Geoenvironmental Engineering (Environmental Geotechnology):
Landfills, Slurry Ponds & Contaminated Sites
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Lecture - 24
Subsurface Monitoring Around Landfills - Part 2

So, good day to all of you and let us continue with our discussion on subsurface monitoring around landfills. We will quickly recap what we did last time and that is carry on and cover little more about how we do this monitoring.

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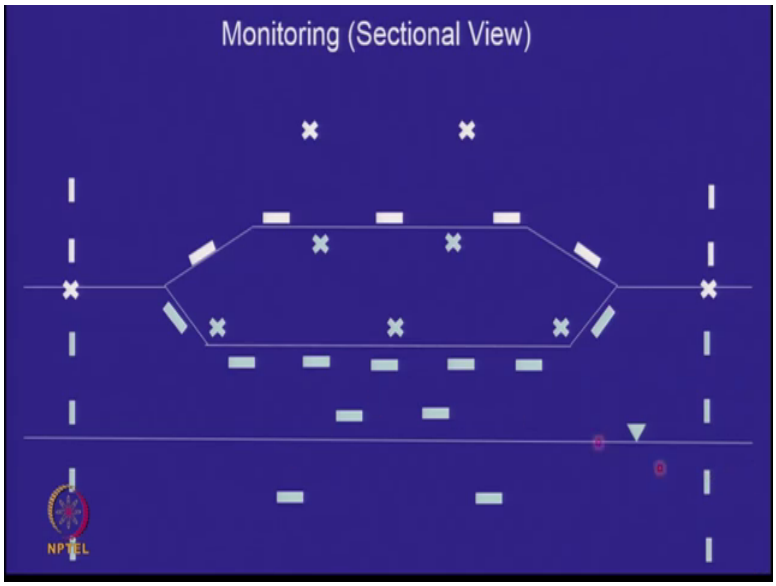

So, if you recall last time we talked about monitoring above the landfill, below the land fill and on the ground surface and on the surface of the landfill. We are basically focusing on how to monitor the environment beneath the landfill.

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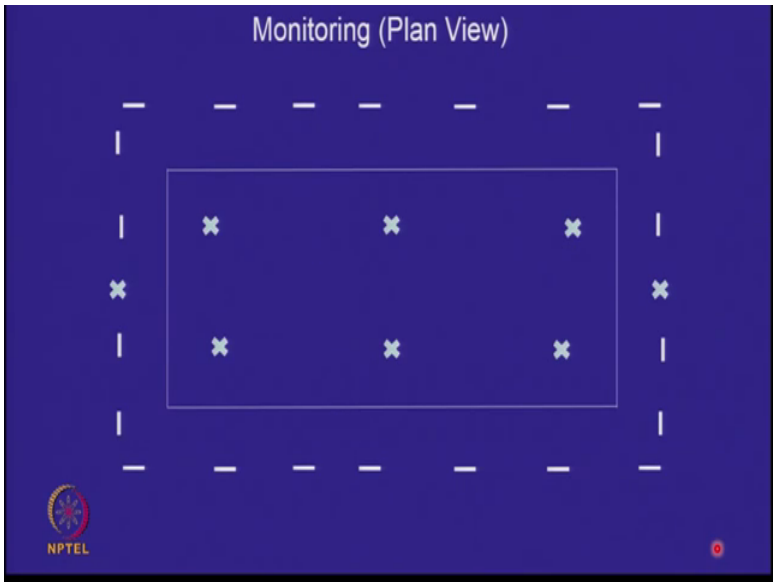

And that is to detect early, and to ensure that no contamination crosses the boundary of the landfill. In plan also we would be doing monitoring around the perimeter of the landfill and at various points above the landfill on the landfill surface and beneath the landfill.

