Collection and Distribution of Water

- Deals with the transport of water from the source through the treatment plant to the consumers.
- It requires
  - intake structures,
  - transmission lines,
  - distribution pipe networks and
  - other essential accessories.
Surface water Intakes

- Floating intakes
- Submerged intakes
- Tower intakes
- Shore intakes
- Pier intakes

Reservoir Intake
Tower Intake

Submerged Lake Intake
River Intake

- Major components
  - Screen inlet
  - Intake pipe
  - Intake sump
  - Suction pipe
  - Pumps
  - Gate and foot valves
  - Access

Intake Structures

Figure: an example of a lake intake
locating the positions of intakes

- Avoid wastewater discharge points and pollution hazard
- enable withdrawal of water from a range of levels
- Magnitude and direction of stream or current velocities should not affect the function and stability of the intake structure.
- Reliable access roads and power sources should be available
- should be near to treatment plant
- Should not interfere with navigation requirements,
- major environmental impacts should be avoided

Design Criteria for intake structures

- Design capacity = Q max-day
- Intake velocity should be ≤ 8 cm/s
- vertical positions intake ports should be such that good quality water is withdrawn.
- Locate the top intake port at a distance not less than 2 m from the normal water level and the bottom port at least 1 m above the bottom.
Intake design

- **Volume of sump** → detention time. A detention time of at least 20min is recommended.
- At least two sumps - to avoid interruption of service.
- **Height** (with a freeboard about 0.5m)
- Location of the bottom of the sump should be > 1.5m below the lowest stream level or > 1m below stream bed.

**Example 1: River Intake design**

- Given the following information proportion a suitable river intake.
  - Daily demand 5000 m³
  - Pump capacity: 50 l/s (working 8 hr/day)

```
HWL 1209.1 m
LWL 1202.5 m
V 1200.1 m
River bank
```
Example 1 Solution

- Capacity of each pump daily = 8 x 3600 x 50 / 1000 = 1440 m³
- Number of pumps = 5000 / 1440 = 3.47 ≈ 4
- Hourly flow of each pump = 5000 / (4 x 8) = 156.24 m³/h
- Take detention time, $T_d = 20$ min
- $\Rightarrow$ capacity = $T_d \times Q = (20/60) \times 156.24 = 52.08$ m³

Example 1 Solution

- Effective height of sump = 6.6 + 1.5 = 8.1
- Free board = 0.5
- Total sump height = 8.6 m
- If we use circular sump diameter = 2.86 m
Pipelines and appurtenances

The selection of pipe materials is based on
- carrying capacity
- strength
- ease of transportation and handling
- availability
- quality of water
- cost (initial and maintenance)

• **Cast iron pipes:**
  - highly resistant to corrosion, strong but brittle,
  - easy jointing, withstanding high internal pressure, long life
  - very heavy and difficult to transport
Pipelines and appurtenances

- **Steel pipe:**
  - strong, very light weight and can withstand higher pressure than cast iron pipes.
  - cheap, easy to construct and can be easily transported
  - cannot withstand external loads, affected by corrosion and are costly to maintain.

- **Cement-lined cast iron pipes:**
  - cement protect against corrosion.
  - very small coefficient of friction than unlined cast iron pipes.
Pipelines and appurtenances

• **Plastic pipes:**
  ▫ corrosion resistant, light weight and economical.
  ▫ Rigid (unplasticized) uPVC is stronger and can withstand much higher pressure for a given wall thickness.

---

Pipelines and Appurtenances

• **Valves:**
  ▫ to isolate segments of a pipeline, to regulate rate of flow, to control pressure, and to allow release or entry of air from pipe system.

