Ground Water Hydrology
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Module No # 04
Lecture No # 16
Well Flow for Special Conditions; Partially Penetrating Wells; Horizontal Wells

Welcome to his lecture number 16 in which the topics covered are well flow for special conditions followed by partially penetrating wells at will be followed by horizontal wells and collector wells.

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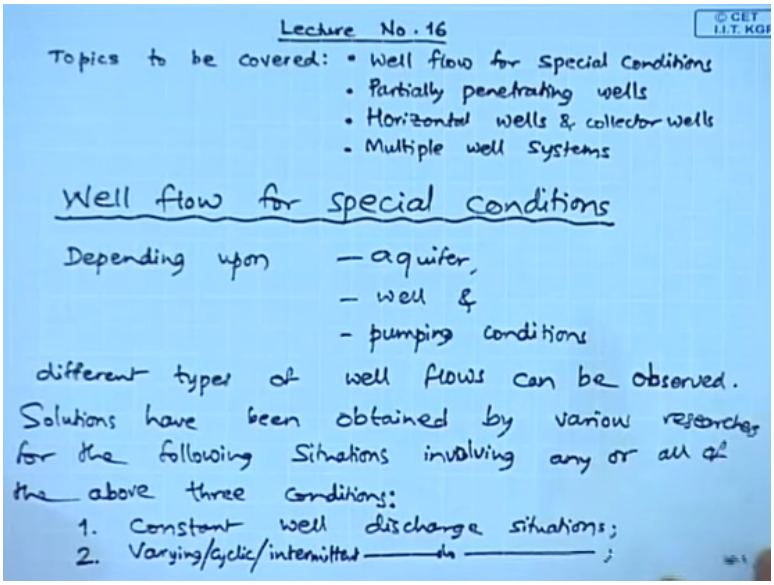

And lastly the lecture with multiple well systems now we will start with the first topic of this lecture for well flow for special conditions. So in this topic so the depending upon the 3 parameter that is on aquifer, well and pumping conditions. So different types of well flows can be observed and again so this is as we see so this aquifer well as pumping conditions.

So these are such a 3 vital parameters so which may make the things quite intensive and quite complicated. So therefore we will not be able to focus very much into these parameters. So at least so here so but researchers have obtained for problem consisting of different well conditions as well as different pumping conditions for the following special situation or circumstances that

is solutions have been obtained by various researchers for the following situations involving any or all of the above the three conditions.

So these conditions means the aquifer conditions the well condition as well as the pumping conditions. So based on four different conditions so the which are list so the solutions have been obtained by various researchers. So these different situations are listed here the first one is the constant well discharge. And we already have discussed many of these constant well discharge situations and this is followed by varying cyclic stroke intermittent discharge situations.

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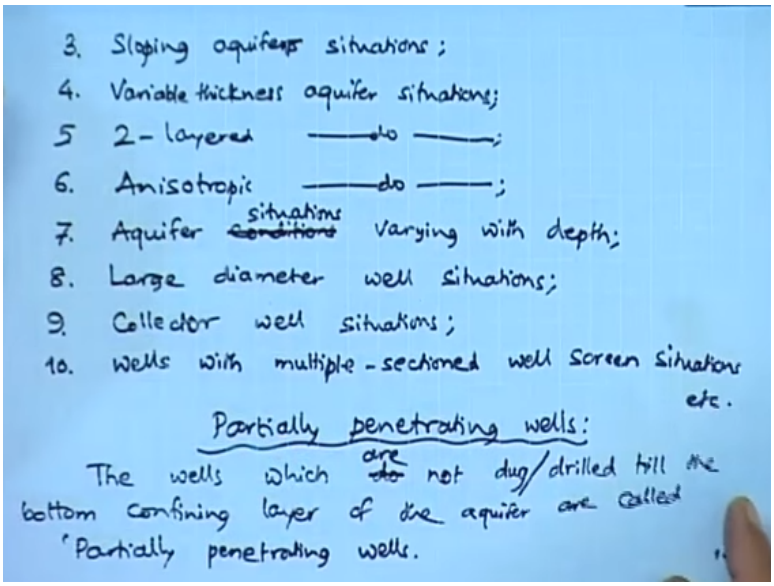

And next we will go the next situation is sloping aquifers or sloping aquifer situations followed by variable thickness aquifer situations followed by two layered aquifer situations followed by anisotropic situations followed by aquifer conditions aquifer situations are there.

