Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module – 02
Urban Water Supply
Lecture – 08
Fluctuations in Urban Water Demand

In lecture 8, Fluctuations in Urban Water Demand will be covered.

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The different concepts that ~~would be covered~~are covered in this lecture are:

- Fluctuations in demand
- Assessment of fluctuations
- Effect of fluctuations.

Fluctuations in demand

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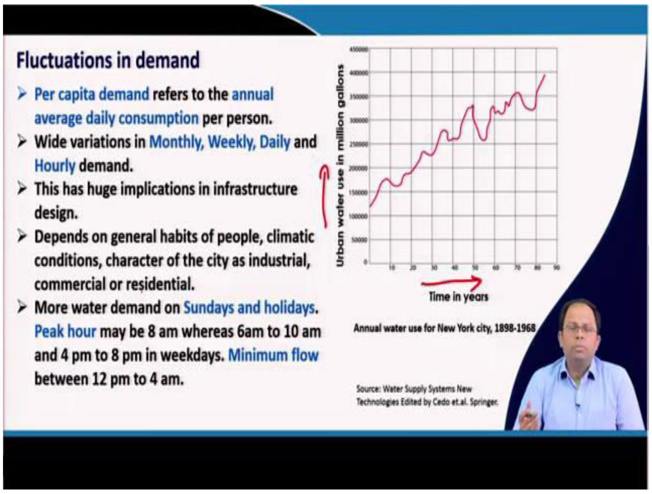

~~Fuctuations~~Fluctuations in demand refer~~s~~ to the annual average daily consumption per person.

- Wide variations occur~~s~~ hourly, ~~day to day~~daily, ~~week to week~~weekly ~~and even month to month~~, monthly ~~right month to month or we can also call it season to season.~~ or from season to season. It is important to

~~So, there is wide variations in this particular figure. So, even though when we determine this is the total water resource required for an urban area or this is the total water demand for an urban area we need to~~ understand the temporal because it has huge implications in infrastructure design, ~~variation in the demand during different because when we overall estimate the water demand it is like the average value it is for the overall urban area for a annual total water demand we will say in that terms.~~pump design, the operation of pumps, maintenance requirements

- ~~But at the end of the day we have to bring it down to per day and this value per day~~ etc. ~~varies by a huge margin. So, when we design our infrastructure, when we design our pumps, when we decide on how to operate, how long to operate our pumps, we need to have absolute values or the exact values of the demand for that particular day.~~

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~~So, that is why we need to understand the fluctuations in demand for water demand for an urban area. So, this is not only huge implications in infrastructure design, but it has got huge implications in the operation and maintenance of the infrastructure as well.~~

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- ~~So, this~~Fluctuations depend~~s~~ on the general habits of people. For example, an office going person would use more water in the morning according to domestic water demand.

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- ~~So, some of this you know maybe some of the daily demand hourly demands depends on the general habits. For example, people go to office then they come back. So, at certain times they will use more water and then it~~ D~~d~~epends on the climatic conditions, it depends on the character of the city as ~~a~~ industrial, commercial or residential.
- It depends on the character of the city. For example, ~~in industrial city there could be different shifts~~ there could be different work shifts in industrial cities, which may cause a difference in the usual peak hours considered.~~and so, you will see that before the shifts people will you know use water and then while coming back from the shifts they will use water. So, those kind of time periods will coincide with the demand or the peak demands for that particular urban area. So, this so, these are the different things that needs to be considered.~~
- ~~And, then we have got~~ M~~m~~ore water demand can be observed o~~o~~n Sundays and holidays. 6 am to 10 am, and 4 pm to 8 pm is the peak hour on weekdays, whereas ~~and peak hour may be around~~ 8 am on weekends. ~~whereas, 6 am to 10 am and 4 pm to 8 pm is the peak hour on weekdays.~~ So, during Sundays, the peak hour is 8 am. The minimum flow is observed between 12 pm to 4 am. ~~and whereas, for the other weekdays the peak hour is 6 am to 10 am and then in the evening from 4 pm to 8 pm.~~

These constitute the ~~So, this is the difference~~ fluctuations in the water ~~demand and minimum flow is observed usually between 2 pm to 4 am. So, these are kind of demands this could be differences in demands could be changed and~~ demand and ~~accordingly~~t~~. T~~ ~~t~~he ~~entire~~ water supply infrastructure~~, the entire equipments that is there in the~~ ~~such as the equipment, pipeline etc. that are used to supply water that has to be actually adjusted.~~~~be appropriately done~~has to be designed considering these fluctuations.

