2/3/2017

Guidance Document for Water Budget Calculation

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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-1.2.

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

Table-1.2

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-2.1 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

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**

Table-2.1

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 4.1 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 4.1.
- 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.

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*

Table-4.1

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. 200 students.
- Then we need to check fixture flow rates, if rates are not compatible with table-2.1, 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.

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	2132.00
Bathroom Faucet	1.3	gpm	1.5	min	1	1.95	200	390.00
Bath	25	gal/bath	1	bath	0.1	2.50	200	500.00
Washing Machine	36.9	gal/cycle	1		0.31	11.44	200	2287.80
Urinals	0.5	gpf	1	flush	1.74	0.87	200	174.00
Toilet	1.28	gpf	1	flush	4.75	6.08	200	1216.00
Kitchen Faucet	1.8	gpm	7.82	min	1	14.08	200	2815.20
Drinking Use	0.5	gpd	1		1	0.50	200	100.00
Dishwasher	11.15	gal/cycle	1		0.04	0.45	200	89.20
TOTAL						**48.52**		**9,704**

Table-6.1.1

- 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.

Months	Net Indoor Monthly Demand (gpm) = No. of days * 9,704
January	300,830
February	271,718
March	300,830
April	291,126
May	300,830
June	291,126
July	300,830
August	300,830
September	291,126
October	300,830
November	291,126
December	300,830
TOTAL	**3,542,033**

Table-6.1.2

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 4.1. 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 = 15,000 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

Months	Monthly Average ET Estimates (inches)	Plant Factor	Landscape Area (sq.ft)	Landscape/Outdoor Water Demand (gal)
January	0.31	0.6	15,000	1,738
February	0.49	0.6	15,000	2,747
March	1.17	0.6	15,000	6,560
April	2.21	0.6	15,000	12,391
May	3.58	0.6	15,000	20,073
June	4.05	0.6	15,000	22,708
July	4.45	0.6	15,000	24,951
August	3.8	0.6	15,000	21,307

September	2.47	0.6	15,000	13,849
October	1.37	0.6	15,000	7,682
November	0.57	0.6	15,000	3,196
December	0.3	0.6	15,000	1,682
Total Yearly Demand				**138,885**

Table-6.2

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-6.3
- Then we need to get evaporation values losses (monthly average), as shown in third column of table-6.3
- Runoff co-efficient in our case is 0.95 (based on roof type)
- Building area in our case is 20,000 sq.ft

Months	Monthly Average Precipitation (inches)	Monthly Average Losses (inches)	Net effective Precipitation (inches)	Runoff Co-efficient	Building Area (sq.ft)	Net Available Rain Water (gal)
January	0.24	0.31	0.00	0.95	20,000	0
February	1.16	0.49	0.67	0.95	20,000	7,892
March	0.83	1.17	0.00	0.95	20,000	0
April	1.24	2.21	0.00	0.95	20,000	0
May	0.46	3.58	0.00	0.95	20,000	0
June	0.79	4.05	0.00	0.95	20,000	0
July	5.50	4.45	1.05	0.95	20,000	12,436
August	6.20	3.8	2.40	0.95	20,000	28,424
September	2.29	2.47	0.00	0.95	20,000	0
October	0.89	1.37	0.00	0.95	20,000	0
November	0.35	0.57	0.00	0.95	20,000	0
December	0.39	0.3	0.09	0.95	20,000	1,013
Total Yearly Demand						**49,764**

Table-6.3

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

Months	Net Indoor Monthly Demand (gal)	Landscape Water Demand (gal)	Available Rain Water for reuse (gal)	Net Water Demand (gal)
January	300,830	1,738	0	302,568
February	271,718	2,747	7,892	266,573
March	300,830	6,560	0	307,390
April	291,126	12,391	0	303,517
May	300,830	20,073	0	320,903
June	291,126	22,708	0	313,834
July	300,830	24,951	12,436	313,346
August	300,830	21,307	28,424	293,713
September	291,126	13,849	0	304,975
October	300,830	7,682	0	308,512
November	291,126	3,196	0	294,322
December	300,830	1,682	1,013	301,499
Yearly Demand	**3,542,033**	**138,885**	**49,764**	**3,631,154**

