Ground Water Hydrology
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Module No # 08
Lecture No # 40
Modeling and Management of Ground Water : Ground Water - Surface Water Interaction

Welcome to lecture number 40 of ground water

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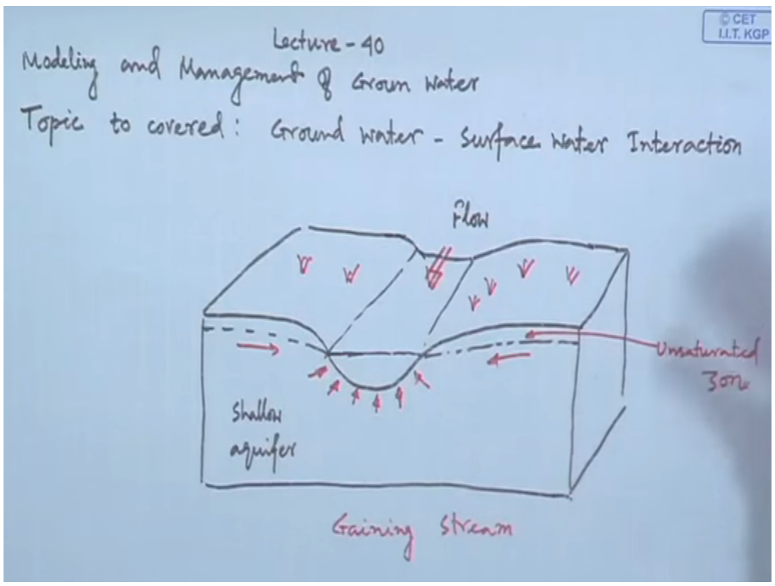

Welcome to lecture number forty of ground water hydrology course. Today we will talk about this modeling and management of ground water, under this, the topic that we will cover in this particular lecture is ground water, surface water interaction. In lecture 39 we have talked about this conjunctive subsurface modeling with surface water for, over length flow case and we have already talked about this Waddle zone flow.

So in this particular lecture, we will talk about ground water surface, water interaction. So let us consider one shallow aquifer and we have ground surface and then we have one stream. So this is the direction of flow for the stream flow and let us says that this is our water table and this is the stage height in your stream and this is the water level and the nearby aquifer which is again shallow aquifer or unconfined aquifer.

In this case there will be flow from your ground water table towards the stream and the aquifer will contribute some amount of water in stream. So again we have unsaturated zone here and this is basically top cover, so grass cover or any other kind of cover is there on both the sides. So this is a situation where or aquifer is contributing in the stream, so we can say that this is basically gaining stream that means stream is gaining from our aquifer.

Now if we see the water table contour for this particular aquifer then it will be some kind of interesting thing because there will be deviation of water table contour. If there is a stream in between a particular aquifer region.

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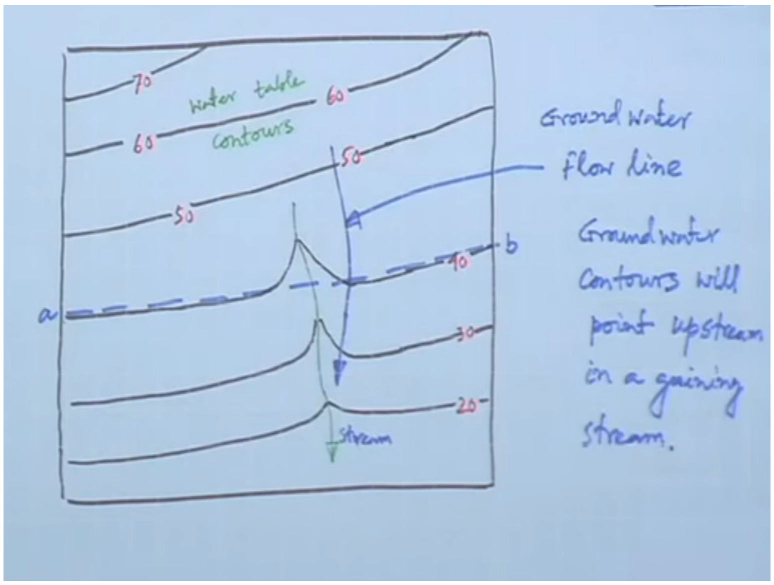

So let us say that this is my old domain, now I have contour of different hydraulic head level. So let us say this is level 76, this is 50. Now we have this stream here which is starting from this point, now if you have that contour near to this stream there will be some deviation. So this is corresponding to 30, this is corresponding to 20.

