

Wastewater Treatment Lecture 6

Wastewater Engineering –
QUANTITY OF WATER

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Water: The Essence of Life

Water is fundamental to all life. It covers 70% of Earth's surface.

Living organisms are composed of 60-65% water. Water exists in three states: liquid, solid, and gas.

The Hydrological Cycle

1

Evaporation

Water transforms into vapor.

2

Transpiration

Plants release water vapor.

3

Condensation

Vapor cools and forms clouds.

4

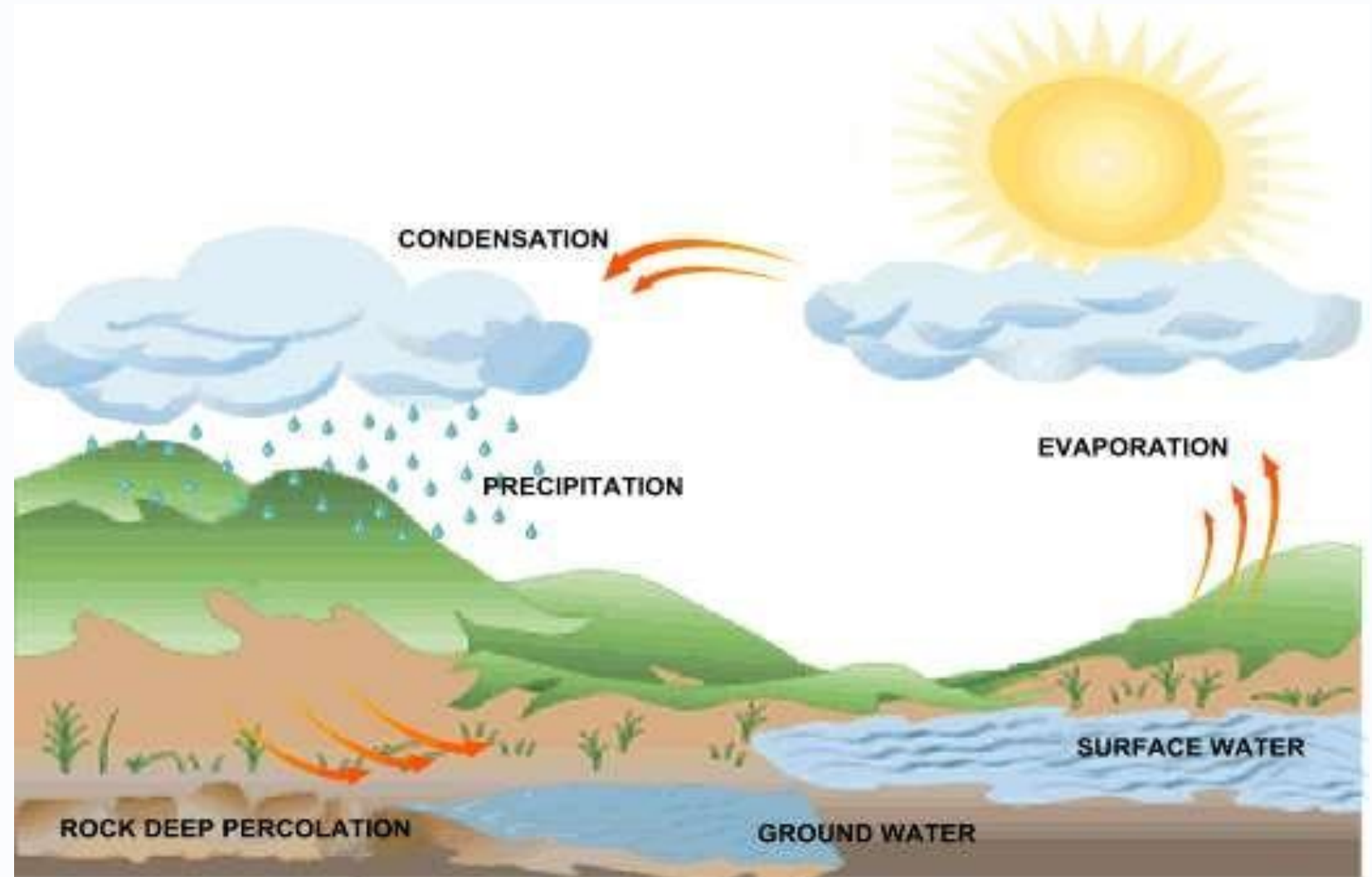
Precipitation

Water falls back to Earth.

