Water Supply Engineering
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Lecture - 11
Water Sources and Collection of Water

Hello friends. Now we are in week three of this course Water Supply Engineering. And in the previous couple of weeks we discussed the very basics of the various sources of water, how much water is available on the earth and then in the different continents how it is distributed and what are the different water uses we go through and then in the next week we did discuss about the water demand.

So what is the concept of water demand, how we estimate the demand, how we can estimate the fluctuations in the demand, the hourly variations, seasonal variations, daily variations, all those we discussed in the previous week. This all concept gives us an idea of how much water will be required by say a community or by a city or by a town.

So now we are going into the next stage of conceptualizing or designing or understanding a water supply system. And in this week we will talk about the water sources, not in general water sources as we discussed earlier that there are the water available in atmosphere in groundwater and surface water and in the sea. All those things are there but now we will be focusing more on to the say water supply project perspective.

So what could be the available water sources and then what is the intake and how we convey that water to the next stage from the intake. So that is what we are going to discuss in this lecture in this week, in fact entire week.

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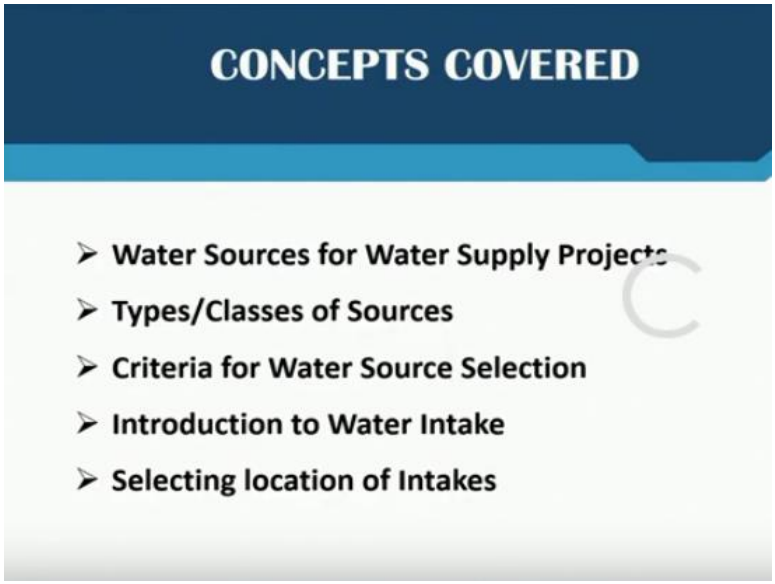

And the first lecture is what we will be discussing is the various water sources. Then what are the various types and classes of the sources, the criteria for selecting a water source and we will have an introduction to the water intake and how we select the ideal location or a good location for a intake. So this is what primarily we will be discussing in this particular lecture.

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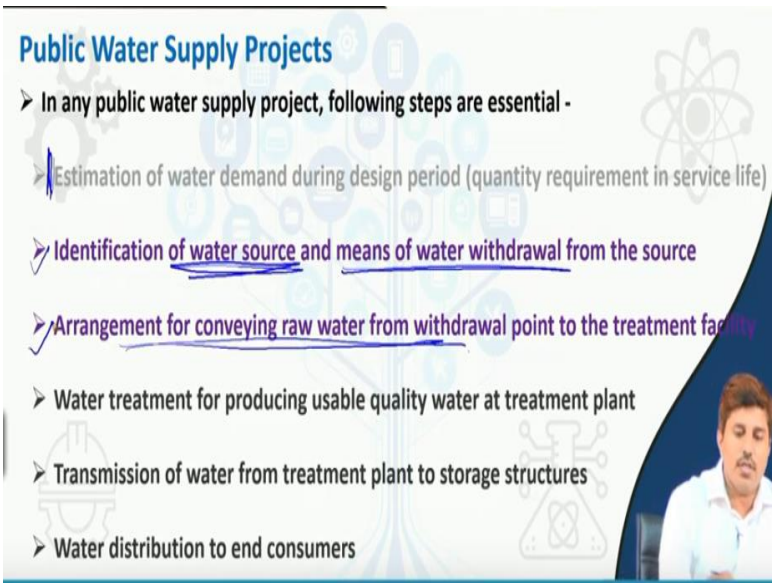

So to begin with, we discussed about the water supply, the overall water supply projects earlier also. So if we see any public water supply project will have several steps. The first and foremost step is essentially the estimation for the water demand during the design period, which is basically the quantity required in its service life, what so ever service life is there of the system.

