Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 04
Pumping and Storage
Lecture - 16
Pumping Stations

Pumping and Storage will be covered in Module 4, Lecture 16

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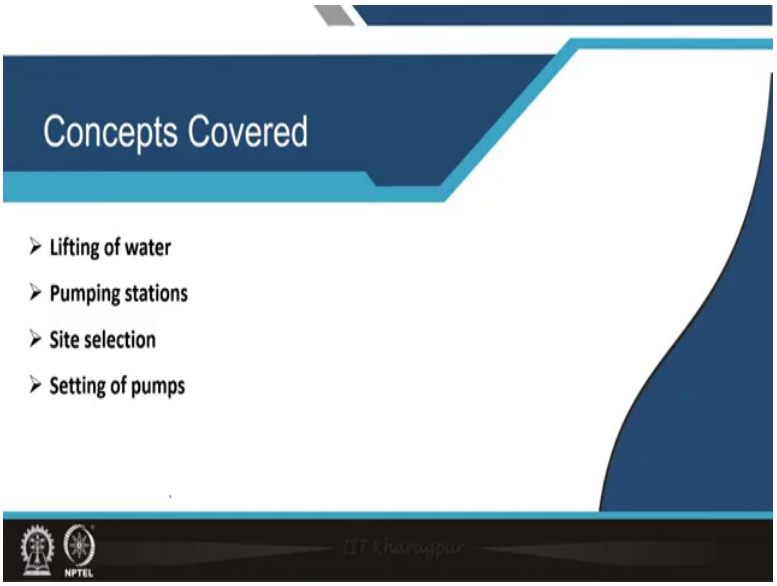

The different concepts covered are on the lifting of water, pumping stations, site selection for pumping stations and setting or sizing of pumps.

Lifting of water

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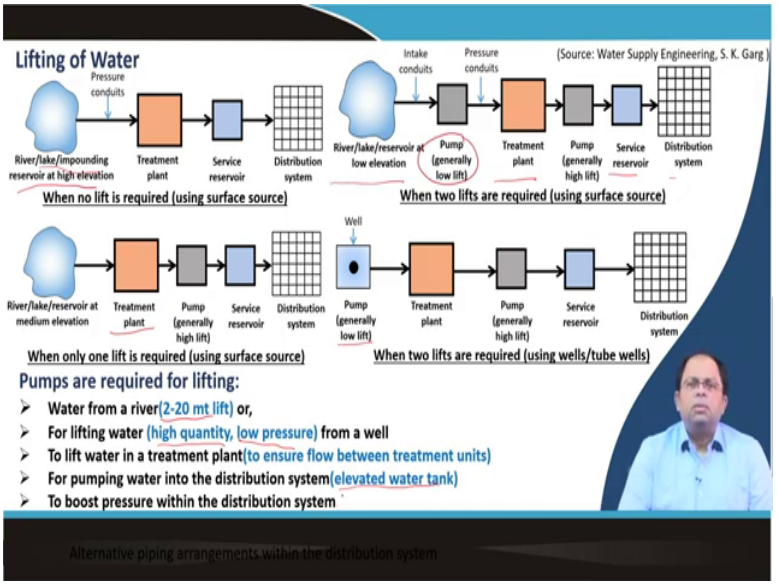

In water supply systems, the different components may be arranged in different ways, such as:

When no lift is required (using surface sources)

Here, lift refers to the lifting of water from surface sources. In these systems, the river, lake or the impounding reservoir is at high elevation, and water will flow from that elevation to lower elevations because of gravity. Water automatically reaches the treatment plant and can then be sent to a service reservoir and then to the distribution system. The assumption is that the water body is above the treatment plant, and the treatment plant is above the service reservoir. However, in most cases, it will be required to lift the water. High pressure enables flow through the pipelines, and hence, it is called pressure conduits instead of gravity flow.