5

Runoff

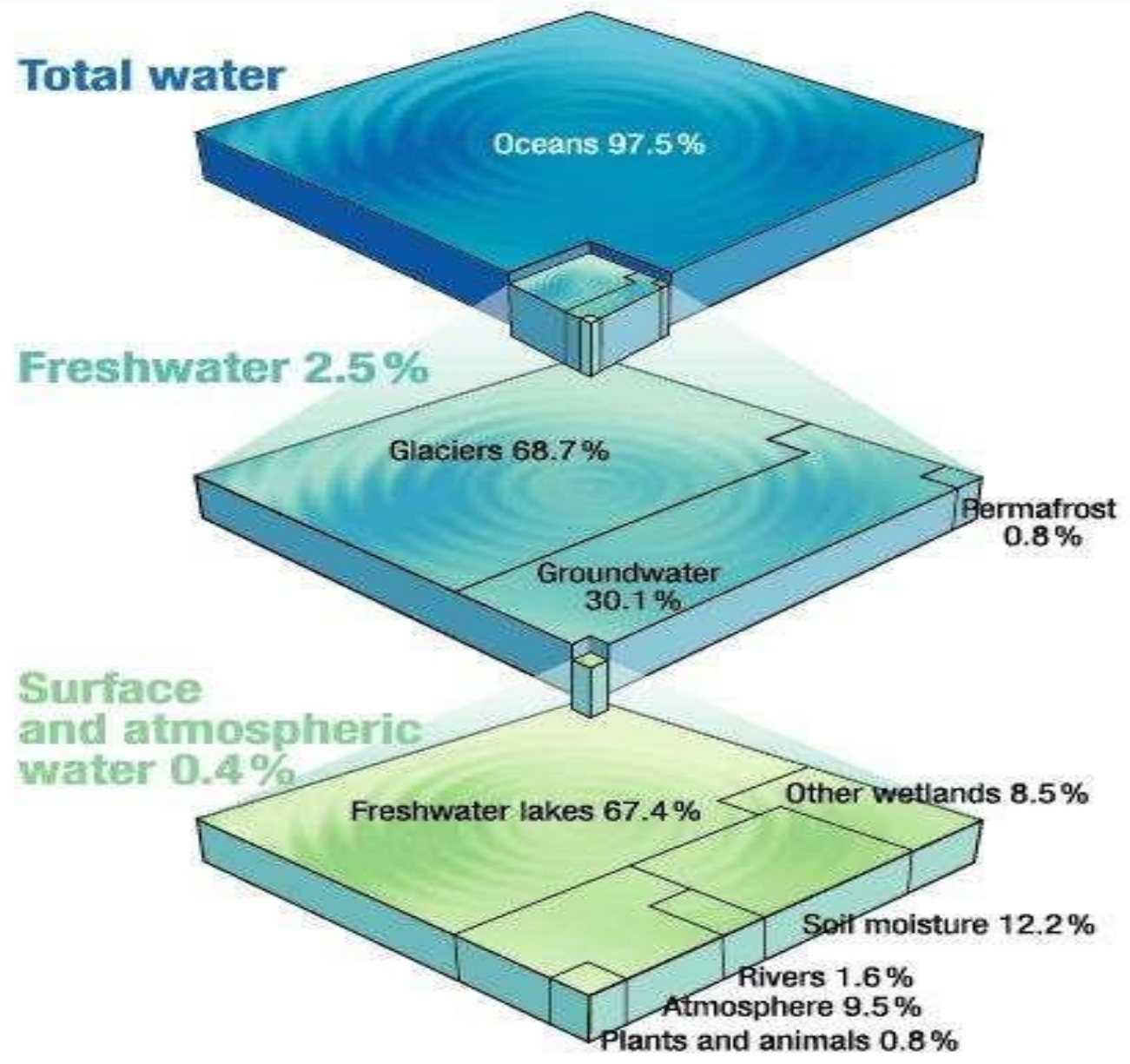
Water flows over land surfaces.



Earth's Water Distribution

Oceans hold the vast majority of Earth's water.
Freshwater sources are crucial for human use.