So how much quantity is needed in that service life. So that is the first and generally the foremost step and this we discussed in just previous week, week two of this course. The next step is identification of water source and means of water withdrawal from the source. So once we know how much water is required, the next step would be from where we can withdraw this much of water and how to withdraw this much of water.

So the point are that what are the water sources available and what is the means of withdrawal okay. So these two are the very important aspects again in a water supply project and we have to kind of see that what is the most sustainable source available and what is the best means of water withdrawal and then we have to design that those systems or conceptualize those systems.

The next step is arrangement for conveying raw water from withdrawal point to the treatment facility. So once we withdraw the raw water from source, we have to supply this water to a next stage which is the treatment facility. So what arrangements is needed for that. So these are the two things that basically we will be targeting in this particular week.

So this we have already covered in the earlier week and point number two and three we will be basically discussing this week. Apart from this of course once it is done then it goes to the for treatment procedure and then the it is transmitted to the say intermediate storage or storage reservoirs whatever are there and then it goes through a distribution system to the end consumer.

So we will talk about the remaining points later. What we are going to discuss primarily in this week is the identifying the water source, then setting up a mechanism for water withdrawal from the source and the conveyance of water from source to the treatment stage.

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So practically as just we were discussing if we see the various components of a public water supply system, so we have the three major components of a water supply system. I am saying major components is as you can see that there is transmission work written at two stages, which are basically intermediate stages and is also quite important, but the major aspect remains that we collect water we treat purify water and then we supply water to the consumer.

In between we need transmission work for so say this is your catchment and say for say this is the source of water. So we have to install a collection system here, right here at the source of water which is going to be our collection work okay and then this water which is being collected from here this intake point is transferred to the, this is your water treatment plant which we typically referred as WTP.

So this is the WTP, this is your treatment purification work. So this particular part is the treatment and purification work. While connecting these two parts from here to here we need to transport that water, we need to convey that water from here to here and that is achieved through a transmission work. So we generally use pumping and we pump the raw water from here to here through a typically we call as rising main or raw water mains.

So through raw water mains we pump it from here to from the collection works to the treatment works or purification work what we also call as, that needs some pumping. So this is the first stage transmission and then once the water is treated the purified

water is again pumped to storage reservoir or services storage or in between. So it again needs a second stage transmission.

So this is your treated water mains, treated water pumping mains which brings in here and from this point forwards it goes to the distribution works for the distribution purpose. So this is the major components of a typical water supply system and the collection works and the transmission works are the two things that we will be discussing in this particular week.

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So collection work essentially is for water withdrawal from source okay. So we say at water withdrawal system or water intake system, water intake is generally the more popular system. So that is what we say and then transmission work is the conveyance of raw water from collection unit to the treatment unit and these are the things that we will be discussing henceforth in this particular week.

Thereafter of course, there would be treatment or purification work which is essentially the water treatment plant, then the transmission work for treated water from WTP to the services storage and distribution work for the distributing the treated water to the end consumers and this is generally achieved through pipe network. So we will discuss these three aspects later once we go to the later weeks.

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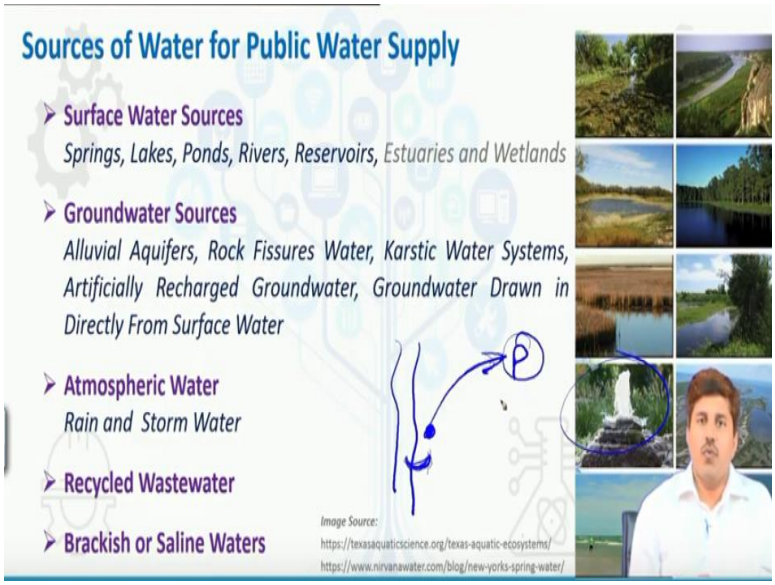

Now, as we said that our main focus of study in this particular week is the water sources and intake and then conveyance to the treatment facility. So first let us talk about sources. Now sources of water for public water supply are numerous okay. So as we have seen earlier also that water can be stored in several forms okay at several different distinct locations.