Now if we draw one obituary line here. So we will see that in aquifer region, your ground water table is not deviating this is groundwater flow line which will be perpendicular to this. So this is basically ground water flow line and these are water table contours. So in this case let us say we have two points A and B.

So starting from A if we move towards this stream then we will find that there is variation and this contour is pointing towards the upstream direction. So in line cross section the water table is at lower elevation at the interest section point and in this case we can say that our ground water contours will point upstream in a gaining stream.

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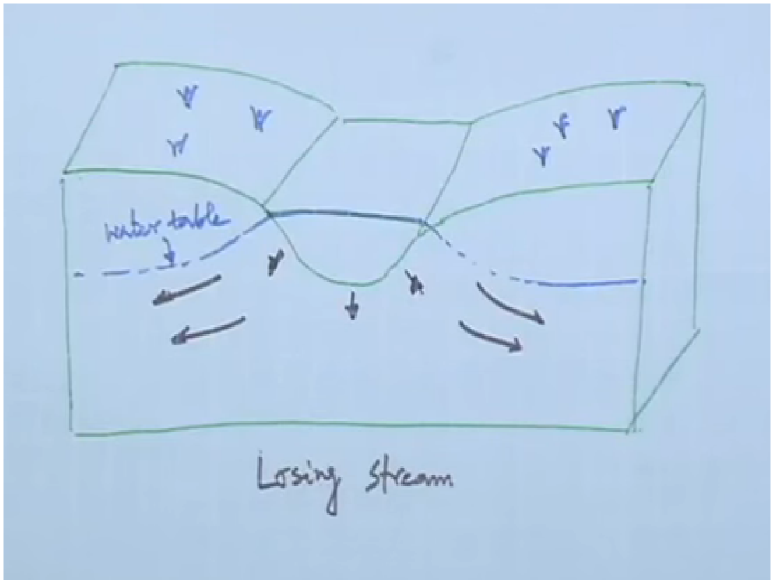

Similarly if we see the thing for losing stream where things are similar but only difference is the water level in our aquifer and stream, so this is our ground surface, now this is the water level and water table in the aquifer is lower than the aquifer level of water in the stream. So this is our water table, so there will be movement of water from stream towards the aquifer. So we can say that this is our losing stream like gaining stream.

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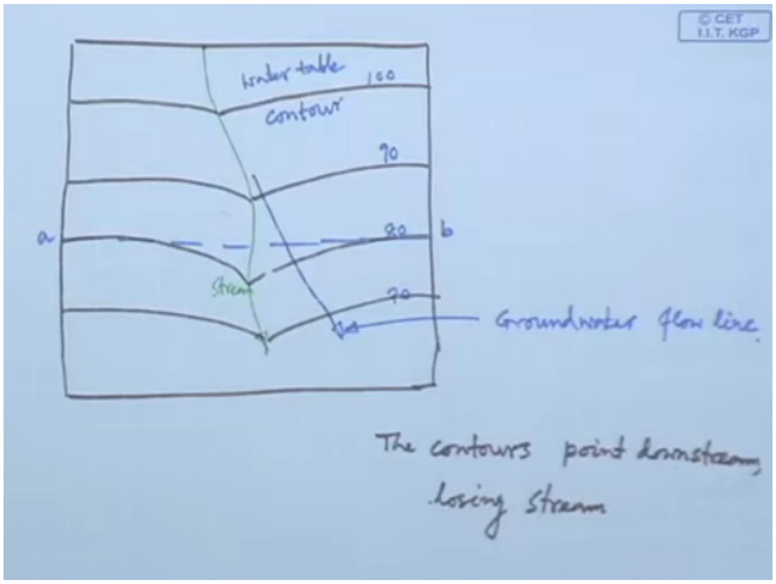

If we draw the contour levels we will see the opposite thing compared to our gaining stream. So let us say this is our stream direction then this is our contour level. So we have this 100, 90, 80, 70 water table contours. So in this case if we draw straight line as we have drawn in for gaining stream we will find that this contour will point towards the downstream direction and that is at the intersection point with the stream.

So we can say that in this case our groundwater flow is like this which is away from our stream flow direction. This is groundwater flow line, so in this case we can say that if the contour point downstream. So this is losing stream, so difference between losing and gaining stream is that the groundwater flow line. In case of our gaining stream because towards the stream but in case of our losing stream.

