Estimate Water Demand

Assumptions

Wing	Peak Factor
Residential Wing	2.5
Administrative Wing	2 to 4
Commercial Wing	2 to 4
Industrial Wing	2.1
Fire Fighting	1

Industrial production:

- Milk production per day: 180,000 L/day
- Milk production by an average cow: 25 L/day
- Water requirement for an average cow: 115 L/day
- Time factor: 24/24 = 1
- Peak factor: 2.1

Firefighting:

- Diameter of nozzle of hydrant = 3 inch
- Velocity = 3 fps
- Flow occurs for 30 minutes
- Fire incidents occur once a day.
- Number of hydrants working at a time = 2

Steps of Calculation

All wings have water demand for personal consumption. However, the industrial wing additionally has water demand for production purposes.

For personal consumption:

1. Current and future population is obtained from "Estimate Population" report.
2. Water requirement per capita is obtained from BNBC 2020.
3. The following formula is used for estimating water demand:

$$Demand = Population \times LPCD \times TimeFactor$$

4. Peak water demand is obtained by multiplying the previously obtained water demand with peak factor.

For production purposes:

1. Milk production per day is given.
2. Milk production per day for an average cow is assumed.
3. Daily water consumption by an average is assumed.
4. By using data from step 2 and 3, we can get the amount of water required per liter of milk production.
5. Daily water demand is calculated by multiplying that with total milk production per day.
6. Peak water demand is obtained by multiplying the previously obtained water demand with peak factor.

In addition to the above, water demand for firefighting is also estimated.

For firefighting purposes:

1. Firefighting water demand remains constant across time.
2. Fire hydrants' nozzle size, velocity, flow duration, number of incidents per day, and number of fire hydrants are assumed.
3. Flow of water per hydrant is determined by multiplying area with velocity.
4. Water demand for each hydrant is determined by multiplying flow with duration.
5. Total water demand is obtained by multiplying that with number of fire hydrants.

Sample of Calculations

Residential Wing

Type: Villa

- Type of occupancy: A1
- Per capita consumption (lpcd): 260
- Time factor: 24/24 = 1
- Peak factor: 2.5
- Present population: 56
- Present water demand: $56 \times 260 \times 1 = 14{,}560$ L
- Present peak water demand: $14{,}560 \times 2.5 = 36{,}400$ L
- Population after 10 years: 62
- Water demand after 10 years: $62 \times 260 \times 1 = 16{,}120$ L
- Peak water demand after 10 years: $16{,}120 \times 2.5 = 40{,}300$ L
- Population after 20 years: 69
- Water demand after 20 years: $69 \times 260 \times 1 = 17{,}940$ L
- Peak water demand after 20 years: $17{,}940 \times 2.5 = 44{,}850$ L
- Population after 30 years: 76
- Water demand after 30 years: $76 \times 260 \times 1 = 19{,}760$ L
- Peak water demand after 30 years: $19{,}760 \times 2.5 = 49{,}400$ L

Administrative Wing

Corporate HQ:

- Type of occupancy: E1: Offices
- Per capita consumption (lpcd): 45
- Time factor: 24/8 = 3
- Peak factor: 2.5
- Present population: 53
- Present water demand: $53 \times 45 \times 3 = 7{,}155$ L
- Present peak water demand: $7{,}155 \times 2.5 = 17{,}888$ L
- Population after 10 years: 67
- Water demand after 10 years: $67 \times 45 \times 3 = 9{,}045$ L
- Peak water demand after 10 years: $9{,}045 \times 2.5 = 22{,}613$ L
- Population after 20 years: 69
- Water demand after 20 years: $69 \times 45 \times 3 = 9{,}315$ L
- Peak water demand after 20 years: $9{,}315 \times 2.5 = 23{,}288$ L
- Population after 30 years: 72
- Water demand after 30 years: $72 \times 45 \times 3 = 9{,}720$ L
- Peak water demand after 30 years: $9{,}720 \times 2.5 = 24{,}300$

Commercial Wing

Food Court:

- Type of occupancy: F1: Small Shops & Market
- Per capita consumption (lpcd): 45
- Time factor: 24/12 = 2
- Peak factor: 3.5
- Present population: 40
- Present water demand: $40 \times 45 \times 2 = 3{,}600$ L
- Present peak water demand: $3{,}600 \times 3.5 = 10{,}800$ L
- Population after 10 years: 52
- Water demand after 10 years: $52 \times 45 \times 2 = 4{,}680$ L
- Peak water demand after 10 years: $4{,}680 \times 3.5 = 14{,}040$ L
- Population after 20 years: 54
- Water demand after 20 years: $54 \times 45 \times 2 = 4{,}860$ L
- Peak water demand after 20 years: $4{,}860 \times 3.5 = 14{,}580$ L
- Population after 30 years: 56
- Water demand after 30 years: $56 \times 45 \times 2 = 5{,}040$ L
- Peak water demand after 30 years: $5{,}040 \times 2.5 = 15{,}120$

Industrial Wing (Personal)

Processing Core:

- Type of occupancy: G1: Low Hazard Industries
- Per capita consumption (lpcd): 40
- Time factor: 24/16 = 1.5
- Peak factor: 2.1
- Present population: 30
- Present water demand: $30 \times 40 \times 1.5 = 1{,}800$ L
- Present peak water demand: $1{,}800 \times 2.1 = 3{,}780$ L
- Population after 10 years: 39
- Water demand after 10 years: $39 \times 40 \times 1.5 = 2{,}340$ L
- Peak water demand after 10 years: $2{,}340 \times 2.1 = 4{,}914$ L
- Population after 20 years: 41
- Water demand after 20 years: $41 \times 40 \times 1.5 = 2{,}460$ L
- Peak water demand after 20 years: $2{,}460 \times 2.1 = 5{,}166$ L
- Population after 30 years: 42
- Water demand after 30 years: $42 \times 40 \times 1.5 = 2{,}520$ L
- Peak water demand after 30 years: $2{,}520 \times 2.1 = 5{,}292$

Industrial Wing (Production)

- Milk production per day: 180,000 L/d
- Milk production by an avg cow: 25 L/d
- Water consumption by an avg cow: 115 L/d
- Water required per liter of milk: $\frac{115}{25} = 4\ \text{L/L}$
- Time factor: 1
- Preset water demand: $4 \times 180{,}000 = 720{,}000\ \text{L/d}$
- Present peak water demand: $720{,}000 \times 2.1 = 1{,}512{,}000\ \text{L/d}$
- Water demand after 10 years: 25% growth; $1.25 \times 720{,}000 = 900{,}000\ \text{L/d}$
- Peak water demand after 10 years: $2.1 \times 900{,}000 = 1{,}890{,}000\ \text{L/d}$
- Water demand after 20 years: 30% growth; $1.30 \times 720{,}000 = 936{,}000\ \text{L/d}$
- Peak water demand after 20 years: $2.1 \times 936{,}000 = 1{,}965{,}600\ \text{L/d}$
- Water demand after 30 years: 35% growth; $1.35 \times 720{,}000 = 972{,}000\ \text{L/d}$
- Peak water demand after 30 years: $2.1 \times 972{,}000 = 2{,}041{,}200\ \text{L/d}$

Firefighting Demand

- Nozzle diameter: 3 in
- Velocity: 3 fps
- Flow duration: 30 minutes
- Number of hydrants: 2
- Flow through one hydrant: $Q = AV = \frac{\pi \times (3/12)^2}{4} \times 3 = 0.1473\ \text{f}^3/\text{s}$
- Volume of water per hydrant: $Q \times t = 0.1473 \times 30 \times 60 = 265.14\ \text{ft}^3$
- Total volume of water: $265.14 \times 2 = 530.28\ \text{ft}^3 = 15{,}016\ \text{L}$

Residential Wing

Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Villa	A1	260	1	14,560	36,400	16,120	40,300	17,940	44,850	19,760	49,400
A	A3	200	1	19,800	49,500	22,200	55,500	24,400	61,000	27,000	67,500
B	y1	180	1	23,400	58,500	27,000	67,500	30,060	75,150	33,480	83,700
C	y2	120	1	37,800	94,500	44,400	111,000	50,160	125,400	56,760	141,900
D	z1	80	1	43,120	107,800	51,360	128,400	58,160	145,400	66,080	165,200
Total				**138,680**	**346,700**	**161,080**	**402,700**	**180,720**	**451,800**	**203,080**	**507,700**