So depending on that, we can have various sources of water. There are surface water sources which could be spring okay. So like we have a spring here. So this kind of sources are known as spring where the water in fact it is primarily underground water but it comes on to the surface because of the pressure is higher than the than the basically water table so it comes out and it actually comes out of the surface also.

So the exact pressure at that particular if there is a say some small aquifer or those kind of setup with very high pressure so that brings the water to the surface. So these kind of water coming from the surface is known as spring. This is a very common phenomena in particularly the hilly areas okay. There are lot of spring in the hilly areas and people collect the water from a spring.

At many places in fact, they have a setup to transfer this spring water into the pipes for long distance transport as well okay. So the spring is one of the major sources in fact for fulfilling the water demand. Then there are lake and ponds. So lake as we all know that generally the big storage of surface waters okay. Pond are generally small storage which can be natural or can be manmade at times.

So these also are used to basically serve the as a water source. Ponds is good enough for only very small communities, just villages or rural sector maybe at times not even a complete village. So a village may have several ponds and lakes are generally the bigger and may have adequate water to fulfill the demand of a entire reasonable size of city as well.

Then there are rivers or streams what we call okay. This is again one of the most prominent surface water sources. Many cities withdraw water from the rivers for the municipal supplies. So that is one of the very prominent sources, rivers. Reservoir, if the flow in the river is less so the dam or reservoirs are constructed so that the lot of water can be stored.

And then from reservoir water is pumped for the purpose of municipal water supply. This is again also very common phenomena, okay. Many cities have this kind of setup. So we know that the flow in the river varies a lot, okay. And then there are seasonal variations as well. In dry weather season you may not, the river may not have adequate amount of flow in the water.

So one option is to build a dam or reservoir or barrels kind of thing store the water and pump the water from that reservoir. So this kind of ensures the long term supply from that particular source, okay. Estuaries and wetlands are generally not used for water supply purpose. They do store lot of water at times and for small water projects wetlands and estuaries may be used at times but generally these are not that common.

So more common water sources, surface water sources are generally the lakes, rivers and reservoirs okay. Then, the groundwater sources; again the water which is in the subsurface okay, which typically is underground water. So there are alluvial aquifers which have sufficient porosity to and sufficient porosity and capacity to store water and release water.

So those kind of aquifers are preferred for the for being tapped as a source for water supply okay. There are various other underground structures or formation which retains lot of water okay. There are rock fissure waters. So these kind of like in the

rocky systems many times what happens that we get lot of tube, fissure like the fracture in the rock gives fissure kind of structures and then water can move through this and even the rocks can lead to the substantial permeability okay.

Alluvial aquifers generally are soil which is sufficiently permeable, which can release water and store water but rock fissures are the rock which generally is considered as a impervious material, but due to these fissures formed or due to the fracture of the rock these galleries formed may actually lead to the sufficient permeability or porosity for passage of the water through this.

So these kind of setups can also be tapped as a groundwater sources. There are karstic water systems. Karstic water systems again particularly in the areas where calcium carbonate and those kind of materials are there in the subsurface. So when they dissolve and kind of go through a weathering stage for formation of the rock.

So they may result again in a setup which is having multiple channels and water, particularly the pressure water if it is connecting to a confined aquifer or pressurized aquifer so what happens that through these channels water flows very rapidly.

So this is basically the turbulent conditions will be there and under these turbulent conditions under these turbulent flow or free flow it could be basically turbulent free flow or turbulent pressure flow or at times even both and can lead to the bring can actually bring water to the top. And it may end in fact, as a spring on the surface as well okay. So those kind of subsurface setups can also be tapped as a water source.