This is away from the stream. So another special case of losing stream may be there which some kind of extreme situation.

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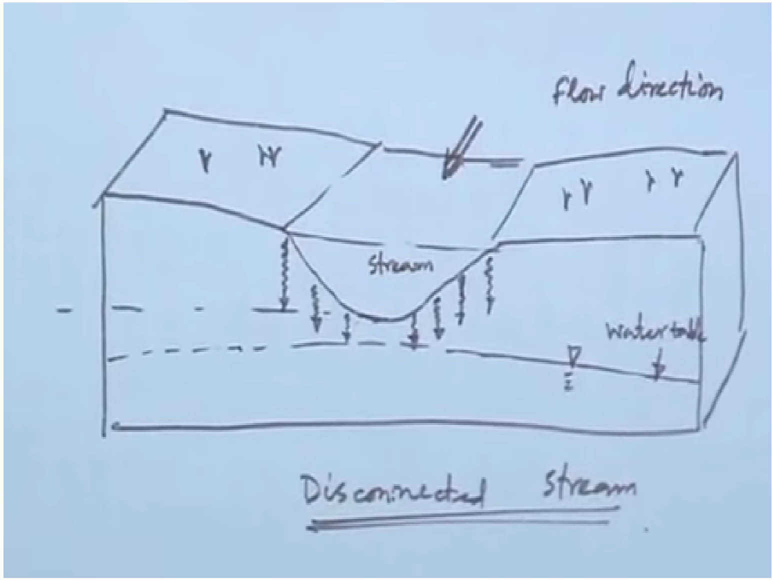

For the stream aquifer interaction, so in this case this is the flow direction and we have again that shallow water aquifer and water table is below the bed level of the stream. So in this case, water table is below, so there will be contribution of flow from our stream and this kind of situation will be there due to excessive pumping in aquifer region. So this is basically disconnected stream.

So in disconnected streams we have groundwater table which is below the stream. This is our stream and this is our stream bed level. So this is always below the stream bed level. So these are called as disconnected streams. Now we need to see of what kind of fluid dynamics is there near to stream and that is in our aquifer part.

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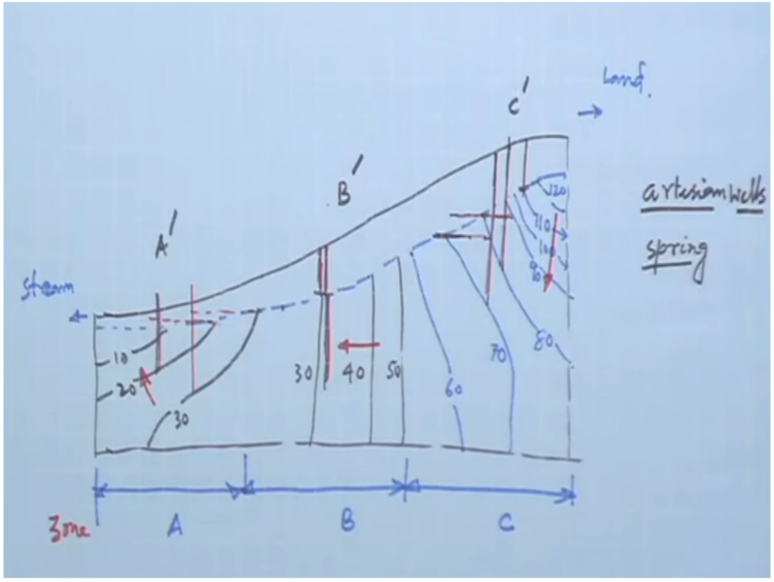

So in this one if we draw 1 obituary cross section cross section, so in this one we can divide this whole region. This is near to stream, this is pointing towards stream and this is towards our land. Now if we divide this whole thing into 3 regions that is A B C. So in this region the behavior of the total head is different. Let us first draw the water table for this cross section, so near to this land there will be sharp change in the contours. Let us say this is 120, this is 1, 10 and this is near to that 60.

Again some 70, 80, this is 90, then 100. So in this region there is vertical flow in this part of the cross section this is zone C or we can say this as zone so next part there will be almost vertical contours, so these are 40, 30 and from there let us say again there is change in the pattern and now this region A things are not that vertical, there is again curve kind of contours which will be available.

So in region B there will be horizontal movement of water and in this region there will be movement of water in upward direction. Now if we install piezometers in these three different regions, then we will see, what is the difference in hydraulic head that will absorb? So let us say that we are installing piezometers heads here, then it will correspond to water level here then if you are installing piezometers here.