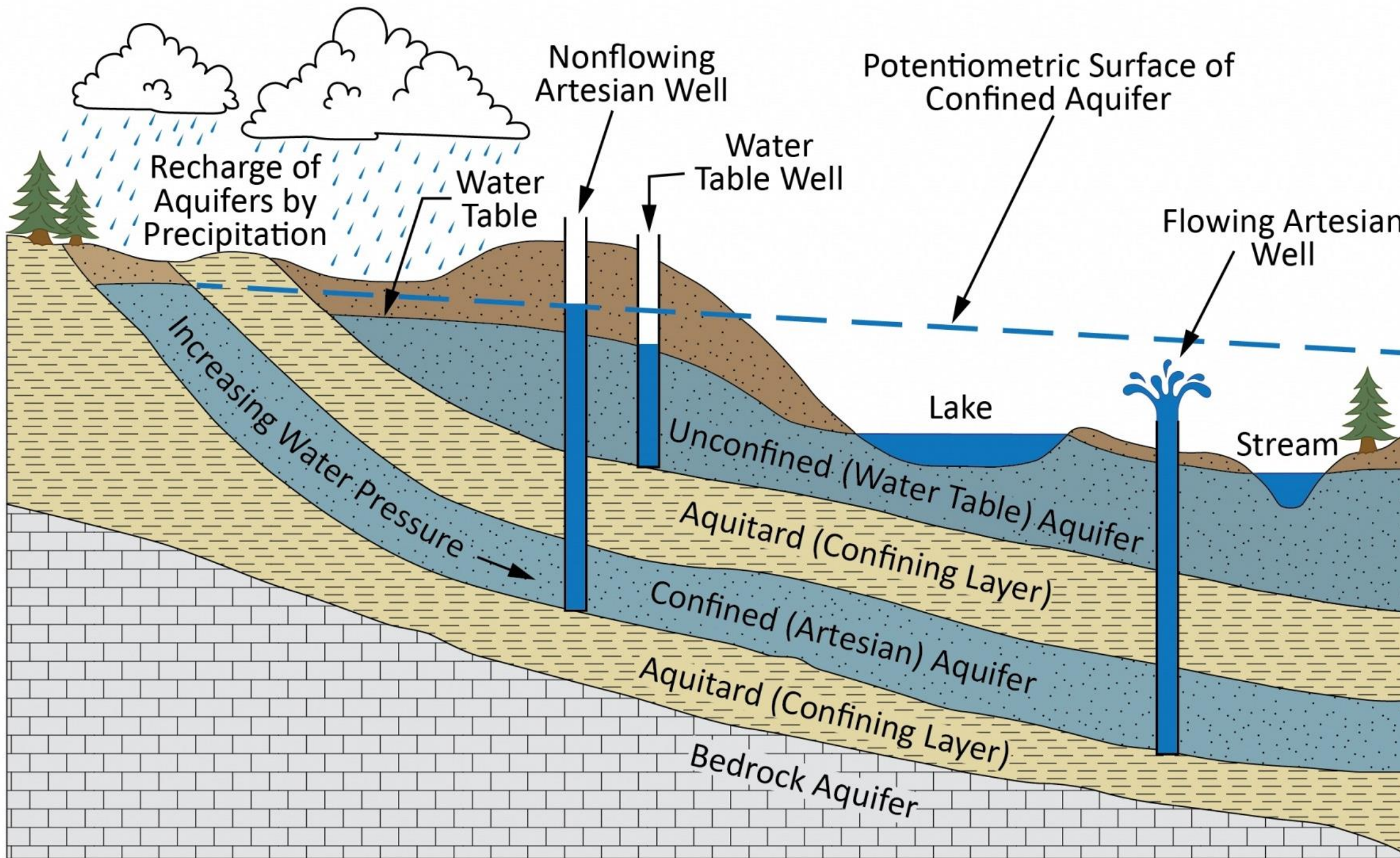
Water Scarcity

Many regions face water scarcity due to climate change and overuse. Sustainable water management is essential.

Glaciers (68.7%)



Groundwater (30.1%)



Permafrost (0.8%)



Detailed Demand Categories

1 Domestic

Includes drinking, cooking, bathing, and cleaning.

2 Industrial

Varies greatly depending on industry type. Can be a significant portion of total demand.