There are other type of like, volcanic rocks may also like when the volcano erupts and then subsidize the kind of structure it provides has a good water storage ability. So although it is in the subsurface, but it can retain good amount of water and that water actually can be tapped for the water supply purpose. There are artificially recharged groundwater.

So we know that the storm water or the treated wastewater can be used for artificial recharge of the ground waters. So those setup or those kind of systems are also

available and this artificial recharged groundwater, so whatever it is reaching to the groundwater can again be pumped up as a groundwater source.

So although it is a basically either treated wastewater or storm water, those kind of sources, but once it reaches groundwater it comes through the pumping and as if we are actually from the overlook it will appear that the groundwater is being pumped. Similarly, the groundwater drawn from a basically surface water storage.

So what happens that let us say, we have a river and if we put a groundwater pumping station at this point, so we think that we are pumping groundwater but what happens this point where our well is, over a long run it gets hydraulically connected to the river okay. Or if there is a lake it will get hydraulically connected to the lake. So what happens although we are pumping water from the underground or subsurface, but eventually what we are pumping is the river water, okay.

So the groundwater may be in direct connection to some surface water body and if we are pumping that groundwater so it is basically indirectly we are pumping surface water, okay although our setup will look like we are pumping groundwater. So that kind of stations are also there at many places, okay the groundwater pumping station just beside the river.

So eventually it is a surface water which is being pumped through a subsurface installation. Apart from these popular surface and groundwater sources, there are atmospheric water sources. So rain water and storm water can be used. Rain water is generally when we collect directly rain at a paved area we call that rain water.

And storm water when it either collected on the paved or unpaved area and flows through a storm water channel finds through a channel which is finds through way to the galleries or channels either paved or unpaved. Those are generally known as storm water drains. So the rain and storm water are practically a form of atmospheric water which comes to the surface.

This also can be later on generally converts, we have already studied the water cycle. So it will eventually fall into the water cycle and may enrich the groundwater or some

subsurface water sources. But it may directly be tapped also and used as a separate water source, okay. So like we know that rainwater harvesting is a pretty popular term these days. So it such as that we directly tap the rainwater for useful purpose.

So that kind of a setup might help in gathering atmospheric water directly without reaching it to the some other surface water source or groundwater sources. Then there is a recycled waste water which is again appearing popular alternate water source okay. Although there are restrictions on the uses of recycled waste water, particularly the direct potable reuse is banned in most of the places if not all.

But there is indirect potable reuse is being happening at several places, Singapore is a prime example, okay. California County and several other places and there are other alternate uses, non-potable uses of the recycled waste water is also getting pretty common. Then the other water source is brackish or saline waters. Now, we all know that sea is the largest resource or source for the water.

And once places particularly in the coastal areas, if there is no suitable alternate water sources available, then the sea water or saline water can also be tapped, purified, treated and put through a public water supply system. So there are many places in the world, many coastal cities in the world which have desalination plants for using sea water for the potable, for the public water supplies, okay.

So seawater can also be tapped that way and it can serve as an important source. So these are the various sources of the water which can be used for public water supply purpose.

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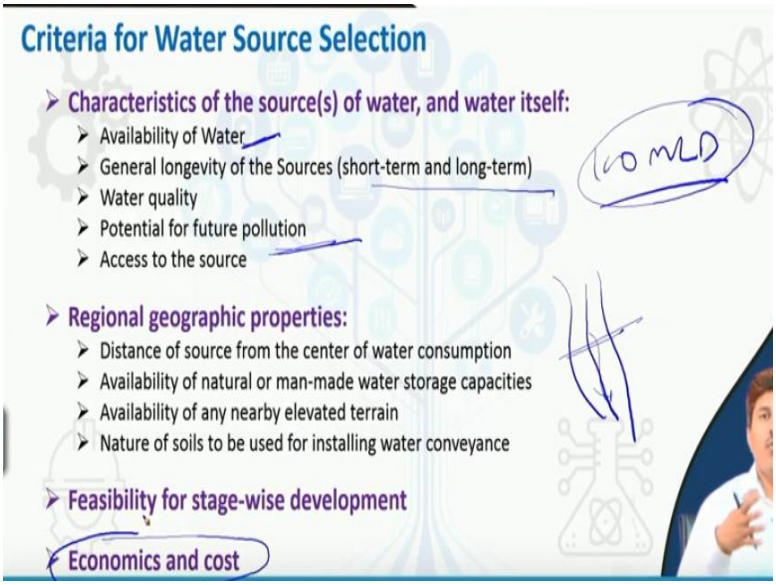

Now how we select a source okay that is very important questions. Now the nature of sources is that at some places we may have multiple sources available, okay and at some places we are almost like almost have no sustainable water, okay. The groundwater which is usually perceived that is available everywhere whatever depth it may be.