The graph given in the above figure shows~~So, in this particular figure you can see that~~ the annual water use for New York City starting from 1898 to 1968. This shows how urban water use (quantity) varies with time. ~~this has been plotted and this on this axis there is years and this axis this is water use in millions of gallons, right.~~ The plot shows several ups and downs and maybe because of several factors ~~involved in~~ affecting water use.~~So, you can see that how water use has steadily increased over the years and, but it has not just increased in a straight line. It has also there are also variation; sometime it has gone up, sometime it has gone down this variation may be because of many many other factors~~ S~~.~~

~~So, s~~ome of these factors could be because of certain events in the city; it may be~~, may be certain it may be linked with economic it could be~~ linked with the economic situation of ~~that~~ a particular city, urban development, etc. ~~maybe there is a there is lot of development was happening in that particular time. So, there was lot of water requirement and so on.~~

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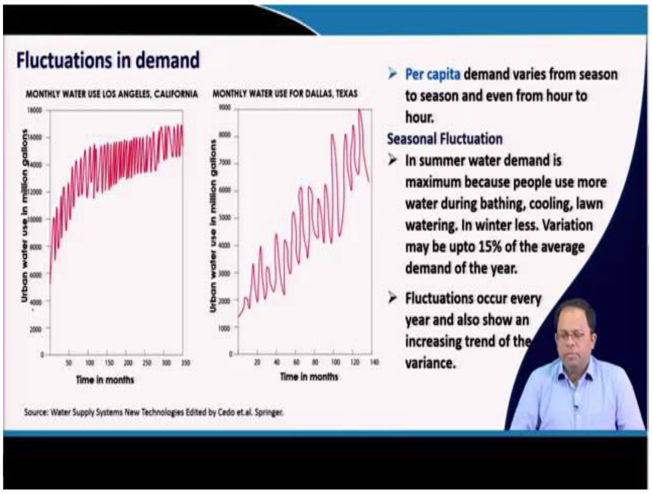

Seasonal fluctuations

In summer, the water demand is maximum because people use more water during bathing, cooling, lawn watering. In winter, these demands may be less. Variation may be up to 15% of the average demand of the year. ~~These variations may be up to 15% of the year's average demand;~~ It may be 15% higher in summer and lower in winter~~, and vice~~

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versa. So, then we talk about fluctuations in this per capita demand also varies from season to season and of course, it varies even from hour to hour.

But, when we talk about seasonal fluctuation we usually seen summer water demand is maximum because people use more water during bathing, cooling, lawn watering and so on. In winter the demand is less, but as I was discussing earlier sometimes people keep their taps open and all and that actually may lead to higher also used during winter as well variation may be up to 15 percent of the average demand of the year.

So, if based on the average demand we can see a variation of 15 percent during this part. In summer it may be 15 percent higher during winter it may be 15 percent lesser as well. So, this is what we can see over here. This is againConsider the case of water supplyurban water use in California – and TexasLos Angeles, California. Monthly variation in demand is notable from the graphs given in the above figure. Another point to note is that the amount of variation also shows an increasing trend. This is again in US water use in millions of gallons you can see the vary and this is the time in months and you can see that different months the variation is different. So, the different amount of water is being used. So, that is actually being recorded over here.

And, again when we talk about variation we also see that the fluctuations occur every year and also show an increasing trend of variance. So, that means, sometimes we see that; that the, it is not only the fluctuations the variance of the fluctuations also keep on increasing. So, it depends if the demand if the mean is you know higher then and we also see a change in the variance as well.