Administrative Wing

Facility / Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Peak Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Security Checkpoint	E1: Offices	45	1	2	90	180	135	270	135	270	135	270
Inspection Bay	K3: Repair Garage	15	2	2	120	240	150	300	180	360	180	360
CMS	G1: Low Hazard Industries	40	3	2.5	1,440	3,600	1,800	4,500	1,920	4,800	2,040	5,100
Logistics & Customs Office	E1: Offices	45	3	2.5	1,620	4,050	2,025	5,063	2,160	5,400	2,295	5,738
Veterinary Office	E2: Research & Testing Laboratories	70	3	2	2,520	5,040	3,150	6,300	3,360	6,720	3,570	7,140
Parking Lot	K1: Parking Garage	15	1.5	2.5	360	900	450	1,125	473	1,181	495	1,238

Facility / Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Peak Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Exhibition Center	I4: Small Assembly without Fixed Seats	15	3	3	6,750	20,250	8,460	25,380	8,775	26,325	9,135	27,405
Corporate HQ	E1: Offices	45	3	2.5	7,155	17,888	9,045	22,613	9,315	23,288	9,720	24,300
Park Op. Center	E1: Offices	45	1	2	225	450	315	630	315	630	315	630
IT Center	E3: Essential Services	70	1	1.5	350	525	490	735	490	735	490	735
R&D Facility	E2: Research & Testing Laboratories	70	3	2	1,680	3,360	2,100	4,200	2,310	4,620	2,310	4,620
QA Office	E2: Research & Testing Laboratories	70	1	2	980	1,960	1,260	2,520	1,330	2,660	1,330	2,660
Fire Station	E3: Essential Services	70	1	2	1,120	2,240	1,400	2,800	1,470	2,940	1,540	3,080

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Water Pump Station	L: Utility	10	1	1.5	60	90	80	120	80	120	90	135
Power Plant	G1: Low Hazard Industries	40	1	1.5	360	540	480	720	480	720	520	780
Training Academy	B2: Facilities for Training	100	3	3	12,000	36,000	15,000	45,000	15,600	46,800	16,200	48,600
Central Mosque	I3: Large Assembly without Fixed Seats	15	6	4	36,000	144,000	45,000	180,000	46,800	187,200	48,600	194,400
Residential Estate Office	E1: Offices	45	3	2.5	2,025	5,063	2,565	6,413	2,700	6,750	2,835	7,088
Solid Waste Dump	L: Utility	10	3	2	420	840	540	1,080	570	1,140	570	1,140

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Sewage Treatment Plant	L: Utility	10	1	1.5	90	135	120	180	120	180	130	195
Total					**75,365**	**247,350**	**94,565**	**309,948**	**98,583**	**322,839**	**102,500**	**335,613**

Industrial Wing

Facility / Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Peak Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Cow Barn A	G1: Low Hazard Industries	40	1	2.1	600	1,260	800	1,680	840	1,764	840	1,764
Cow Barn B	G1: Low Hazard Industries	40	1	2.1	600	1,260	800	1,680	840	1,764	840	1,764
Milking Rotary	G1: Low Hazard Industries	40	1.33	2.1	532	1,117	692	1,452	745	1,564	745	1,564
Milking Center Utilities	L: Utility	10	1	2.1	40	84	60	126	60	126	60	126
Chilling & Filtration Block	G1: Low Hazard Industries	40	1	2.1	280	588	400	840	400	840	400	840
Raw Milk Silos	H1: Low Fire Risk Storage	10	1	2.1	50	105	70	147	70	147	70	147
Processing Core	G1: Low Hazard Industries	40	1.5	2.1	1,800	3,780	2,340	4,914	2,460	5,166	2,520	5,292