Some places it is at like just you dig 4, 5 feet and you will get the water, you will hit the water table. At some places you need to go maybe more than 1000, 1200 feet and still you do not hit the water table, okay or you do not get a freshwater aquifer. So the problem is that the groundwater although available, although is generally considered to be available everywhere, but there is a huge disparity and more so ever, the quantity also might be very limited at certain places.

So the potential of groundwater acting as a sustainable source is not uniform, okay. Apart from the groundwater let us say a city may have a lake may have a river flowing beside it or may have nothing about it. So **so** how to basically plan or how to select a water source is very important when we conceptualize water supply project, okay. Now the selection of water sources depends on several criterias, okay.

What could be these criterias? So first and foremost criteria is basically the characteristic of the source of water and the characteristic of water itself. So whatever source we are selecting, how much water it retains. So what is the availability of

water in the source, okay. We cannot select a very narrow running stream with limited amount of water for public water supply of a large city, okay.

Because the channel or the river or the stream whatever we may call that, does not have sufficient amount of water. So when we are planning a water supply, public water supply system, we have to as we discussed earlier that we estimate the demand now we have an idea of how much water is needed.

Now whether source that we are selecting one of the very important criteria should be that it should be able to meet the requirements. If your source is not able to meet the requirement you cannot rely on that single source. Then the option is to look for alternate source or go for multiple sources. So let us say if my requirement is for say 100 MLD, 100 million litres per day.

Now I am having a river which is flowing which does not and it is not possible to extract this much of water from that river for say. Remember, we cannot extract all the water from river anyway okay. We have to leave certain environmental flow in the river, that is one criteria. Even there is a withdrawal limit. Even if you keep the environmental criteria aside, you cannot withdraw each and every drop of water from a river. That is technically infeasible, okay.

And more so ever, there are environmental regulations which suggest that minimum certain percentage of flow must be maintained in the streams and rivers. So we cannot withdraw all the water from a river or stream. Similarly, if we have a lake, so it is not practically possible to make that lake empty, okay. How much the recharge lake is getting in a year's time or on a certain scale.

And so we have to understand that how much water sustainably can be withdrawn from a source; now whether this amount of the water which can be withdrawn from a source is sufficient enough to fulfill the requirement of my water supply project. If the requirement of my water supply project is lower than the amount of water available at one single source, we can select that source at least from availability perspective.

But if it is not, then we have two option. Either we discard that source and look for an alternative source which can provide that much of water or we keep that source for partial supply and look alternative source for the remaining water requirement, okay. So that is one criteria, availability of water. So how much water is available at that particular source? Then the other criteria is the general longevity of this source, okay.

This is again a very important criteria because whatever source we are trying to tap how much like how much sustainable that source is in a longer timeframe okay. So generally in short-term and in long-term whether that source would be able to meet the requirement of the water that is there from that community or the requirement of water which we need to cover under this project.

So for say if you are trying to tap a river water, okay, now you say that average flow is sufficient enough to meet the requirement, but what about the dry weather flow, lean flow. So when in the summers when river runs at minimum flow, what is amount of water that can be withdrawn from river during that hours and remember the demand is usually highest in the summer, okay whereas the flow is lowest.

So whether in the low flow condition that river or that stream will be able to meet the demand of the city or town needs to be seen. So even on average basis you may have sufficient water available, but whether this is available in a long run in a basically short-term and long-term timeframe. So that also needs to be seen. Then the water quality, okay. What is the quality of water in the source.

That is again, you cannot select a source which is having very bad quality because that will require enormous amount of expenses for the treatment purpose, okay. So it is advisable to select a source with a good water quality, okay. Of course the treatment is to be provided but whatever treatment steps you can minimize by selecting the good quality water is always good. Then potential for future pollution.

It is not just the quality that is there one has to see that what is the potential for future pollution or future quality deterioration. So I say that okay, today it is of reasonable quality, but if I presume that in the next five years, it is going to turn kind of in a

septic conditions, I should avoid that. Because then I may do a lot of investment for abstracting water or putting a system to withdraw water from that particular source.