So, in the future, this variance may continue to increase with the increase in water demand due tothat means, it is not during the more you know in future different factors. if the demand is increasing we see that maybe because of the different characteristics of the people or the different types of people and we see there is the water use actually varies during different seasons and the variation is also gradually getting increased over time.

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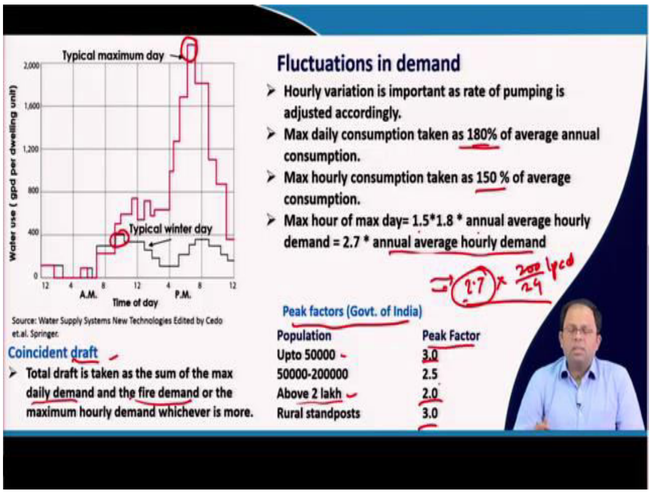

In the graph shown in the above figure, the Then in this particular image you can see that this black line is for arepresents winter water consumption, during the winter and thisand the red line is during this is this red line is for actually your this water use and then this is the represents summer time.consumption. Large variation between winter and the summer months is observed and is typical. The

So, you can see this hourly variation is important as the rate of pumping is adjusted accordingly. and this is typical and this actually shows that during a particular day; that means, during a winter you see that this is the point where the highest water demand was there.The morning peak and the evening peak is evident from the graph. The evening peak is greater than the morning peak and indicates that the water that has to be supplied during the evening peak hours (4 pm to 8 pm) is much higher than

And, this is also another there are two peaks – there is a morning peak, there is the evening peak. So, this one is a little bit lower and during summer then you see that the peak is somewhere around over here. So, this is around 8 pm in the evening you see the highest peak, right. In the morning the peak is less, in the evening when people come back they may use more water for different purposes; maybe they will take a bath, they will do some amount of cleaning and all. So, this is where you see the maximum usage of water.

~~So, that means, the water that is to be supplied during you know 4 pm to 8 pm is actually much higher compared to what has to be supplied during this particular time period.~~ other times of the day. Thus, understanding the ~~So,~~ hourly variation is important as the rate of pumping is adjusted accordingly. *M~~and m~~aximum daily consumption* is usually taken as 180 percent of average annual consumption.

~~So, that means, maximum daily consumption; that means, in a particular you know per day we take that maximum day during a year is around 180 percent of the average consumption for that particular year and if I take~~ *M~~m~~aximum hourly consumption* of a particular day ~~it~~ is ~~taken~~ considered around 150 percent of the average consumption of a particular day.

~~So, if I take the~~ The m~~m~~aximum hour of the maximum day is given as:

Max hour of max day = 1.5 x 1.8 x annual average hourly demand

= 2.7 x annual average hourly demand

~~so, it is not only 180 percent of average, but it is also 180 into 150 percent of the average. So, that is 1.5 into 1.8 into annual average hourly demand which comes around 2.7 into annual average hourly demand.~~

For example: i~~So, i~~f ~~the urban has a~~an urban area has ~~-~~an ~~demand for~~ average annual demand ~~for~~ of 200 ~~liters per capita liters per capita per day~~ lpcd (24 hours), then ~~we divide it by 24. So, this is per hour. So, this is~~ the average demand per hour is 8.3 litres (200 lpcd/24 hours).This value can be multiplied by ~~So, now, we multiply it by~~ 2.7 to obtain ~~get~~ the maximum hourly demand ~~for the maximum hour~~ of the max day. So, at some point of time, the water demand ~~So, this is how we determine the maximum demand.~~