3 Commercial

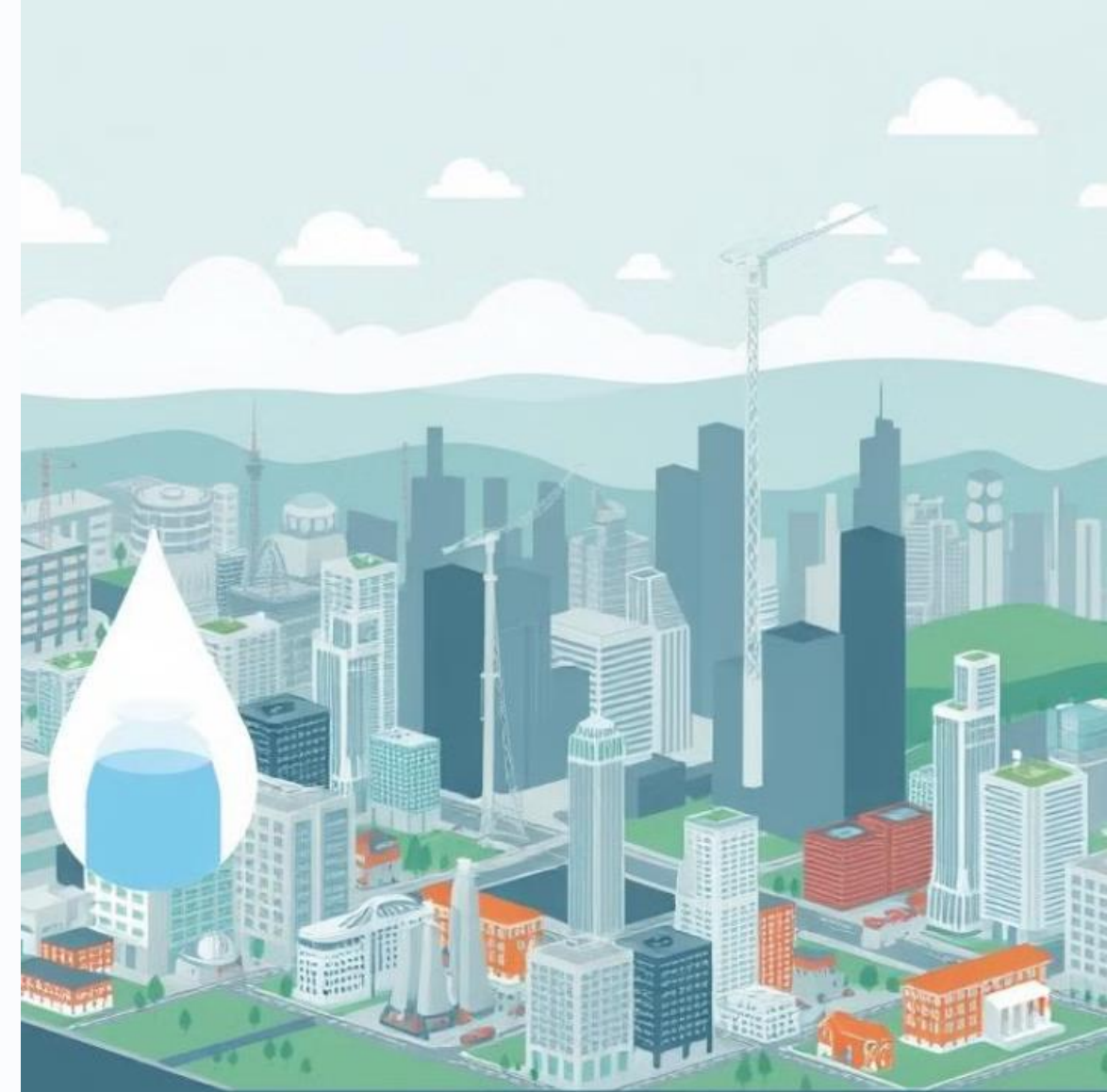
Includes schools, hospitals, offices, and retail spaces.

4 Public Use

Essential for maintaining public health and safety. Includes fire fighting and sanitation.

5 Loses and wastes.

Due to defective pipe joints, cracked and broken pipes, faulty valves and fittings