Aquifer situations varying with depth so next it is so these are corresponding to the aquifer conditions then the well that is the large diameter wells large diameter wells situations followed by collector well situations followed by wells with multiple section well screens sectioned well screen situations etc. So here we should not restrict we should not be under the impression that so these are the ten situations which we may encounter after all it is groundwater which is the sub surface water and then so the situation may depend upon varies this one.

It may depend upon varies aquifer conditions or well condition or pumping condition or combination of these three. So therefore so these are the ten major situations which the researchers have considered and then obtained solutions. So these solutions are fully analytical solutions they are analytical come field or experimental situations or it is fully experimental solutions or combination of others.

So this is actually this is how the well flow for special conditions involving the either aquifer or well or different type of pumping conditions is handled. With this we will go to the next chapter next topic of this lecture that is on partially penetrating wells. So here we should know note that some of the wells do not penetrate for the entire thickness of the aquifer. So here such wells are known as partially penetrating wells so the wells which do not or other which are not dug or say drilled till the bottom confining layer of the aquifer are called partially penetrating wells.

So very simple and straight forward concept so in case of the partially penetrating wells unlike the fully penetrating well where in so there is radially involved flow all around the circumference of the well. So where as in case of partially penetrating wells the flow is even more slightly is should say slightly more complicated in the sense. So there is flow not only through the inner surface of the inner cylindrical surface of the well but also through the bottom at the horizontal surface of the well or say the bottom of the well.

So therefore in this case unlike the fully penetrating wells wherein we assume that the stream lines the flow is radially inward and in the horizontal direction. Of course there as to be some slope but for simplicity we do assume that the flow is horizontal radially inwards and horizontal whereas in these case so the especially on the bottom the flow will be in the upward inclined direction.

Whereas in the in case of the through the sides that is the cylindrical curved this inward surface of the partially penetrating well the flow will be generally or mildly sloping horizontal as well as radially inward flow.

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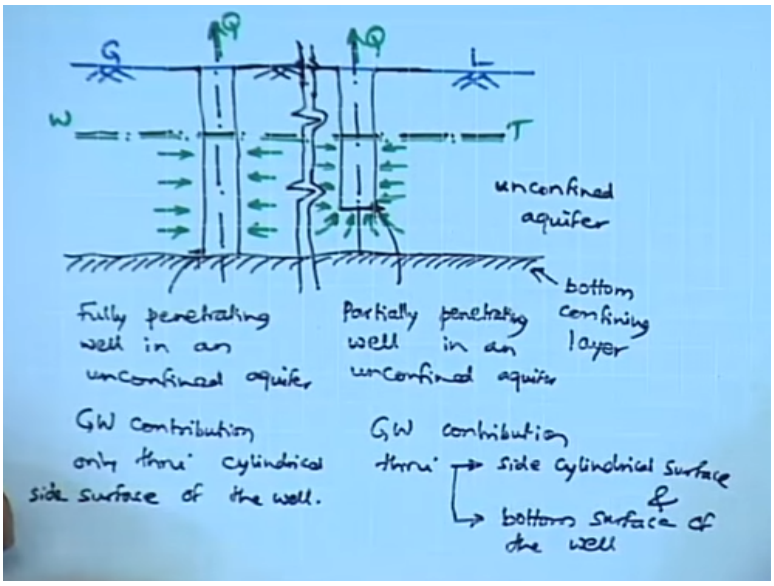

And the following sketch will represent this one so let us say this is a let us consider for simplicity one water table aquifer. So sticking to the convention of green for water table and so this is a water table and then there is this ground level and in this case let me show a fully penetrating as well as the partially penetrating well. So this is the bottom confining layer and here.

In this case let us say so this is fully penetrating well of course say this there will opening here always and also another well which is partially penetrating let us it just is dug only up to say this fraction and then below this even though it is an aquifer. So this is a unconfined aquifer and then similarly so this is a here so this is a fully penetrating well in an unconfined aquifer whereas this is partially penetrating well in an unconfined aquifer.

Let me show here with the break line so in this case now let us say suppose these are the flow lines into this fully penetrating well which almost horizontal. Where as in case of this partially penetrating well so of course here also the through the cylindrical surface the flow lines are radially inward and almost horizontal whereas through the bottom also there ill her some ground water.

And in this case so these as the both are the discharging well which is represented by this letter Q. So here so therefore we do get the upward or in the inclined direction inclined upward

through the bottom of this partially penetrating so here so we can write down so this is a ground water contribution only through cylindrical side surface of the well.