Table-6.4

Appendix II

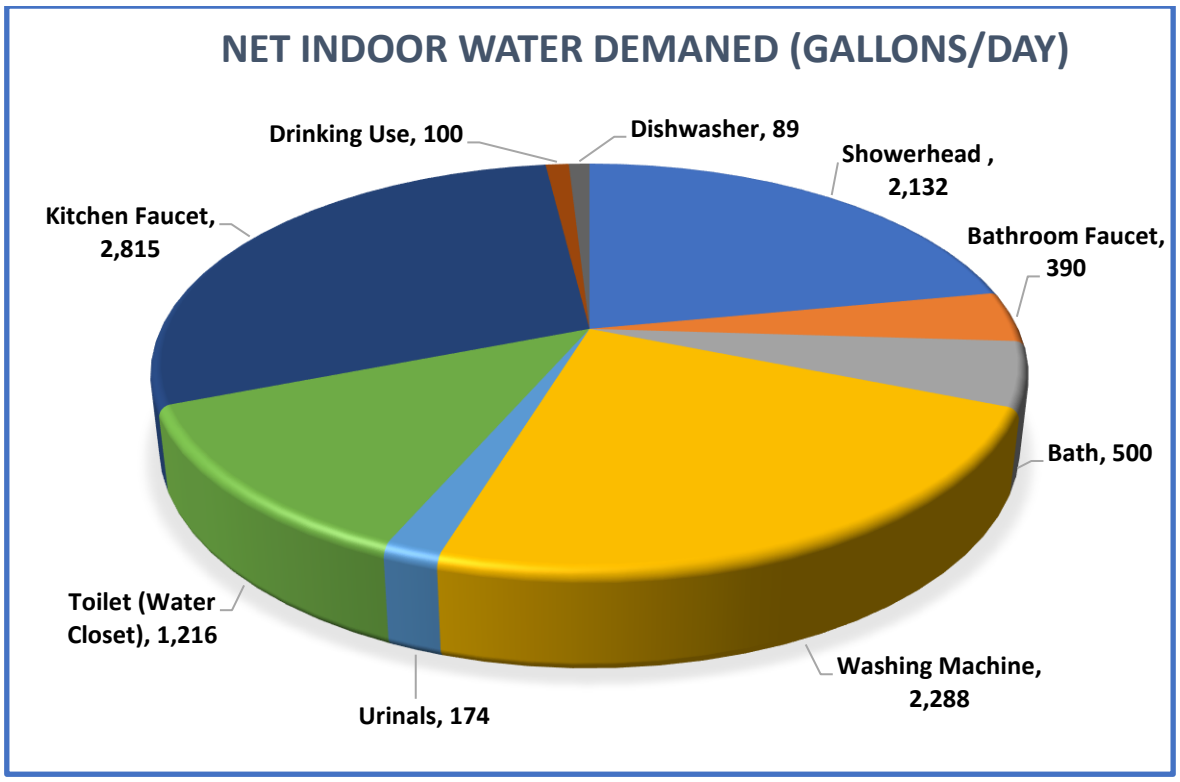

Figure-A1

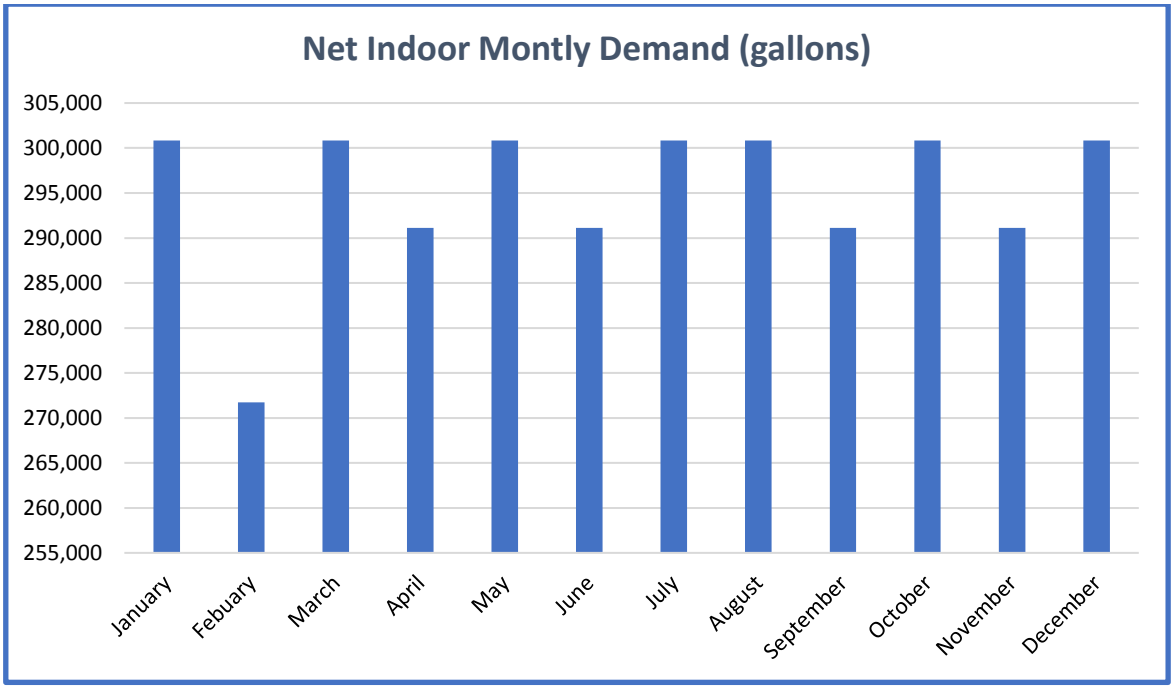