Residential
Water delivery



Industrial
Water delivery



Commercial
Water delivery

Water Loss and Waste

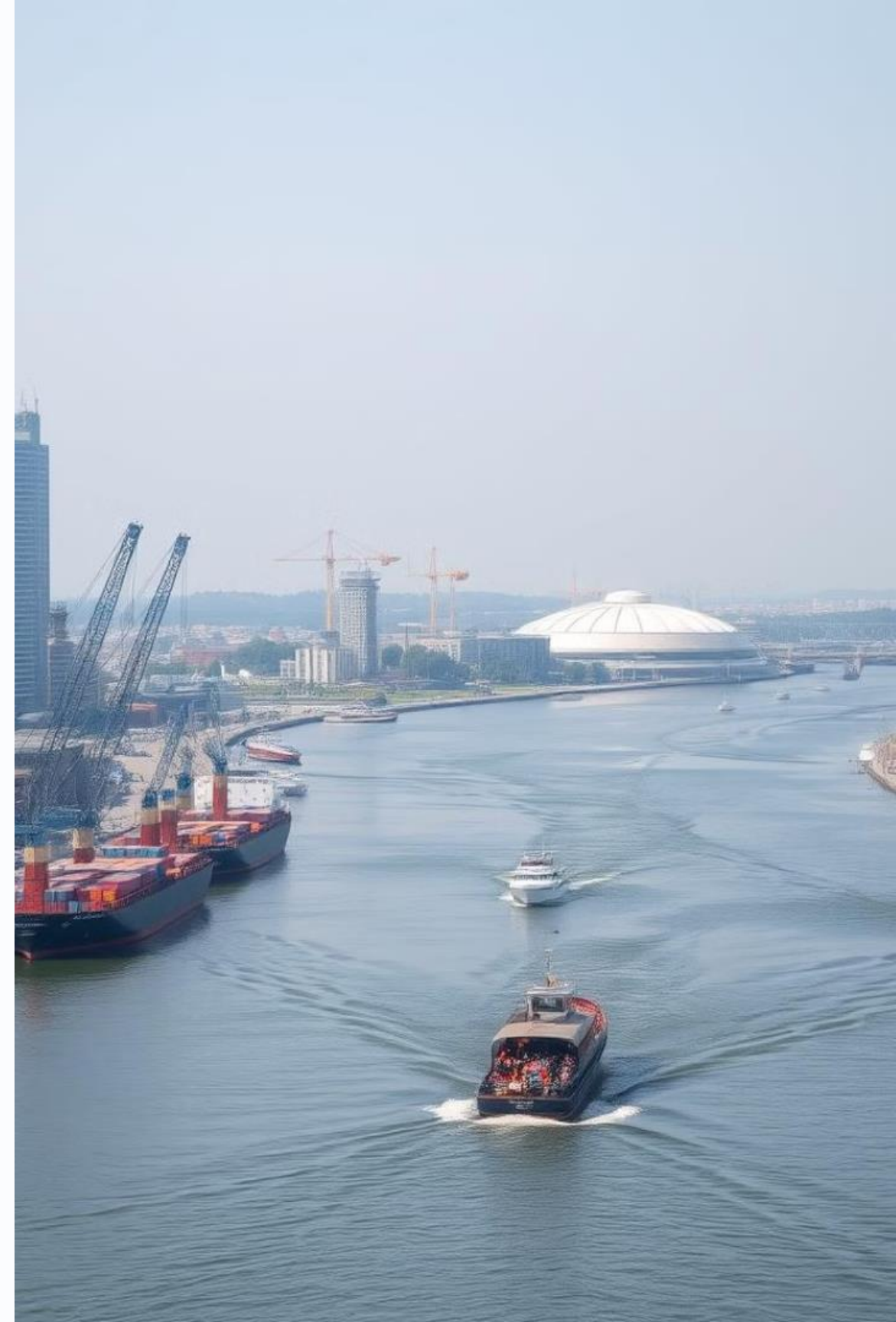
- Losses occur from leaks, bursts, and outdated infrastructure. Wasteful practices exacerbate water shortages.

كميات التزود المائي للأغراض المنزلية ونسبة فاقد المياه 2012 - 2022

السنة	كمية التزويد (م ³ م)	نسبة فاقد المياه %
2012	354	47
2013	381	48
2014	429	52
2015	440	51
2016	447	52
2017	458	48
2018	466	48
2019	474	47
2020	493	50
2021	521	53
2022	520	50

Factors Affecting Water Demand

Water demand is influenced by various factors. These factors play a crucial role in urban planning and resource management.



Factors Affecting The Water Demand

Size of the city



Big city



Small towns

Climate condition



More in summer



Winter

Less in winter

Cost of water



Rate



Rate

Distribution System



Pressure high



Pressure low

Supply system



Good supply



Bad Supply

Quality of water



Good quality

Bad quality

Habit of people
عادات الناس
Living style



Variations in Water Demand

1

Seasonal Changes

Demand fluctuates seasonally, with higher usage during hotter months for irrigation and cooling.

2

Daily Fluctuations

Water usage peaks during certain times of the day, influenced by daily routines and activities.

3

Weekly Patterns

Demand can vary throughout the week, influenced by weekdays versus weekends and specific events.