Whereas in this case GW stands for ground water ground water contribution through that is side cylindrical surface and that is the bottom surface of the well. So through the side cylindrical surface mostly horizontal radially inward and mostly horizontal flow whereas through the bottom it is an upward inline flow. So therefore so here you can denote this as so this is in case of unconfined aquifer.

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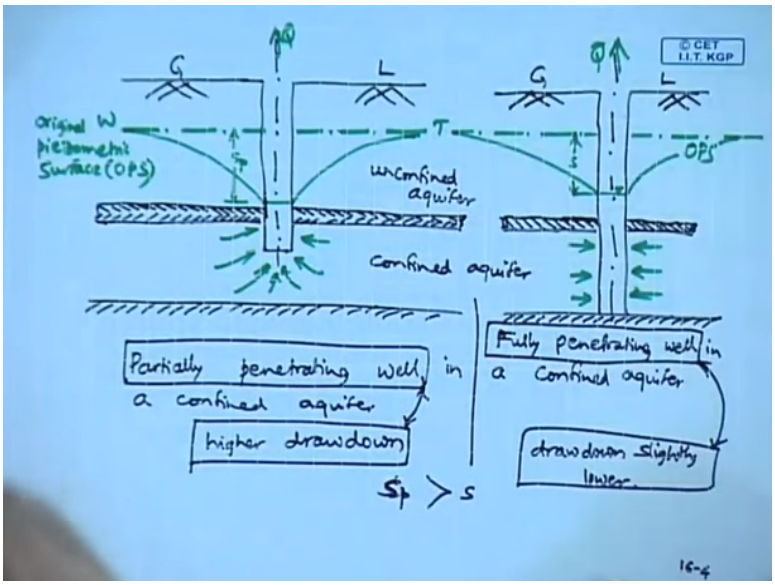

Now let us also consider a confined aquifer a partially penetrating well in an confined aquifer partially penetrating well in a confined aquifer. Of course this is not much different from partially penetrating well in an unconfined aquifer only thing is in case of confined aquifer. So it is the flow takes place under pressure and suppose this is the let us say this is the so this is the ground level and then this is the water table and let us also consider say suppose this is the bottom confining layer of the confined aquifer and then say let us say this is the top confining layer.

And say let us say this is the so this is the aquitude or the impervious layer which distinguish this unconfined aquifer which is at the top and the confined aquifer. So this is the unconfined aquifer and this is the confined aquifer and in this case so the so this is the original water table of

piezometric surface original peizometric surface denoted by the letter WT and then so here with this full had the well been fully penetrating and may be let me show it here.

So this is and say this is the original peizometric surface so this is also the same original peizometric surface let me abbreviate this as OPS and here this original peizometric surface and this is fully penetrating. This is the partially penetrating well and in this case this and here we have this is a fully penetrating well in a confined aquifer and obviously so this is the centerline of the well partially penetrating well.

This is the fully penetrating and so these are the so this is the both are discharging wells and in this case so what will happen is in case of a full for full penetrating so the drawdown curve will be somewhat like this where as for the same this one the drawdown curve for partially penetrating for the same confined aquifer I am sorry I am sorry I used the wrong color this one.

So whereas in case of this partially penetrating well the this one that drawdown in this case if we denote this drawdown by the letter SP representing the drawdown for partially penetrating well and where as in this case so the drawdown for fully penetrating in this case we can write down the relationship that is SP that is the drawdown is greater than S and so in the case of this one so the stream lines will be like this where as in case of fully penetrating well.

So obviously they are the streamlines are almost horizontal and radially inwards like this so in case of partially well so the drawdown so this is a higher drawdown and as compared to the fully penetrating so this is a drawdown slightly lower so this is the higher drawdown for partially penetrating and drawdown slightly lower. So this is for fully penetrating well okay.

And here so like this so the area of the circle of influence they all may be more or less are same but only thing in case of partial penetrating well so the drawdown will be more for simple reason that the area which is observed which is drawing water is more because this area which draws water is the not only the cylindrical curved surface but also the bottom surface of the well which most of the cases is horizontal.

So therefore since the area is more so then obviously the amount of water extract is over it is also and then so therefore and the drawdown in case of partially penetrating well is more. So with this

so this will complete the second topic of today's lecture and today we will go to and then this next we will go to the third topic which is one horizontal wells and collector wells.