~~So, you can see that this at some point of time if during a particular year water required would be you know 2.7 times more than the average.~~ ~~could~~can reach 2.7 times the average hourly demand and the ~~-So, my~~ network or the pipelines ~~that will carry this~~ to carry water has to be designed accordingly. Pumping arrangement should also be made based considering this peak value.~~So, that they are able to carry this kind of water. Similarly, I need to have pumps so that it would be able to supply this amount of water~~

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during that particular hour, right. So, we have to design our entire system based on the peak demand. T

So, there is another demand which is called the *coincident draft* or the total draft. (Draft means demand) or draft is basically the demand. The So, total draft is taken as the sum of the maximum daily demand and the fire demand. So, either we take the maximum daily consumption which is around 180 percent of the average and plus we take the fire demand or the maximum hourly demand (2.7 times annual average hourly demand) whichever is more.

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This should be considered while designing the infrastructure. So, either we take 2.7 times of the annual average hourly demand or we take maximum daily consumption plus the fire demand whichever is more is the coincident demand or this is the amount of water that has to be supplied during some fighting some fire. So, this is what we need to decide. So, this is the either of coincident draft or this maximum hour max day whichever is higher we will design our pipe network based on that.

So, GThe government of India has mentioned peak factors based on the population. has also given certain other another way to actually estimate what should be the amount of water required for particular time periods. So, they have introduced peak factors. So, when the network is we designed, our network and all we will assume the, we will first determine the annual average hourly demand can be estimated firstly and then we can add acertain amount based on the peak factor can be added toand then determine the actual flow in the networks and we have to design our networks or we have to design our infrastructure based on that.based on which infrastructure design can be done. For

So, up to a a population of upto 50,000, the the peak factor is given as 3; for a population between 50000 and 2 lacs, the peak factor is 2.5; and for a population more than 2 lacs, it is given as 2. So, the higher the population, the smaller is the peak value is assince the variation from person to person cancels each other in the case of large cities with a large population. For whereas, the more we go down the population size increases like 2 lakhs the peak factor becomes 2 and rural standpostsstand posts, it is given as again it is 3. Now, why does it reduces when we have got higher population? That is because the more higher the population is then we see that the variation actually you know becomes

~~lesser why because some people would be using more some people would be using less. So, they actually cancel each other out.~~In a pipe network, a larger peak factor can be considered for

~~So, usually the peak factor becomes lesser in case of larger cities or similarly when we in a pipe network when I design a pipe network you will see that the pipes~~Pipes ~~which are near my~~supplying to individual houses, ~~house there the peak factor is higher where the pipes which are more towards the you know the mains that is the~~ and a smaller peak factor can be considered for main lines.~~ there the peak factor is low, right. So,~~ These peak factors can be considered while designing the infrastructure.~~because they actually because there are so many different kinds of people at the end of that line that they cancel each other out so that you know variation is less.~~

~~So, this peak hour factors has to be adopted when we design any kind of water supply infrastructure.~~

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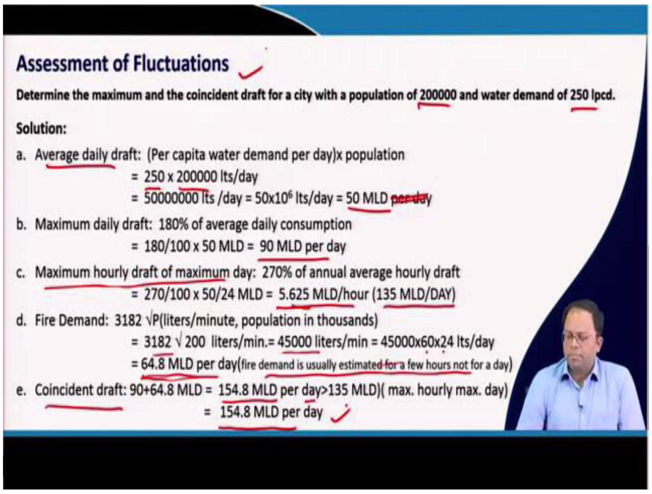

Problem: ~~So, if I D~~Determine the maximum and the coincident draft for a city with a population of 2 lakh and an average ~~a~~ water demand of 250 lpcd.