When only one lift is required (using surface sources)

Here, the water source may be already at a higher level, and water can be conveyed to a treatment plant without lift. Lift is required to transport the water from the treatment plant at the ground level to a high elevation service reservoir or an overhead tank so that it will

automatically flow to the distribution network. This is achieved using a high lift pump. A pump is operated to lift water once or twice a day based on the water supply requirements.

When two lifts are required (using wells/tube wells)

A low lift pump is employed to lift the water from a deep tube well because the total head is not high. Water is then conveyed to the treatment plant at the ground level from where it is lifted to a service reservoir using a high lift pump right. Here, water is pumped from the water source, unlike the previous systems.

When two lifts are required (using surface sources)

If the surface water source is lower than the treatment plant, water is conveyed through intake conduits to the pump, which generates pressure and conveys water to the treatment plant through pressure conduits. A high lift pump is used from the treatment plant to lift the water to an overhead reservoir and then finally to the distribution network.

The previous section detailed the positioning of pumps for different systems.

<u>Pumps are required for lifting:</u>

- Water from a river with a lift of approximately 2 to 20 metres.
- Water from a well in high quantity, but the pressure is low.
- The water inside a treatment plant to ensure flow between different processes such as sedimentation, coagulation etc. For example, if the treatment plant is set up in undulating terrain, it may be needed to lift the water within the treatment plant itself. Similarly, when rapid gravity filters are employed, lifting water may be required, after which water can be allowed to flow down.
- Water into the distribution system (elevated water tank). High lift pumps are used to boost pressure within the distribution system. Overhead reservoir height affects the water pressure. Distance water has to travel, overcoming friction can help determine the height of the overhead tank. This distance may vary with time-based on the requirements posed by urban growth or development of a new neighbourhood which may not be exactly predictable. So, when water is needed to be provided farther than planned, the pressure of pipe water may reduce and get lowered than standard

requirements. In such situations, pumps may be employed to boost pressure in the system. These are called boosting stations.

Pumping stations

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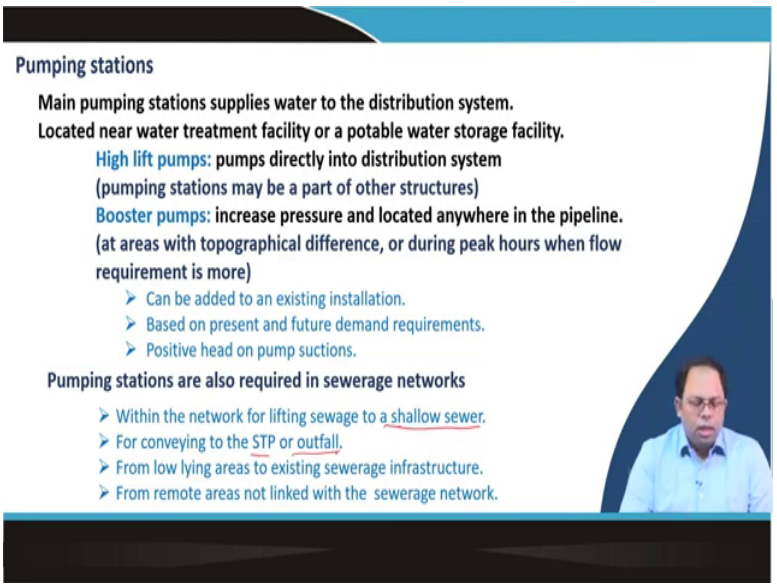

Pumping stations supply water to the distribution system and usually are located near the water treatment facility or a potable water storage facility. It is required to locate the main pump or the high lift pump near the water treatment plant or near the overhead tank. Multiple factors need to be considered, such as the distance between the storage reservoir and the treatment plant, availability of land, pressure requirements, terrain etc. And it could be either near the water treatment facility or towards the water storage facility because a pump can be installed anywhere along the pipeline.

High lift pump - pumps directly into the distribution system, and the pumping station may be part of other structures such as the treatment unit to pump the water to the overhead reservoir or along with the overhead tank.