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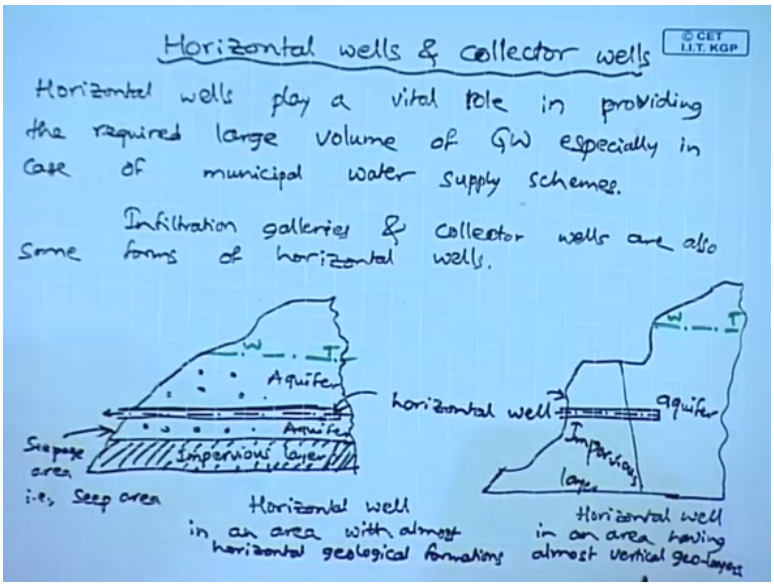

And here so these horizontal wells play a very major role in a especially in providing the large amount of ground water that is required generally in case of say municipal water supply schemes. So here so for the simple reason that for horizontal wells so their basically their the flow into the well is along the axis of the horizontal whereas in case of these vertical penetrating the flow is perpendicular to the well axis the ground water flow is perpendicular to the well axis.

Whereas in case of these vertical penetrating wells the flow is perpendicular to the well axis the ground water flow is perpendicular to the well axis. Whereas in case of horizontal this one and the horizontal wells so the actual flow is perpendicular to the horizontal well axis but the combine flow is along the horizontal well axis. So here they play a very vital role in providing the adequate ground water supply.

So here horizontal wells play a vital role in the required large volume of ground water especially in case of municipal water supply schemes so here this then of course there is infiltration galleries are the type of this one so this is infiltration galleries and collector wells are also some form of horizontal wells and in this case suppose this is the horizontal well.

And then followed by in this case there is a water table so here this is the this will be water table and here this is the aquifer and here you so this is the impervious layer this is the impervious layer so this is a the aquifer is here so here also this is aquifer and then this is the horizontal well. So this is the and here this is the sea page area or say which is also generally referred to also simply seep area and this is the water table.

And here we can say so this is the break line am showing here so this is a one this one where in the formation of this the ground water layers is almost in the horizontal direction. So it can also be in the whereas this ground water this rocky formations, geological formations, may be mostly in the vertical directions also in such case so the horizontal well will be somewhat different.

So in this case let us say this is say is an impervious layer and here this and then the here it is aquifer and here let us say this is the water table. Si in this case the general formation of the geological formation direction is not the vertical this one. And again here also I can show a horizontal well which will be so this is a horizontal well in an area with almost horizontal geological formations similarly this is horizontal well.

So this is a yeah this is a horizontal well in an area having almost vertical geological formation or geo layers. So this horizontal wells as you can see so depending upon the in this case obviously the area that is a seep area is much more and so therefore because the gradient in this case is quite less as compared to vertical wells so therefore the Darcy's law will be more applicable and then obviously that is the reason why the output by this horizontal wells is much more than a regular vertical well.

And let me also bring it to the notice of what are known as the collector wells so this collector wells is well which consist of a number of radially horizontal wells which join a well which is generally for this one.