Average daily draft: (Per capita water demand per day) x population

= 250 x 200000 litres / day

= 50000000 litres / day = 50×10^6 litres / day = 50 MLD

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Maximum daily draft: 180% of average daily consumption

= 180/100 x 50 MLD = 90 MLD per day

Maximum hourly draft of maximum day: 270% of annual average hourly draft

= 270/100 x 50/24 MLD = 5.625 MLD/hour (135 MLD/day).

This is the maximum value based on which the infrastructure has to be designed. Coincident draft can be determined after comparing the maximum of the sum of the maximum daily demand and the fire demand or the maximum hourly demand. So, fire demand has to be calculated.

Fire Demand: 3182 √P (liters/minute, population in thousands)

= 3182 √ 200 liters/min. = 45000 liters/min

= 45000 x 60 x 24 litres / day

= 64.8 MLD per day (fire demand is usually estimated for a few hours not for a day. Here, it's considered for the entire day)

Coincident draft: 90 + 64.8 MLD = 154.8 MLD per day > 135 MLD (max. hourly demand of max. day)

= 154.8 MLD per day, determines the infrastructure network.

This shows how fluctuations determine infrastructure design in an urban area.

~~, this is the average water demand of 250 lpcd then we if I find the average daily draft this is per capita water demand per day into population.~~

~~So, we find that the total requirement is 250 into 2 lakh people this many liters per day which comes to around 50 into 10 to the power 6 liters per day which is around 50 million liters per day million liters per day, sorry. So, this is the amount of waters that is required for this particular city that has to be supplied. So, this is the average daily draft.~~

~~Now, maximum daily draft would be 180 percent of this. So, 180 percent of average daily consumption is 180 into divided by 100 into 50 MLD that is 90 MLD per day. So, that means, I have to design my system to supply 90 MLD. So, if I just consider the maximum daily draft, but actually if I consider the maximum hourly draft of maximum day it is 270 percent of you know 50 MLD.~~

~~So, that comes to around 5 that comes to around 135 MLD per day and if I convert it to hour because it is maximum hourly draft of maximum day per hour it comes to around~~

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5.625 MLD per hour. So, this is the amount of water that has to be supplied per hour. This is the maximum value and we have to design our networks based on that.

Now, I if you remember I just told you earlier that we have to also consider the coincident draft. So, to understand the coincident draft we also have to first determine the fire demand. So, we estimate the fire demand using Kuichling's formula which is 3182 into root P this is liters per minute and population is given in thousand and when we give 3182 into root 200 then we get around 45000 liters per minute which comes to around this 45000 into 60 into 24 liters per day, which is around 64.8 MLD per day.

So, this is fire demand. Even though it is estimated for a few hours not for the entire day, but for calculation we have done it for the entire day. So, this is the fire because it is not like the fire will burn throughout the day, but we still assume do this estimate and we say that this is the maximum fire demand that is possible for this particular urban area which is 64.8 MLD per day maybe there is a event where the fire has been going on throughout the day we have seen certain cases like that.

And, so, coincident draft is around fire demand plus the maximum daily draft. So, that is 90 plus 64.8 which is 154.8 MLD per day which is greater than the maximum hourly draft of maximum day which is 135 MLD. So, we take 154.8 MLD per day as the coincident draft, which is the maximum demand that is there for a particular hour we have to use that and using that we will determine the size of our network or the size of our pipeline, size of our pumps and so on.

So, this is how we will determine this is how fluctuations actually influence the demand or fluctuations actually influence the infrastructure, water supply infrastructure in a particular urban area.