Booster pumps - increases pressure and can be located anywhere in the pipeline. These are generally required in areas with topographical differences. For example, suppose there is a hilly area within the locations served by a distribution network connected to an overhead supply. In that case, it is required to supply water to be distributed at a higher pressure to

reach the houses located on the area at this high elevation. It may not be economical to decide the height of the overhead reservoir based on the extra pressure requirement only for the small hill area. Instead, a small booster pumping station can be located to increase the water pressure to enable supply to the hilly zone. Boosting stations may also be required when the flow requirement is more such as when the pressure gets dropped than required when a lot of people open taps and use water during peak hours. These pumps could be added to an existing installation. A booster pump can be used if there is a need to expand the network based on present and future demand requirements from the existing fixed network served by an overhead tank. It can also help in achieving positive head on pump suctions.

Requirement of pumping stations in sewerage network:

Similar to the water supply, pumping stations are required in the sewerage system to handle stormwater or raw sewerage as well. Pumping stations are required

- Within the network for lifting sewage to sewers laid at an upper level due to various constraints.
- For conveying to the STP or outfall such as into a river where sewage comes out of pipelines and are discharged into water bodies. These outfall points could be at a higher level, and there may be a need to pump the sewage using lifting stations.
- From low lying areas to existing sewerage infrastructure
- From remote areas not linked with the sewerage network, a pumping station may be used to boost the sewage and connect it to the sewerage network.

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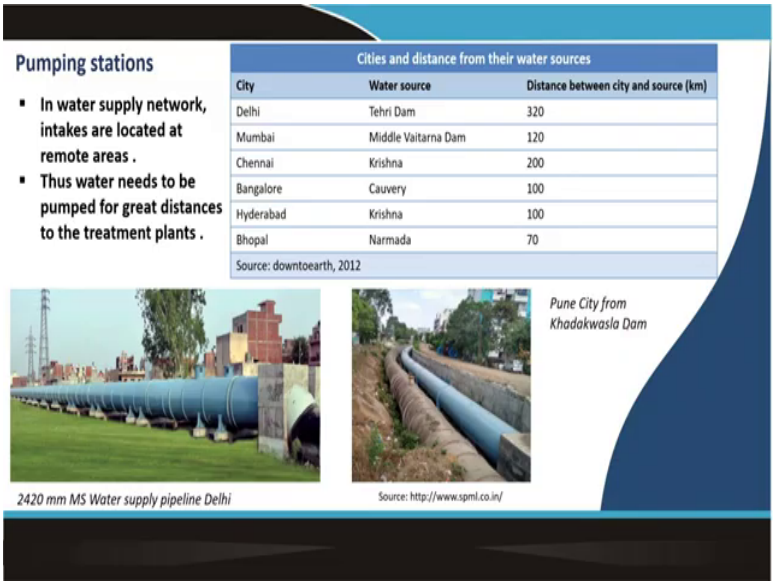

Pumping stations are of different kinds, such as a high lift pumping station or a low lift pumping station. It is generally observed that the intakes or the points from where water is drawn is far away from the area which is served, requiring to pump water for long distances. This required high-pressure pumping stations. The above figure shows the water supply pipeline for Delhi, which is 2420 mm in diameter, and a pipeline from the Khadakwasla dam in Pune.

In case of Delhi, water is being taken from Tehri dam, which is 320 kilometres away, which is the main source. Similarly, the Middle Vaitarna dam supplies water for Mumbai, which is around 120 kilometres away, Krishna river supplies water to Chennai that is around 200 kilometres away, Kaveri river for Bangalore at 100 kilometres distance, Krishna river for Hyderabad that is 100 kilometres away and Narmada river for Bhopal around 70 kilometres away. So, water has to be pumped so that it can be transported at such large distances.

Site selection for pumping stations

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Availability of space is an important criterion. It is easier to consider the government land as its rules out the need for acquiring land if the government land location is suitable since these infrastructure are made by government departments or the government itself.

