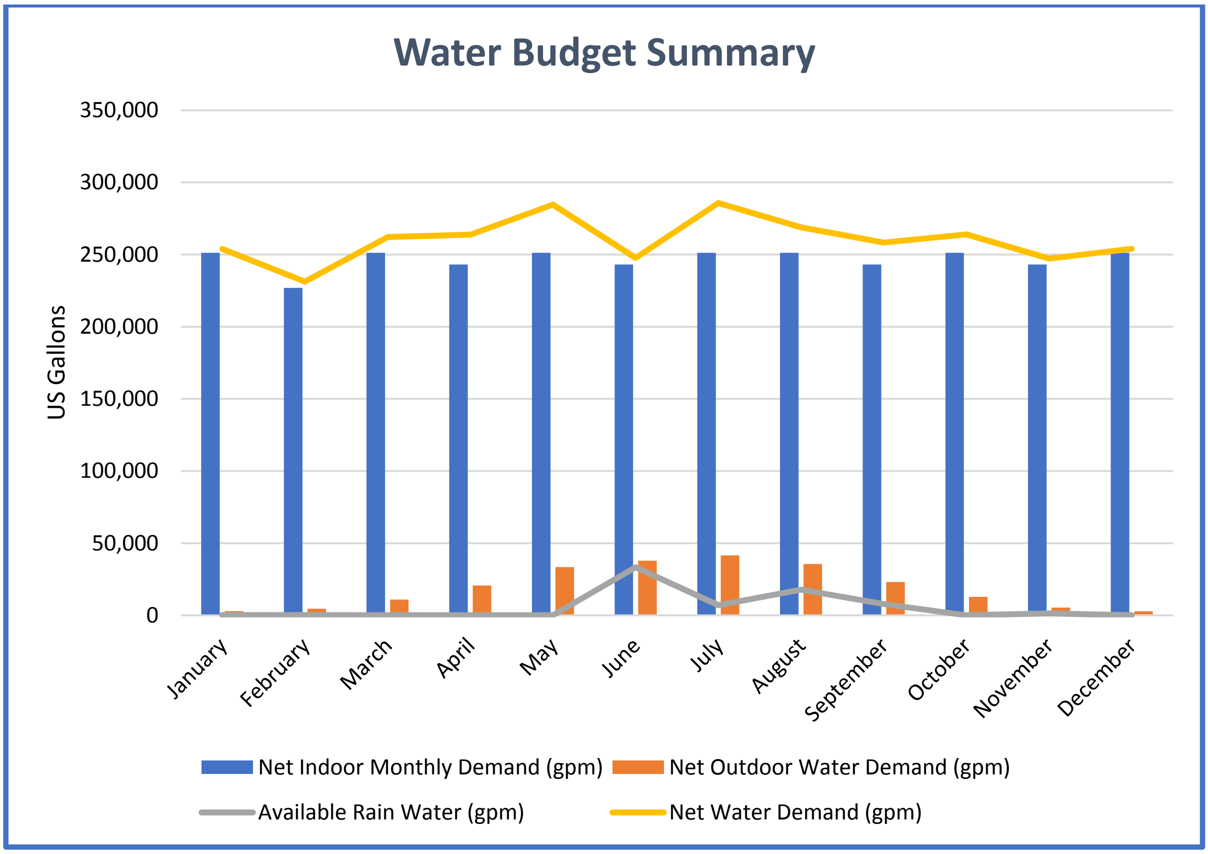


Figure A4. Water budget results