So it will exactly level with the water table and if we further go down then there will be again lowering of the piezometric level. So let us say this is our region C prime, so with zone C. This C prime is nested monitoring locations and in this nested monitoring locations. We can see that for A monitoring will in this region. There will be equivalent water surface which will correspond to this level again for monitoring in this region.

There will be equivalent water surface which will be corresponding to this level and this is at the top surface. So this will correspond to our original water level but interesting part is that almost in two cases we have found that for a particular region or piezometric head is lower than the water table and the location in this case if we try to draw the thing then we will see that this is almost static. Even if we go down there will not be that much change in the water level in the piezometers.

So this is almost same because vertically no variation in contours in this region, that is region A. So this thing we can denote it as B prime, now in C prime region or else we can denote it when piezometers with the straight thing. So in this region A, let us say that we have one nested network of a prime. So if we install piezometers here, what will observe is that our water surface piezometric head will be above water table.

So we can say that there will be in first case this is lower than our water table. This is almost similar to water table, there is not much deviation but in this case it is higher. So if we can install piezometers here, so there will be spontaneous water flow from these piezometers and if we have deep viols in demographic depressions particularly in river valleys, then the water is spontaneously come out and that is known as parting chambers.

When water is discharged naturally to the surface and discharge point is called as springs. So artesian wells, if we install wells and water comes out spontaneously then we say that these are artesian wells. If water comes out naturally to the surface then we say that these are spring. Another most important point that is bank storage. What is the effect of bank storage on?

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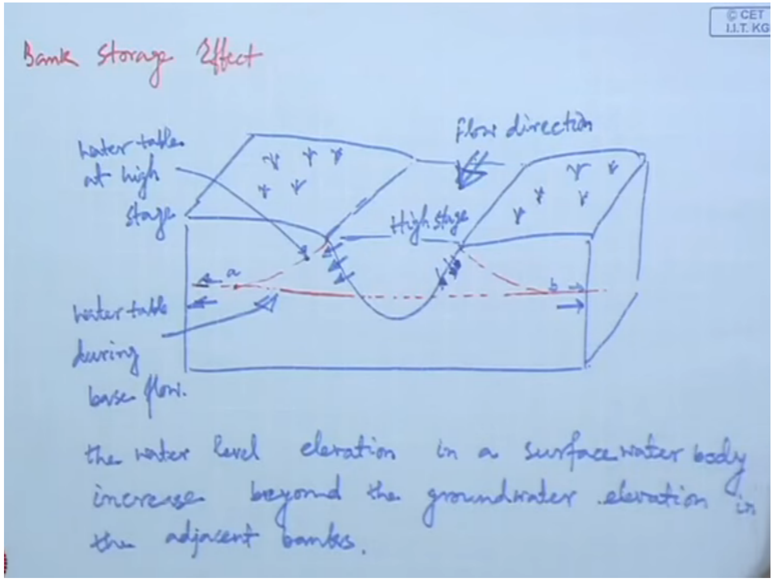

Groundwater surface water interaction bank storage effect. So if we draw it you will see that with our shallow groundwater aquifer, these are our ground surface. In this case water level which is this and interestingly. This is our water table during base flow. So points A and B are there. So what is this bank storage? We have flow direction and we have high stage here.

Bank storage occurs when the water level elevation in a surface water body increase beyond the groundwater elevation in the adjacent banks. So we have flow direction then we have high stage. So there will be movement of water in this direction through banks there will be movement of water towards the aquifer so this is called as bank storage.

This is water table at high stage interestingly there will be movement of water from bank from stream towards this bank and there will be elevation of water table and after some time when it reaches. When the balance equilibrium reaches in the system there will be higher water table near to stream compared to this lower groundwater table during base flow and in that equilibrium condition still beyond this point A and B. There will be movement of water from these beyond these two points in this direction.

This is very complex in nature and water near the stream, in that case water near the stream in that case water near the stream moves towards the stream. But it is beyond this A and B points which are intersection points during high stage levels and streams there will be movement of water towards the aquifer. So these are the direction of water flow situation, so if you want to model this thing in practical situation then we need to idealize this particular system with some simplified assumptions.