However, there may be a need for acquiring land at a particular location to locate a pumping station. Certain criteria have to be followed, such as:

- It depends on the location of the place from where water is received and where water is supplied.
- Away from sources of pollution and contamination. In case of a heavy rainfall, runoff from one zone to another may lead to the mixing of polluted water with treated water.
- Above the highest flood level in case it is adjacent to a river. The reason is that, flood water may again flow back into the pumping station and may contaminate the entire system. This is very critical for sewerage networks. A topographic survey and flood plain analysis can help to understand the previous incidents of flood during a certain number of years. In the case of a river, dry weather flow and changes in river course are also to be considered while locating pumps to ensure sufficient water availability

during peak demand. The location of intakes and the location of the pumping station is more or less synonymous in this particular aspect.

- Availability of water, power - water is required for both the maintenance of the pumping station and for use by the working staff. Power is essential to run the system.
- Roadway access - for removal of machinery, bringing machinery etc.
- The surrounding land use - it is better not to have in a very dense residential area. There is a risk of flooding in the surrounding areas because of pump failure or due to heavy rainfall.
- Drainage that enables runoff away from the structures
- Fire hazards - because these are all mechanical equipment running for long periods, there is a risk of fire occurrence.
- Size and type of pumping stations
- Operators health and safety issues - particularly important for sewage treatment plants
- Visual impact particularly odour noise problems.

Setting of pumps

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The above figure shows a 500 million litres per day water pumping station in Bangalore and a water pumping station in Kolkata. A large hall or structure houses several pumps which are aligned one after another and connected to one line.

It is necessary to understand how these pumps are set up, how they are connected with the supply lines or the exit lines, and at what level it is set up, etc. Pumps can be placed both below and above the level of water in the sump well. Water first reaches the sump well where it is stored. So, a sump well is present near the pumping stations.

If a pump is below the water level:

- Pump is not kept in the same chamber as the sump. It is placed in the adjoining dry pit, so one chamber is dry, and one chamber is a wet chamber, where the water comes in.
- All the pumps are connected to a common suction pipe as shown in the above figure, from which the water is drawn.
- Sluice valves are used to isolate pumps by stopping the flow of water inside the pump. This is done to make repair works easier to do periodically.
- Priming is not required since pump is below water level. Priming refers to allowing the entry of water inside a pump to replace the air; If the air is not removed, then the water cannot enter when the pump is rotating. In this case, since the pump is below the sump level, the pressure of water automatically allows the water to get inside the pump and then the pump starts running, eliminating the need for priming.
- Pump drive (electric usually) is above and connected via vertical shafting. Pump drive refers to the movement or mechanisms inside the pump employing an electric or a fuel motor. The drive is usually placed at a higher level and generally outside. So the risk from flooding is kept minimum. A shaft connects to drive the moving mechanism inside the pump, which could be either horizontal if it's at the same level or vertical when it's at a different level. In this case, it is vertical.

If a pump is below the water level:

- Elevation as per the suction lift and usually limited to 5 meters

- Pump drives are at the same level and horizontally coupled (because it is at the same level).

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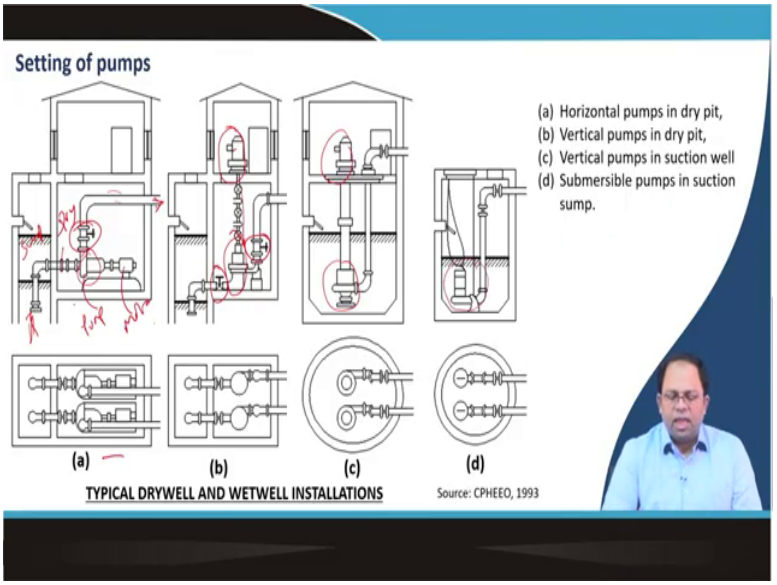