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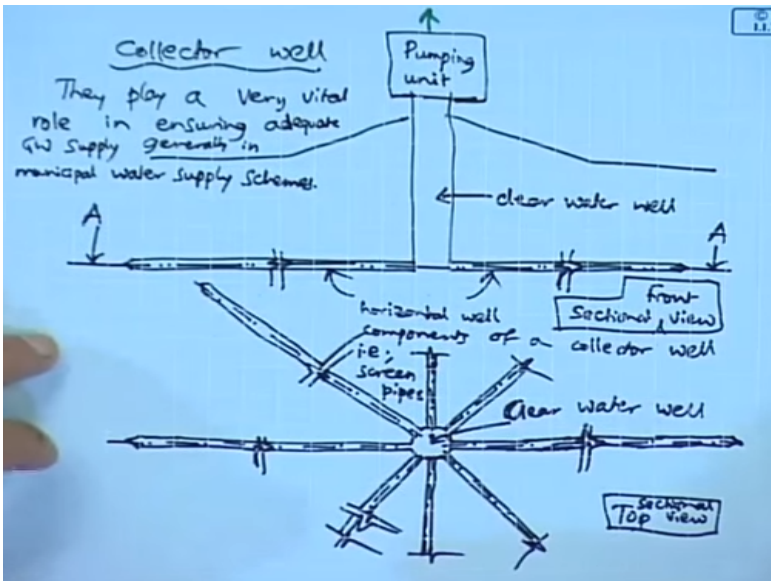

Now let us consider the collector well and this case suppose this is the suppose this is the top view and here this is the of course here if you want again there can be a break line. So this is the pumping unit so through which the water is pumped so this is the sectional view section front view. So these are so it is horizontal wells horizontal well component of a collector wells.

So this is the sectional front view and then the same thing let us draw the top view so in the top view it will be so here this will be so all these there radially emanating. So here you can show the axis. So that can be any number of this radial horizontal well horizontal well which together constitute what is known as the collector well.

So in this case so this is the top view of this collector well and so here so this is and this is horizontal components which area generally so this is they are referred to as screen pipes and so together so it will form a collective well. So this is here this is the so this is the clear water well okay.

Obviously so this is the clearway well and so this is a collectable which is basically the combination of number of horizontal wells horizontal wells generally located in the same level and so here can say this is so this is section so this is a sectional top you of a collectable. So these so here they play a very vital role in ensuring adequate ground water supply generally in municipal water supply schemes.

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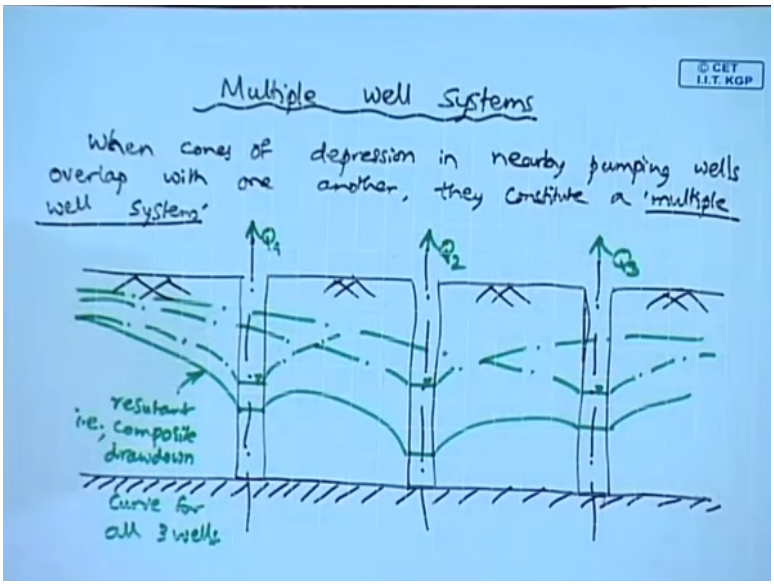

So now we will go to so this completes the third topic and last topic of today's lecture is on multiple well systems as a name itself says there are number of wells which are involved in this multiple well system. And here so this is a multiple well system as a name itself if self-explanatory so there are number of this wells this multiple well system and here so this is a now let us consider.

So this is a so we can write on when cones of depression in nearby pumping wells overlap with one another they constitute a multiple well system. So basically a multiple well system has nearby wells and then so these wells each one of them have a cone of influence cone of depression and then this cone of depression of this nearby wells so they will overlap with one another.

So let us show with this one that is a multiple wells system with say three wells where in the cone of depression cone of depression of each of this wells is overlapping. This case so let us say this is these are the three wells and let us consider that this this is the common bottom impervious layer and each of this wells are discharging wells. So this is Q1 this is Q2 and then this is Q3 and each of them let us say the suppose this is the cone of depression for this well and so there will be another cone of depression for the other.

And similarly the third cone of depression for the so resultant cone of depression will be something like this. So this is the resultant that is composite drawdown curve for all three wells.

So these are the individuals drawdown curves for each of the curves and these are the individual drawdown curve for each of the wells and then so this is the resultants. So like this so this multiple well system says will stop at this and in the next lecture we will discuss the further topics thank you.