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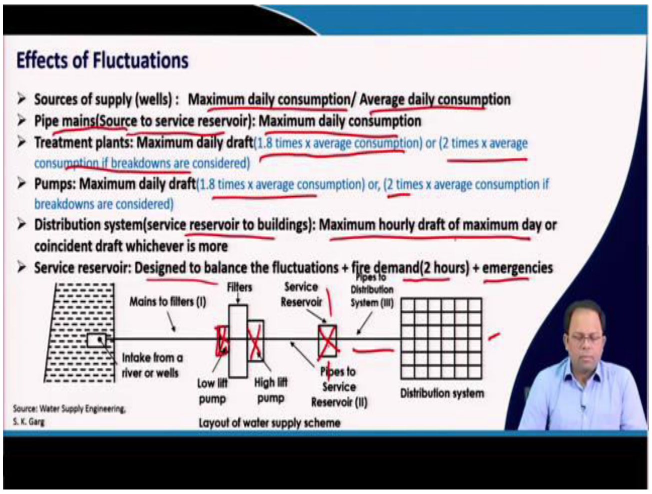

Effects of Fluctuations

So, let us look into what is the actual effect of fluctuation on the different parts of the water supply infrastructure or equipment. So, Ffor example, for the supply wells, the maximum daily consumption or average daily consumption can be considered. There is no need to consider that is sources of water in if it is a well like a, you know you are drawing ground water for an urban area, the maximum daily consumption or average daily consumption is considered.

So, when we design our wells it would be based on maximum daily consumption. So, there we are not bothered about the, per hour draft for designing the supply wells or something because water can be drawn from the wells continuously at a steady rate. Similarly, maximum daily consumption can be considered for designing Pipe mains (source to service reservoir)we can always continuously draw water from the well and supply it in a reservoir and this could be done at a steady rate. So, maximum daily consumption is considered and that is all..

So, again it is not average consumption. It is maximum daily consumption has to be considered when we determine the size of our wells because depending on the size we

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Then, we have for the pipe mains that is the main lines that is source particularly may be from those wells the main pipelines that brings to the service reservoir; that means, from where water will be distributed or from the treatment plants to the service reservoir the main lines. Here again we will do it based on maximum daily consumption. Before the Until the ssservice reservoir, everything could can be done at a steady rate and, so so, maximum daily consumption is good enough.can be considered. Hourly consumption difference is considered at will be taken care by the service reservoir. itself.

So, The mtreatment plants maximum daily draft can be considered for treatment plants (Either, (1.8 times x average consumption) or (2 times x average consumption if breakdowns are considered)).either you know we can take 1 8 that is maximum daily consumption is 1.8 times into average consumption either we can take that, but we can take a little bit higher because there is sometimes there is breakdown in the plants and all. So, we take a safety factor and we take around 2 times into average consumption if breakdowns are considered.

So, similarly FFor pumps, the maximum daily draft is considered ((1.8 times x average consumption) or, (2 times x average consumption if breakdowns are considered)). we take around 1.8 times into average consumption or 2 times if breakdown is considered. FNow, for distribution system, from service reservoir to buildings, the ; so, this is the pipe network which originates at the service reservoir and then goes to your building. Here we take maximum hourly draft of maximum day or coincident draft can be considered based on whichever is more. The service reservoir is designed to balance the fluctuations and

So, this is where the actual supply happens because reservoir is where water is stored. You can store the water in a steady state steady rate and then you can use the water out of the reservoir at a much higher rate at certain time other period you can use it at a lesser rate. So, actually the purpose of reservoir is to balance this particular demand supply for fire fighting (2 hours) and emergencies., right. So, we will discuss that in later chapters.

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The layout of the water supply scheme is given in the above image showing the intake from water source,So, you can see that over here in this particular pipeline maximum hourly draft of maximum day or coincident draft whichever is more that is actually taken. So, this service reservoir is basically designed to balance the fluctuation and so, the service reservoir size is fire demand for 2 hours plus emergencies breakdowns and all that has to be considered when we design the service reservoir.