The above image shows the different ways of set-up.

Horizontal pump in dry pit – Horizontal and vertical section of the set-up is shown in the above image. Sump, dry pit, pump, motor, pipe and valves are marked in the above figure. Valves restrict water from coming back; the valve present at the front prevents water to get in.
Vertical pumps in a dry pit – Here, the motor is placed in the above chamber. A vertical shaft drives the pump. Valves prevent water from getting back in when the pump is not running. An electric motor is present.
Vertical pumps in suction well – Pump is below the water level (inside the suction well), and the motor is outside and in the above chamber
Submersible pumps in the suction sump - The entire pump is actually submerged.

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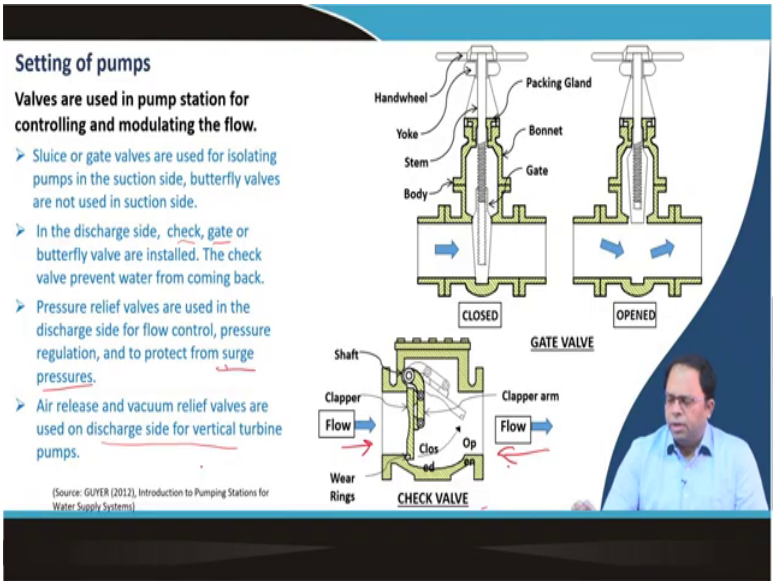

Valves:

Valves are used in pump stations for controlling and modulating the flow.

As discussed earlier, it may be needed to restrict flow, allow flow, etc. Even though multiple pumps are connected to the same pipeline, it may not be needed to operate all the pumps together, and such valves can isolate certain pumps from the system. In case of a Centrifugal pump, it is needed to prevent the water from coming in otherwise, the pump will rotate in the opposite direction because of the pressure of water. Valves can be useful to achieve all these.

- *Sluice valves or gate valves* - are used for isolating pumps in the suction side (suction side is the side from where water is drawn in), and *butterfly valves* are not used in the suction side.

- On the discharge side, a *check, gate or butterfly valve* is installed. The check valve prevents water from coming back. These three valves follow similar principles but are different in their design, as shown in the above figure. In the case of the check valve, the clapper arm movement allows water entry and prevents the backflow of water.

- *Pressure relief valves* are used in the discharge side for flow control, pressure regulation, and protection from surge pressures. Pressure may build up in the system

for various purposes, such as a change in the size of conduits, water hammer effect (water starts moving inside very fast). So to protect from surge pressure and avoid damage, a pressure release valve can be employed, which opens up whenever the pressure exceeds a specific value and allows extra water to get out.