But that because of the poor quality of that water in the future, my all the investment will go in the vain. I will not be able to abstract water from that particular source for a long enough time. So what is the potential for future pollution is also one of the criteria. And then access to the source, okay. So whether that source is physically accessible or not, okay.

If you see that okay there is a source but and it is like it may have sufficient water but it is very far off places or the remote locations, access is difficult. So although these points can be taken care of, but will require huge amount of investment and eventually it will come to the last point, the economics and the cost, okay.

Anyway, so these were the major points for the from the point perspective of the characteristic of the source and characteristic of the water itself. Then there are regional geographic properties also play a role, okay. The distance of source from the center of consumption, how far the source is okay. Groundwater sources as we discussed, groundwater can be tapped from most places in generally.

So groundwater sources we can keep very close to the treatment facility. But let us say you have another place like in Bangalore draws water from over 80, 90 kilometers distance, okay. There are places there are cities which draw water from far off distance.

So if your source is very far from the city, you have to like transporting water from that much distance to bring it down to the point of consumption because central point of consumption is a city or town, if your water source is hundred kilometer away from that. So you will have to have a setup installed, you will have to have acquire land, lay pipelines, then do all the investment.

There is a lot of energy requirement for pumping that water. So although technically it is achievable, but again it requires a lot of money. There is lot of energy footprint associated with this. So that has to be seen like as close the source to the point of

consumption, it is actually better. Then availability of natural or manmade water storage capacities.

If you have near source, the sub natural or manmade water storage capacity, it is good we can withdraw water from the source and put it to the storage capacity. If it is not there again that is a like disadvantage point. Availability of any nearby elevated terrain. So again, if you are having a elevated terrain, you can pump water directly to the elevated terrain and then run the distribution by gravity.

So that kind of setup gives you an advantage. But again, it is a regional geographic property, nothing much can be done if it is not there. Then nature of soils which is used for installing water conveyance. If your source is let us say at certain distance you have to set up a conveyance. It could be pipe, it could be conduit or any form of channel.

Now what is the nature of soil, what is the bearing capacity of soil whether it can sustain that much load, what kind of foundation you need to provide for holding that, whether is a aggressive soil means it can lead to the corrosion of the pipe or those material walls which are being installed in there. So those criteria also can be considered as one of the things to look while selecting the sources.

Then there is a feasibility for stage-wise development, okay. Now we may prefer a source which is which gives an option for phase-wise development because it is not necessary that we plan, let us say in a public water supply project we have, we are designing it for 30 years. But the demand after 30 years is going to be, and the estimated demand after 30 years is going to be 100 million litres per day.

But the demand today is 20, 25 million litres per day. So we do not want to build a set up of 100 million litre capacity on day one, because that will remain under utilized for most of the period. So we should plan okay let us in next 5 years when my capacity is going to reach say 40 MLD or such way. So let us plan a setup for 40 million litres per day and then we will actually look for future expansion.

So in that case, you might actually be looking for a source which at this particular stage is sufficient for 40 million litre per day supply. But you have to consider that under the next stages you have to extend it to a 100 million litres per day. And whether there is sufficient water available, whether there is scientifically it is feasible to kind of do the stage-wise development with this source.

So that also has to be seen and last but definitely not the least one of the most important criteria is economics and cost while selecting the source, okay. And many times when we are actually trying to select a source this becomes the sole criteria. Okay, if we are going for a single criteria, the foremost important criteria becomes economics and cost.

So what is the cost of withdrawing water from that particular source and bringing it out to the treatment facility, okay. So overall, again it could not only be this, it could incorporate all these things like the quality aspect. If you are having two sources so one, abstraction cost might be lower but the treatment cost is higher. Another, abstraction cost might be higher, but the treatment cost is lower.

So in overall, in general, which source provides us the most economic supply option can be chosen. So that is again one of the very important criteria, what is the cost involved in abstraction and treatment and purification of the water and that can be used for identifying the source. So this is specifically about the selection of the sources. So we will conclude this lecture here itself.

In the next class, we will discuss about, so as we have been just talking about how we select the sources, once we select the source the next step is going to be the withdrawing water from the source and that is done through the intake systems or which is typically we refer as intake structures. So we will talk about these intake points in the next class. Thank you.