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Packaging Station	G1: Low Hazard Industries	40	1.5	2.1	1,320	2,772	1,740	3,654	1,800	3,780	1,860	3,906
Bottle Inventory	H1: Low Fire Risk Storage	10	2	2.1	180	378	240	504	260	546	260	546
Cold Storage Warehouse	H1: Low Fire Risk Storage	10	1	2.1	180	378	240	504	250	525	260	546
Shipping Docks	H1: Low Fire Risk Storage	10	1.5	2.1	60	126	90	189	90	189	90	189
Truck Staging Yard	K1: Parking Garage	15	1	2.1	255	536	345	725	345	725	360	756
Effluent Treatment Plant	L: Utility	10	1	2.1	130	273	170	357	180	378	190	399
Total					**6,027**	**12,657**	**7,987**	**16,772**	**8,340**	**17,514**	**8,495**	**17,839**

Commercial Wing

Facility / Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Peak Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Retail & Café	F1: Small Shops & Market	45	2	3	3,600	10,800	4,680	14,040	4,860	14,580	5,040	15,120
Food Court	F1: Small Shops & Market	45	2	3.5	4,500	15,750	5,760	20,160	6,030	21,105	6,210	21,735
Shopping Complex & Super Market	F2: Large Shops & Market	45	2	2.5	7,200	18,000	9,270	23,175	9,630	24,075	9,990	24,975
Essential Services	E3: Essential Services	70	1	2	980	1,960	1,260	2,520	1,330	2,660	1,400	2,800
Communication Services	E1: Offices	45	2.4	2.5	1,512	3,780	1,944	4,860	2,052	5,130	2,160	5,400
Bank	E1: Offices	45	3	2.5	6,750	16,875	8,640	21,600	9,045	22,613	9,315	23,288
Insurance	E1: Offices	45	3	2	675	1,350	945	1,890	945	1,890	945	1,890

Facility / Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Peak Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Veterinary	E2: Research & Testing Laboratories	70	2.4	2	2,520	5,040	3,360	6,720	3,360	6,720	3,528	7,056
Daycare & Gym	B3: Pre-School Facilities	50	2.4	3	7,200	21,600	9,240	27,720	9,600	28,800	9,960	29,880
Automotive Department	K3: Repair Garage	15	2.4	2	540	1,080	720	1,440	720	1,440	756	1,512
Park & Community Department	I4: Small Assembly without Fixed Seats	15	2	3	7,500	22,500	9,600	28,800	9,990	29,970	10,350	31,050
Education Department	B1: Educational (Up to Higher Secondary)	70	3.43	3.5	48,020	168,070	61,466	215,130	63,867	223,533	66,268	231,937

Facility / Building	Occupancy Type	Per Capita Consumption (lpcd)	Time Factor	Peak Factor	Water Demand: Present (lpd)	Peak Water Demand: Present (lpd)	Water Demand: In 10 Years (lpd)	Peak Water Demand: In 10 Years (lpd)	Water Demand: In 20 Years (lpd)	Peak Water Demand: In 20 Years (lpd)	Water Demand: In 30 Years (lpd)	Peak Water Demand: In 30 Years (lpd)
Health Department	D2: Emergency Medical Facilities	300	1	2.5	30,000	75,000	38,400	96,000	39,900	99,750	41,400	103,500
Total					**120,997**	**361,805**	**155,285**	**464,055**	**161,329**	**482,266**	**167,322**	**500,142**

Summary of Water Demand Prediction

Wing	Water Demand: Present	Peak Water Demand: Present	Water Demand: In 10 Years	Peak Water Demand: In 10 Years	Water Demand: In 20 Years	Peak Water Demand: In 20 Years	Water Demand: In 30 Years	Peak Water Demand: In 30 Years
Residential	138,680	346,700	161,080	402,700	180,720	451,800	203,080	507,700
Administrative	75,365	247,350	94,565	309,948	98,583	322,839	102,500	335,613
Industrial	726,027	1,524,657	907,987	1,906,772	944,340	1,983,114	980,495	2,059,039
Personal	6,027	12,657	7,987	16,772	8,340	17,514	8,495	17,839
Production	720,000	1,512,000	900,000	1,890,000	936,000	1,965,600	972,000	2,041,200
Commercial	120,997	361,805	155,285	464,055	161,329	482,266	167,322	500,142
Firefighting	15,016	15,016	15,016	15,016	15,016	15,016	15,016	15,016
Total	**1,076,085**	**2,495,528**	**1,333,933**	**3,098,491**	**1,399,988**	**3,255,035**	**1,468,413**	**3,417,510**