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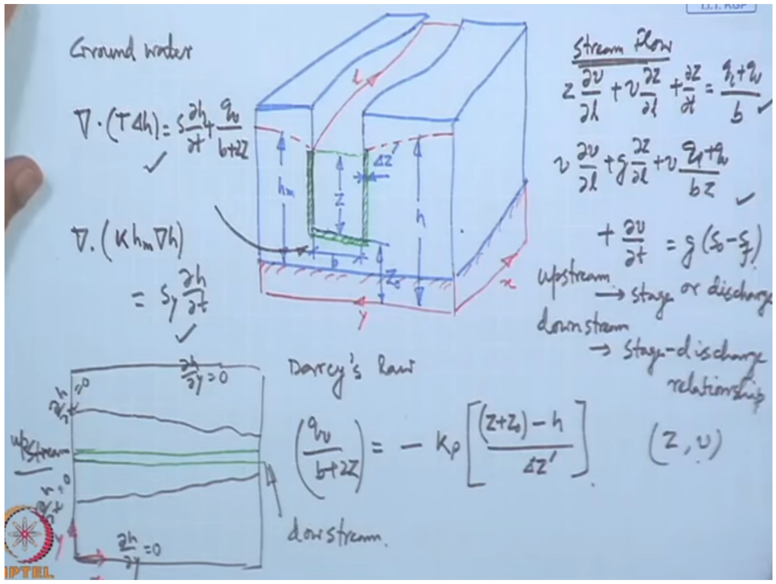

Now let us say that we have some aquifer and in that one, we have some rectangular stream channel. So in that rectangular stream channel, let us say this is groundwater level and here is one region near to this channel that is river weight sediment on both the sides and let us say this is or water level. So with respect to out datum which is below this system, let us say this is our X coordinate system, this is Y coordinate system and this is in the direction of that stream.

This is L and the saturated thickness in this one is taken as M, HM and water table from pre defined datum is H and Z0. This is elevation of the stream bed level from the datum and this is width of the channel B and this is height of water in the channel and we have thickness Del Z prime is the thickness of bottom sediment allowing the weighted perimeter of the channel.

So with this configuration, we can write our governing equation for stream flow. We can write the equation as Z Del V / Del L + V Del Z / Del L + Del Z / Del T = QL and QV / B. So here QV is the flow into the channel per unit width per unit length through its weighted perimeter and QL is the lateral in flow per unit length over the channel banks and from tributaries and again.

We need to have the momentum equation, so this S not is the bed slope and SF is the friction slope. So this is for stream flow no we need to write the equation for groundwater flow. So groundwater in unconfined aquifer will have different thing in that one dot T Del H = S Del H / Del T + QV B + 2 Z which is weighted perimeter of the channel.

Now this is valid for the lower part of the channel and governing equation for the other part that will be K which is hydraulic conductivity. This is HM, this is saturated thickness of the aquifer H M, then Del H. This is S Y or specific ail. In this case, this is storage coefficient and this is specific ail for the aquifer and there will be coupling between this equation.

This equation that is continuing momentum for saturated confining portion and unconfined portion that will be coupled by Darcy's law and this is QV B2Z, this is torsion flex Q the flow into the channel per unit length through its weighted perimeter. So we can say that this is the torsion flex. We should have hydraulic conductivity and this is hydraulic radiant. What is hydraulic radiant?

Here Z + Z not, this is the total head for stream and we have head here that is age for any arbitrary location. Then we have this Del Z prime that is the difference between these 2. So we can say that this is our hydraulic radiant and it is a coupling our all the equation then to solve it we need certain boundary condition for open channel flow or river flow or stream flow.

We can either specify stage or discharge at upstream location and we need to specify stage discharge relationship for downstream location. So this is for stream thing and for aquifers we will consider the whole region as impermeable. So we have stream here which is flowing like this and this parts, this is our X and this is our Y axis.

So this is basically Del H / Del Y this is 0 and this case, this is Del H / Del X is 0. Here also we have Del H / Del X = 0. So we can choose a very large region and we can put that hydraulic head change to 0 that way we can manage the boundary conditions. The initial condition for stream flow is depth and velocities. So depth and velocity that should be known for initial condition and with this configuration we can get the variation.

So variation will be like this where this is our upstream direction and this is our downstream portion. So for any flood wave there will be change in the hydraulic head in the aquifer with the change in the fix of flood wave.