Water Demand Fulration



00 1111 1993 700 2013 2014 2001

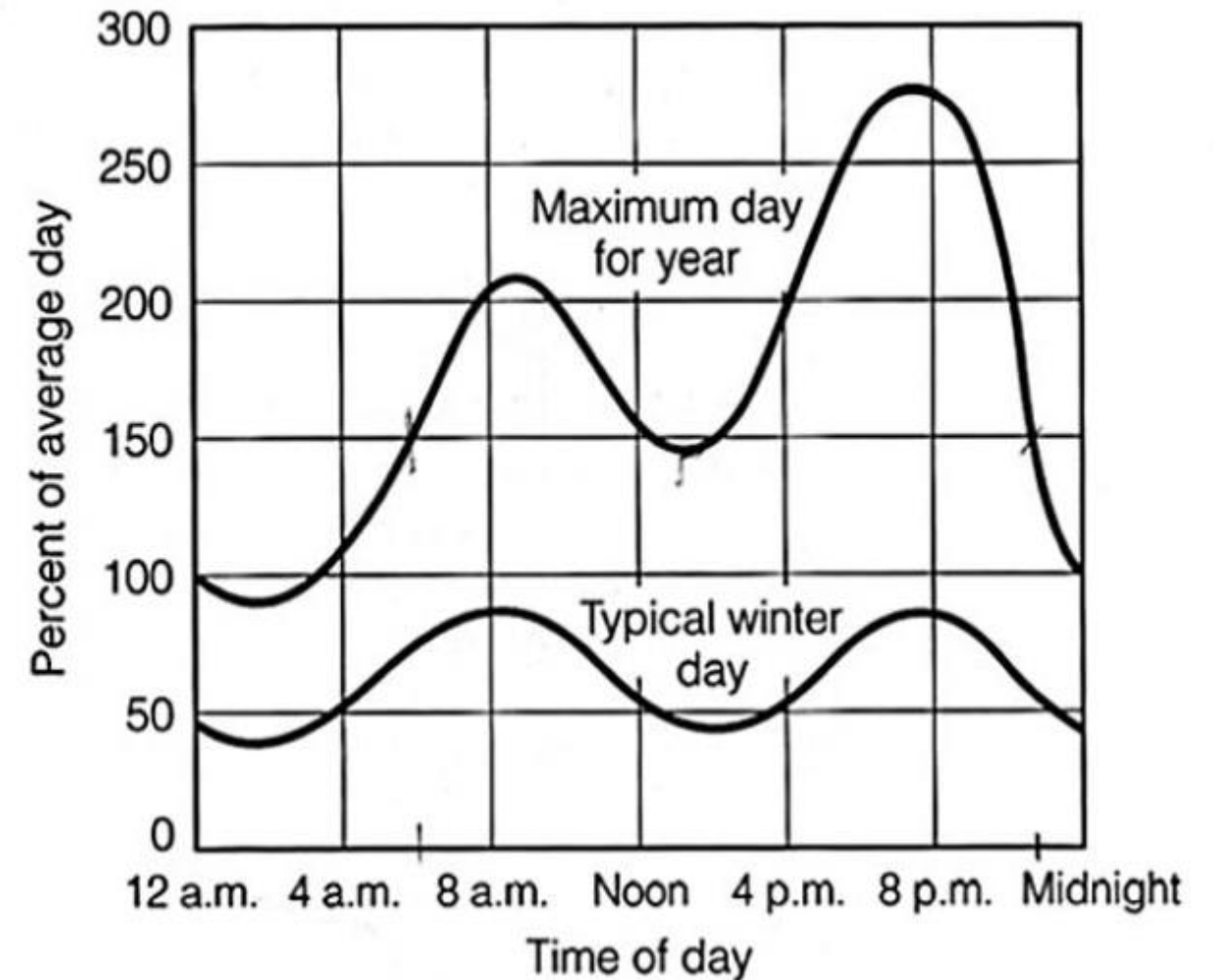
Calculating Water Demand

The R.O. Goodrich formula helps estimate demand variations. It uses time in days to calculate the percentage of annual average consumption.

$$P = 180 * t^{-0.1}$$

Where P is the percent of annual average consumption, and t is the time in days (2/24 - 365 days).

Typical daily cycles in water demand





Daily Water Consumption

Average Daily Demand (ADD)

ADD represents the average water use per person per day. It's calculated by dividing the total yearly water requirement by the design population.

$$Q = \frac{q}{P} \text{ (L/C/day)}$$

- **q** is total yearly water required for city in liters in day.
- **P** is design population.

Maximum Daily Demand (MDD)

MDC is the highest daily water consumption during any single day of the year. It's typically estimated as 180% of the ADD.

$$\text{Max daily demand} = 1.8 * \text{Average daily demand}$$

$$\text{MDD} = 1.8 * \text{ADD}$$

Weekly and Monthly Water Demand

1 Maximum Weekly Demand

This is the peak consumption during any week of the year. It's typically around 148% of the average daily demand.