• **Factors considered in the selection of valves:**
  ▫ include purpose and operation,
  ▫ capacity required,
  ▫ head loss and rate of flow,
  ▫ cost,
  ▫ availability, etc.
Pipelines and Appurtenances

- **Shutoff valves:**
  - to stop the flow of water through a pipeline
  - spacing from 150 to 370m
  - a minimum of three of the four pipes connected at a junction are valved.
  - fire hydrant, in inlet, outlet, and bypass lines
  - Gate valves and butterfly valves

Pipelines and appurtenances

- **Check valves:**
  - semiautomatic device and permits water flow only in one direction.
  - in the discharge pipes of centrifugal pumps → prevent backflow
  - in conjunction with altitude valves
Pipelines and appurtenances

• **Altitude valves**:  
  ▫ to automatically control the flow into and out of an elevated storage tank or standpipe to maintain desired water level elevations.  
  ▫ include double-acting sequence valve, single-acting type, or differential altitude valve

Pipelines and appurtenances

• **Air-release and vacuum valves**:  
  ▫ Air-release valves installed at high points of distribution piping, in valve domes, and fittings, and in discharge lines from pump to discharge the trapped air.  
  ▫ Vacuum valves are used to protect pipelines from collapse as they are emptied, by allowing air to enter the pipes.
Pipelines and appurtenances

- **Pressure reducing valves (PRV):**

- **Pressure sustaining valves (PSV):**
Distribution systems

• Depending upon the level of the source of water and the city, topography of the area, and other local considerations,

  ▫ Gravitational system,
  ▫ Pumping without storage, and
  ▫ Pumping with storage.

Distribution systems

• Gravitational system:
  ▫ action of gravity without any pumping
  ▫ most economical and reliable
  ▫ for cities situated at foothills
**Distribution systems**

- **Pumping without storage:**
  - treated water is directly pumped into the distribution mains without storing
  - High lift pumps → operate at variable speeds → to match variable water demand
  - Disadvantageous (power failure) ← no reserve flow
Distribution systems

- **Pumping with storage:**
  - treated water is pumped at a constant rate → stored in elevated distribution reservoir → distributed to the consumers by the action of gravity
  - excess water during low demand period gets stored in the reservoir → supplied during high demand periods.
  - pumps work at uniform rate → high efficiency
  - quite reliable (even during power failure)
Layout of distribution systems

- **Pipe networks:**
  - *Primary or arterial mains*
    - from the *pumping stations* and from *storage facilities* to the various *districts* of the city.
    - valved at intervals of not ≤ 1.5 km
  - *Secondary lines or Sub-mains*
    - run from one primary main to another
    - located at spacings of 2-4 blocks
  - *Small distribution mains or branches*
    - supply water to every consumer and to the fire hydrants

layout of distribution pipes generally follows the road pattern

four types of pipe network layouts –
- *dead end system or branch system,*
- *gridiron system,*
- *ring system,* and
- *radial system.*
Layout of distribution systems

• **Dead end system**
  - solved easily
  - Lesser number of shut-off valves
  - Shorter pipe lengths and the easy to lay pipes
  - cheap and simple and expanded easily
  - dead ends \(\rightarrow\) prevent circulation of water
  - Problematic if a pipe is damaged

![Diagram of dead end system](image)

Layout of distribution systems

• **Gridiron systems**
  - Discharge, friction loss and pipe size is less
  - Not problematic if a pipe is damaged
  - No dead ends \(\rightarrow\) allows circulation of water
  - Good for fire fighting
  - more pipelines and shut-off valves
  - high cost of construction
  - design is difficult and expensive

![Diagram of gridiron system](image)
Layout of distribution systems

- **Ring systems:**
  - closed ring, circular or rectangular
  - suitable for well-planned towns and cities
  - Generally at high demand areas
  - Not problematic if a pipe is damaged
  - No dead ends → allows circulation of water
  - Good for fire fighting
  - more pipelines and shut-off valves
  - high cost of construction
  - design is difficult and expensive

![Ring System Diagram](image)

Layout of distribution systems

- **Radial systems**
  - For city or a town having a system of radial roads emerging from different centers
  - distribution reservoirs at these centers
  - From mains → pumped into the DRs placed at different centers and then to the service areas.
  - ensures high pressure and efficient water distribution

![Radial System Diagram](image)