Figure-A2

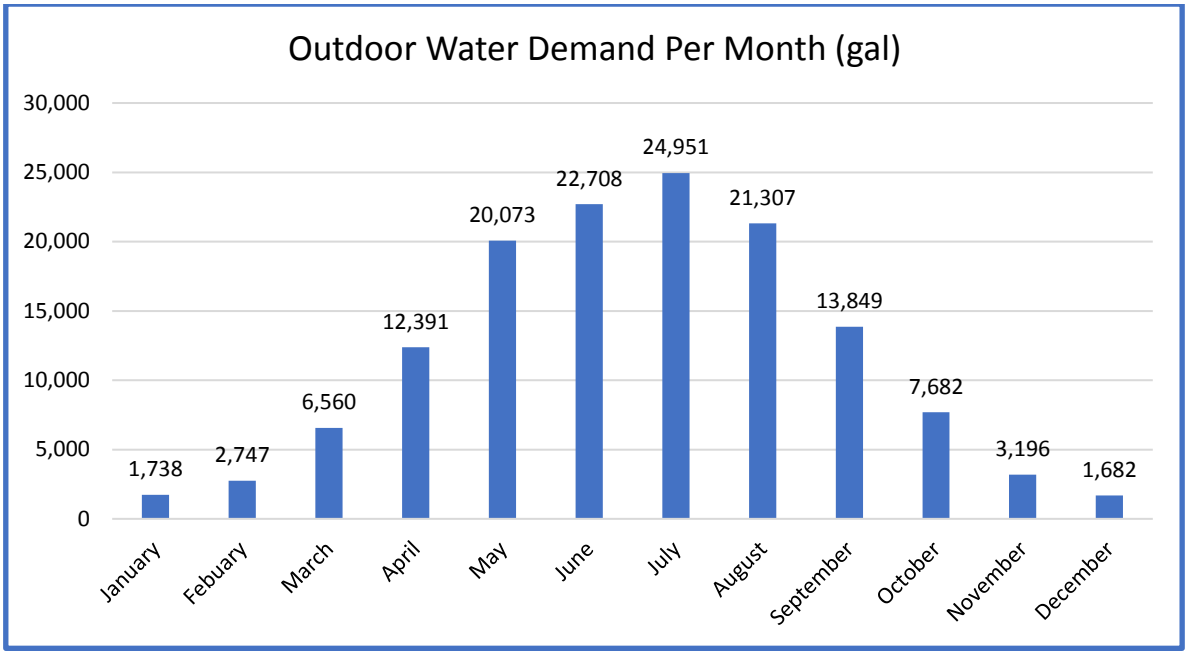

Figure-A3

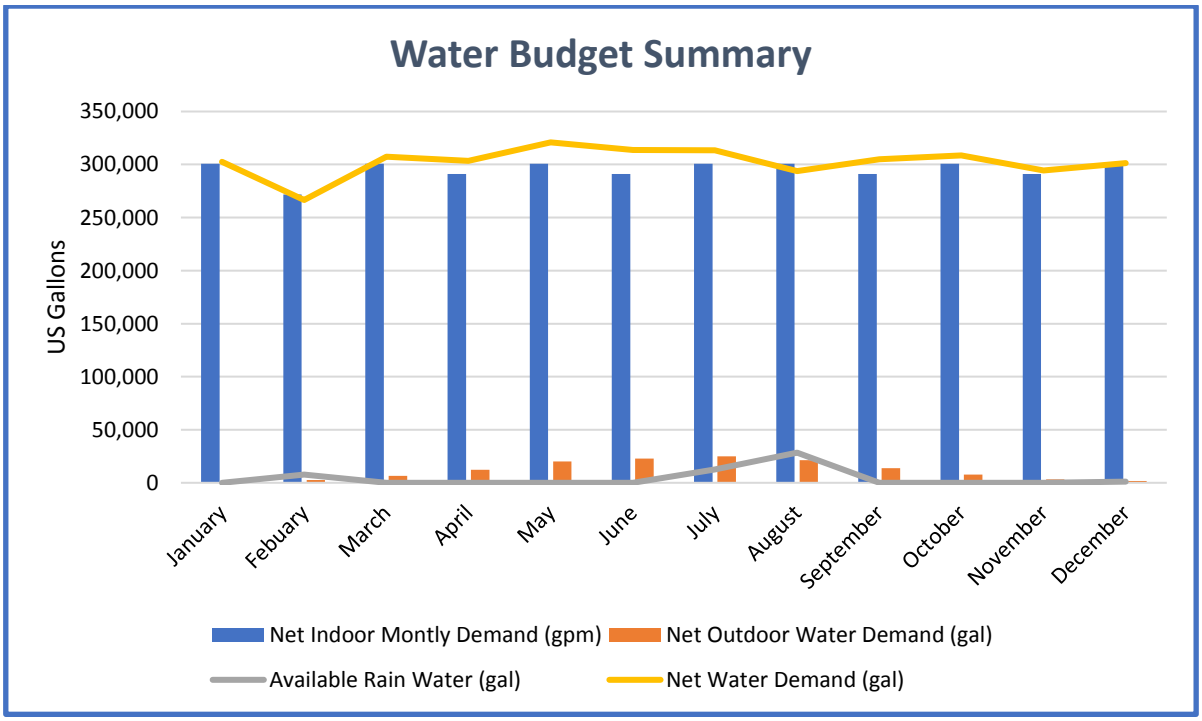

Figure-A4