Max. weekly Demand = 1.48 x
Avg. daily demand

2 Maximum Monthly demand

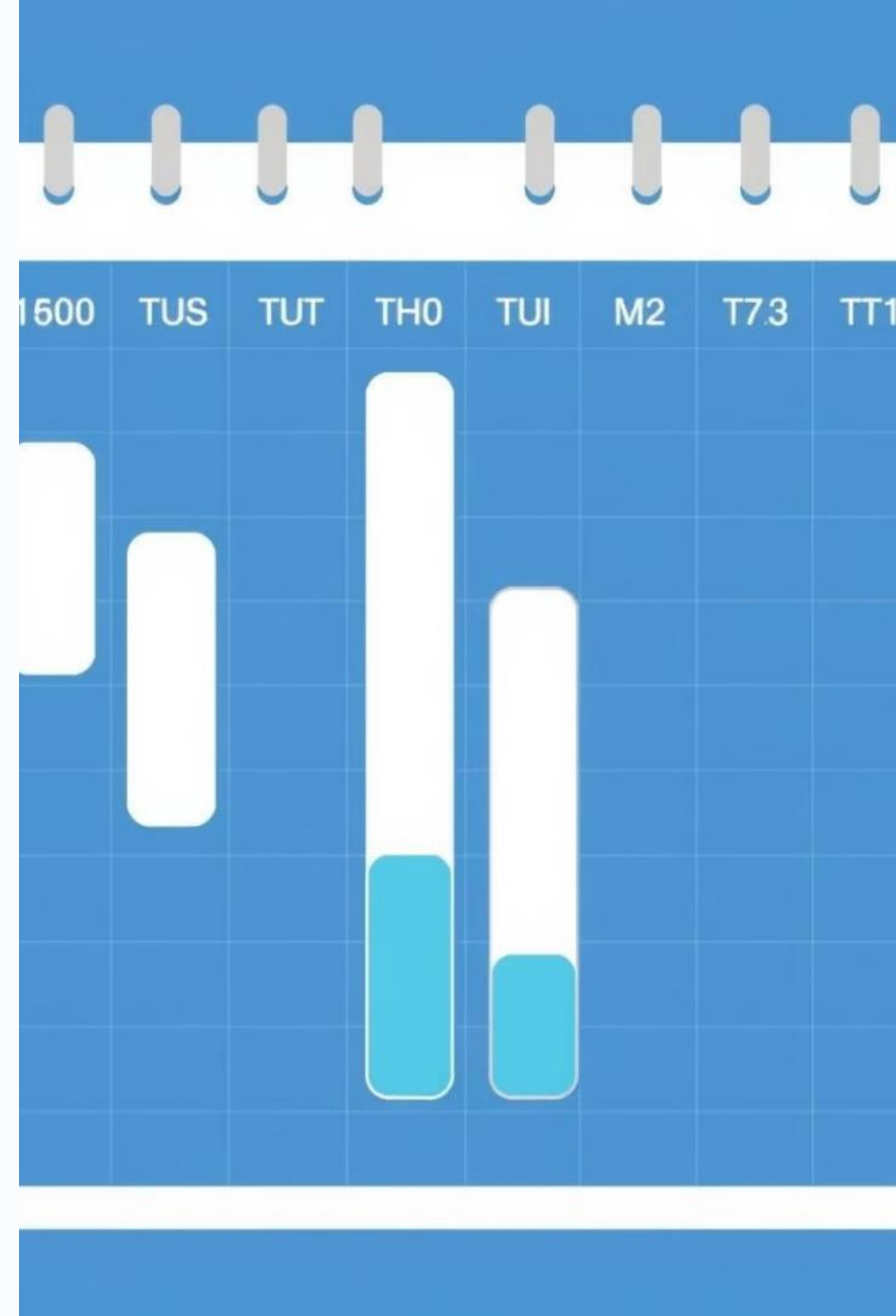
The highest consumption in any given month. It's estimated to be about 128% of the average daily demand.

Max. monthly demand = 1.28
x Avg. daily demand

3 Maximum Hourly demand (MHD)

The peak hourly demand during the year. Crucial for pump design, often calculated as 2.7 times the ADD.

$$\begin{aligned} \text{P.H.D} &= 1.8 \times 1.5 \times \text{ADD} \\ &= 2.7 \times \text{ADD} \end{aligned}$$



Example 1

If the average daily consumption (ADD) is 670 lpcd, calculate the maximum daily demand (MDD) and peak hourly demand (PHD).

$$\text{MDD} = 1.8 * \text{ADD} = 1.8 * 670 = 1206 \text{ lpcd}$$

$$\text{PHD} = 1.8 * 1.5 * \text{ADD} = 2.7 * 670 = 1809 \text{ lpcd}$$



Example

What will be the average daily consumption, max. daily & peak hourly demand. For a town with a population of 85,000 persons and rate of water supply of 160 lpcd.(L/capita/day)

Solution:

$$1. ADD = Q * P$$

$$ADD = 160 * 85000$$

$$ADD = 13.6 * 10^6 \text{ l/d}$$

$$2. MDD = 1.8 * ADD$$

$$MDD = 1.8 * 13.6 * 10^6$$

$$MDD = 24.4 * 10^6 \text{ l/d}$$

$$3. PHD = 1.8 * 1.5 * ADD$$

$$PHD = 36.7 * 10^6 \text{ l/d}$$

$$= 36.7 * 10^6 \frac{L}{day} * \frac{1 m^3}{1000 L} * \frac{1 day}{24 * 60 * 60 sec}$$

$$= 36.7 * 10^6 * \frac{1}{1000 * 24 * 60 * 60} \frac{m^3}{sec} = 0.42 \frac{m^3}{sec}$$



Fire Fighting Required Calculation

*Total amount of water = No. of fires * Discharge * time of each fire*

Kuichling 's formula : $Q = 3182 \sqrt{P}$

Freeman formula : $Q = 1136 \left(\frac{P}{10} + 10 \right)$ معادلات تعتمد على عدد السكان

Buston's formula : $Q = 5663 \sqrt{P}$

[Q = amount of water required in liters/minute]

[P = population in thousands]

(Kuichling formula, Freeman formula and buston formula give higher results.