- *Air release and vacuum relief valves* are used on the discharge side for vertical turbine pumps because air gets inside the pipeline and restricts the smooth movement of water. These valves release the air.

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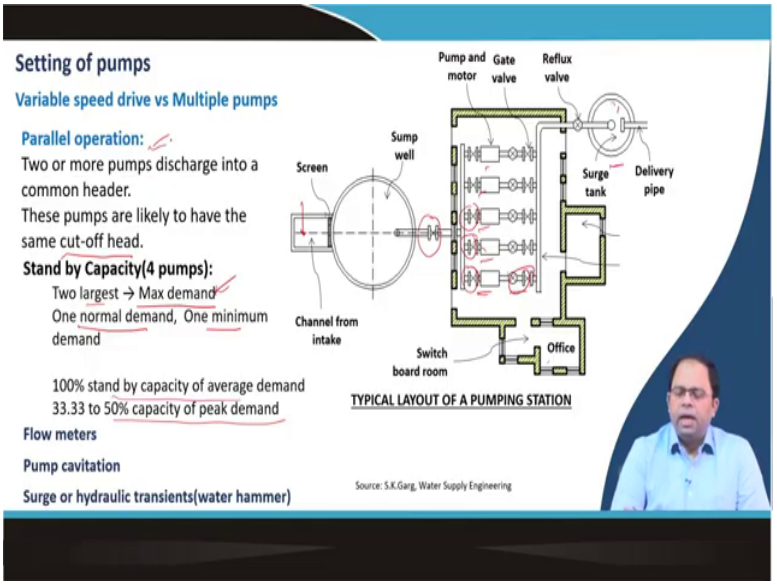

The above image shows the layout of a pumping station. The channel for intake is connected to a screen to restrict the entry of impurities and other larger floating matter. A similar kind of set-up is there in the sewage lifting station, where a screen prevents the entry of unwanted particles. Pumps are prone to damage with the entry of such impurities, and hence it has to be screened out. The sump well is then connected to the common suction pipe via a valve. Multiple pumps are connected to the suction pipe via a sluice valve. In a sluice valve, rotation of a handwheel allows the opening and closing of the valve enabling restriction or passing of water (Refer to the figure of the gate valve given in the previous slide). These pumps are connected to the discharge pipeline via valves (check valves or butterfly valves) to prevent backflow on the discharge side.

Switch rooms for turning on and off the pumps are present in the pumping station. Surge tank to handle the extra pressure in the pipeline. In a parallel operation, multiple pumps discharge into a common header (pipeline), and these pumps are likely to have the same cut off head (highest amount of pressure generated).

While designing the pumping systems, variable speed pumps can be used, or multiple pumps with varying capacity can be installed. This is because the amount of water to be discharged varies with time. A variable speed pump is costly and is generally not used. Also, if one pump (variable speed) fails, there is no backup. So, Multiple pumps of different capacities are generally installed. For example, in a stand by capacity of 4 pumps, two large pumps will serve the maximum demand; one pump can be for normal demand and one for serving the minimum demand. In case anyone fails, the other pumps can compensate. This system enables 100 percent backup or standby capacity of average demand, 33.33 to 50 percent peak demand capacity. In this system, all the pumps may not run at the same time.

Flow meters are used to determine the amount of volume of water that is being discharged. Metering is done at both the pump end and also at the residential end.

Pump cavitation refers to the change in pressure when there is a change in flow along the pipelines or when the flow is disrupted. Surge or hydraulic transients (Water hammer) refers to water moving faster in between certain zones or movement of water in different directions, which creates a sound and disrupts the water flow.

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Conclusion

- Pumps are required in both water supply and sewerage network
- Multiple pumps set-up is preferred over variable size pump,
- and this also ensures backup capacity.

References

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