For service reservoir we consider this variations in fluctuations that has to be considered plus fire demand if we have to meet the fire demand and then emergencies all these things has to be considered when we determine the size of the service reservoir this we will explain detail in a later lecture.

So, in this particular image you can see this is the distribution system this is our service reservoir, over here this is the pipeline to the distribution system distribution system, and the treatment plant. A low lift pump lifts the water to the traeatment plant and the water after treatment is pumped through the pipeline to the service reservoir. So, till the service reservoir, the maximum daily consumption can be considered while designing, except for the mechanical system involved in the treatment units where a higher value can be adopted (twice). Beyond the service reservoir, design can be based on the coincident draft or the higher of the coincident draft and the maximum hourly draft.

and this is our source, may be a river, this is our intake, this is our mains, this is a main line which comes to the treatment plant may be there is a pump involved over here which lifts the water into the treatment plant.

And, from the once the water is treated again there is a pump involved which will leave the water into this service reservoir and, then from service reservoir it is distributed into this distribution network. And, you can see that is why; that means, over until this service reservoir everything could be based on the maximum daily consumption, but of course, because there are mechanical system involves in the treatment units and the pumps there we actually can go for a little bit higher 2 times.

And, whereas, beyond the service reservoir it is based on the coincident draft or the higher of the coincident draft or the maximum hourly draft based on that we will design the network.

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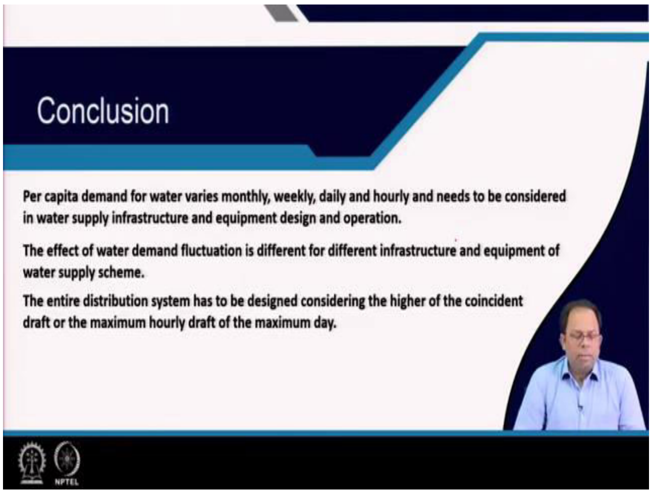

Conclusion

- P~~So, to conclude the p~~er capita demand for water varies monthly, weekly, daily and hourly and needs to be considered in water supply infrastructure and equipment design and operation.
- The effect of water demand fluctuation is different for different infrastructure and equipment of water supply schemes. So, that has to be considered.
- Th~~And, finally, th~~e entire distribution system has to be designed considering the higher of the coincident draft or the maximum hourly draft of the maximum day.

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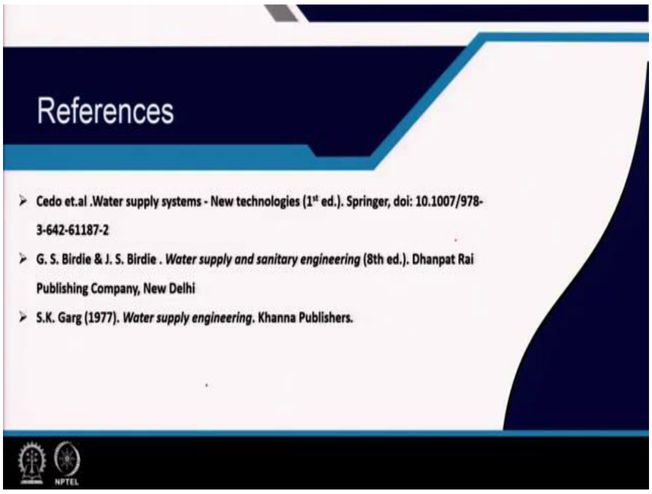

~~So, these are the references you can consider.~~

~~Thank you.~~

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