Because water for fire fighting is required for few times in a year.)



Fire Demand based on type of building

It is the quantity of water required for fighting a fire outbreak. Although the amount of water used in year for fire fighting is small the rate of use is large. The quantity of water required for fire should be easily available and kept stored in storage reservoir. In the city area fire hydrants are provided on the water mains at 100m to 150m apart. The minimum water pressure available at fire hydrants should be 1.0 to 1.5 kg/cm². The quantity of water required for fire can be found by using:

1- Insurance Services Office Formula (ISO, 1980):

$$F = 18 * C \sqrt{A} \quad \text{..... (In British units)}$$

$$F = 220 * C \sqrt{A} \quad \text{..... (In SI units)}$$

معادلات تعتمد على مساحة
الطوابق ونوعها

Where F = Fire Demand in liter/min , gal/min .

A = Area of Floors in m² (Effective floor area).

C = A constant with different values according to Construction

C= 1.5 : wood frame construction

C= 1 : ordinary construction

C= 0.6 : fire resistive construction



Example:

A community with population of 30000 capita has an average consumption of 750 Lcpd and fire flow by a building of ordinary construction with a floor area of 1000m² and a height of 6 stories. Determine the maximum water rate and the total water flow for domestic and fire demand:

$$\text{Max. daily consumption} = 1.8 * 750 * 30000 = 40.5 * 10^6 \text{ L/day}$$

$$F = 220 * C * \sqrt{A} = 220 (1) \sqrt{1000 * 6} = 17041 \frac{\text{L}}{\text{min}} = 24.5 * 10^6 \frac{\text{L}}{\text{day}}$$

$$\text{Max water use} = 40.5 * 10^6 + 24.5 * 10^6 = 65 * 10^6 \frac{\text{L}}{\text{day}}$$

Assuming fire duration is 10 hrs :

$$\text{Total water flow} = 40.5 * 10^6 * \frac{24}{24} + 24.5 * 10^6 * \frac{10}{24}$$

$$= 50.7 * 10^6 \text{ L}$$

Example

Determine the max. demand during a fire for a community with a population of 22,000 persons and an average water consumption of 600 lcpd. The fire flow is for a building of ordinary construction with a floor area 1000 m² and a height of 6 stories. The fire flow is maintained for 10 hours per day.

Given Data:

$P = 22,000$ persons $q = 600$ lpd (Liter/person/day)

$C = 1$

Floor area = $a = 1000$ m² No. of stories = 6

Duration of fire = 10 hours/day

Required: $Q = ?$

Solution:

Step 1:

$$ADD = q * pop. = 600 * 22000 = 13.2 * 10^6 \frac{L}{d}$$

Step 2:

$$MDD = 1.8 * ADD = 1.8 * 13.2 * 10^6 = 23.76 * \frac{10^6 L}{d}$$

Step 3:

$$\begin{aligned} \text{Fire flow} &= 220 * C * \sqrt{A} \\ &= 220 * 1 * \sqrt{1000 * 6} \text{ L/min} \\ &= 24.54 * 10^6 \frac{L}{\text{day}} \end{aligned}$$

Step 4:

$$\begin{aligned}\text{Max. demand during fire} &= \text{MDD} + \text{FF} \\ &= 23.76 * 10^6 + 24.54 * 10^6 \\ &= 48.3 * 10^6 \text{ l/d}\end{aligned}$$

$$\begin{aligned}\text{Total water flow} &= 23.76 \times 10^6 \times \frac{24}{24} \times 10^6 \times 24.54 + \frac{10}{24} = \\ &= 33.98 \times 10^6 \text{ L} \\ &= 33.98 \times 10^3 \text{ m}^3 \\ &\cong 34 \times 10^3 \text{ m}^3\end{aligned}$$

Example Problem

Determine the max. demand during a fire for a community with a population of 40,000 persons and an average water consumption of 700 lpd. The fire flow is for a building of ordinary construction with a floor area of 1200 m^2 and a height of 4 stories. The fire flow is maintained for 8 hours per day.

Solution