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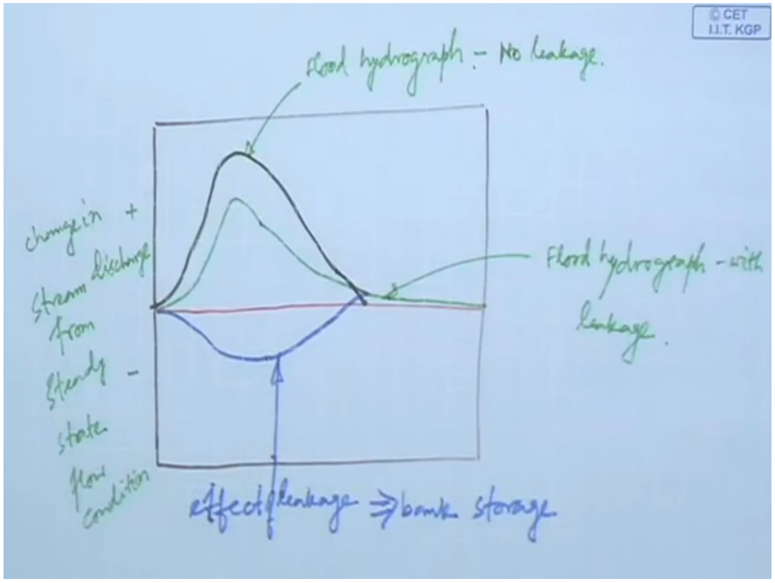

So if we draw one simple figure maybe for some intermediate point here then we will see that if this is our hydraulic head then for flood hydrograph with no leakage this is positive direction, this is negative and this is change in stream discharge from steady state flow condition. So this is flood hydrograph this is without or no leakage. So there will be change, let us consider this is with no leakage.

So it will merge here and with leakage there will be reduction, this green line and if we consider the effect of leakage, then we will see this difference will plotted in this. So this will be the same, so this is basically the effect of leakage. So the net effect of leakage or net effect of bank storage. This is bank storage or we can say that effect of leakage is or bank storage. Now we can have other situations where our pumping will influence

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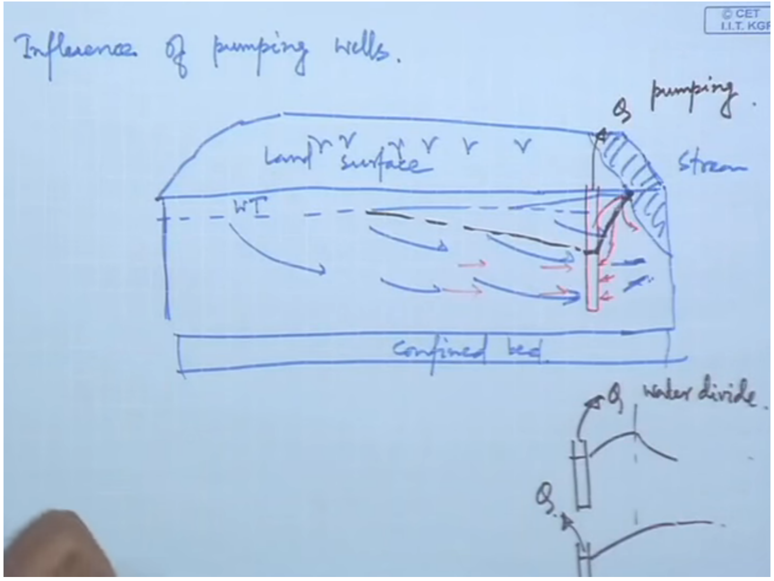

Pumping will influence the whole thing, so let us say that we have region. Now this is our ground surface and this is our water table which is matching here. This is confined bed water table, so there will be flow from this direction towards the stream. This is actually our stream and this is ground surface or land surface.

So there will be movement towards this stream, now if place some well here, interestingly with small amount of pumping there will water divide and again there will be movement. This side also but it will be in normal direction but if we have some amount of heavy pumping then it will be directly connected with it will be directly connected with the stream stage and we will see a different water down in the pumping well.

This is pumping so these are the effects of aquifer on the stream and there is reverse effect of stream on aquifer, so amount of pumping also dictates the water divides. So in the second case where we can have some amount of water divide for low pumping valve but for high pumping valve. This will be directly connected with the stream level, so this aspect is important because our aquifers can directly influence the stream water level.

So there is always interaction between streams and aquifers most importantly if we have 2 reservoirs. Let us say that one reservoir is leaving water at certain rate another reservoir is leaving at different rate. So in between if there is too much extraction. So in stream there will not be much water available, so this is a total effect of stream water aquifer interaction. This ends lecture number 40.