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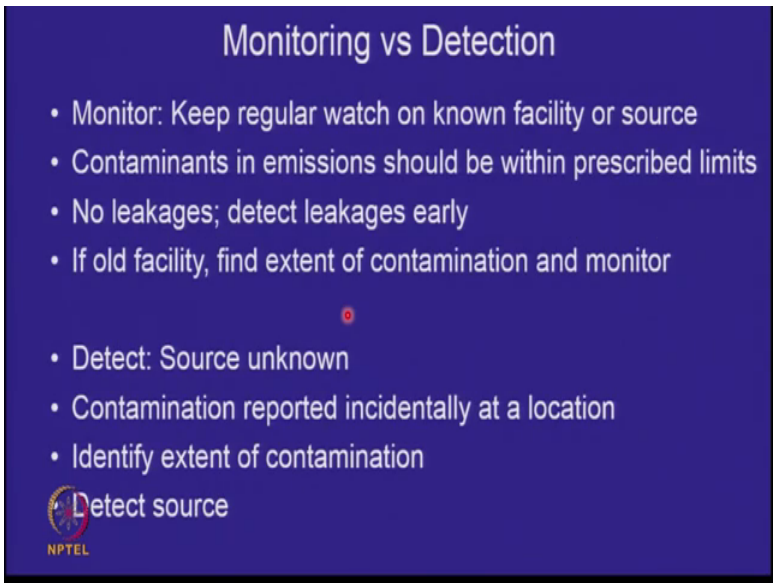

We distinguished last time about the difference between monitoring and detection we said monitoring we know the source, and we are keeping a regular watch and be our main objective is that the contaminants in the emissions should be within the prescribed

limits. There should be no leakages, but if leakage is occur you should be able to detect it early, if we have an old facility we have to first find the extent of contamination and then mount monitor at the boundaries of the contamination.

Finding the extent of contamination is like detection. So, detection is we normally do not know the source, we do get contamination reported from one location then we have to investigate the area around that location and see how far the contamination is spread, we have to identify the boundaries of that contamination, and then walk backwards to detect the source as to where is that contamination coming from.

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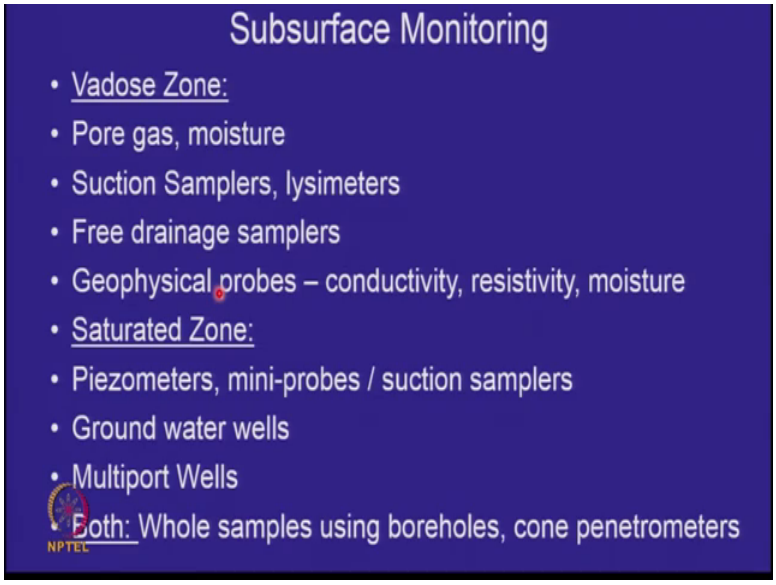

So, in this lecture and in the earlier lecture we are only been looking at monitoring of subsurface environment, when we looked at the subsurface environment we talked about the vadose zone which is a three phase media. And the saturated zone and we said the saturated zone is simpler because you just take out the groundwater and we want to assess the contaminants in the groundwater. It is so much more easier to take out the liquid than to take out the three phases.

So, we looked at various samplers like section samplers and lysimeter last time, we look at the free drainage sampler last time. We began discussion on the saturated zone we looked at ground water wells and today we will be covering multiport wells and also introduce the concept of whole sampling, which will see a little more today you using bore holes and cone penetrometers.

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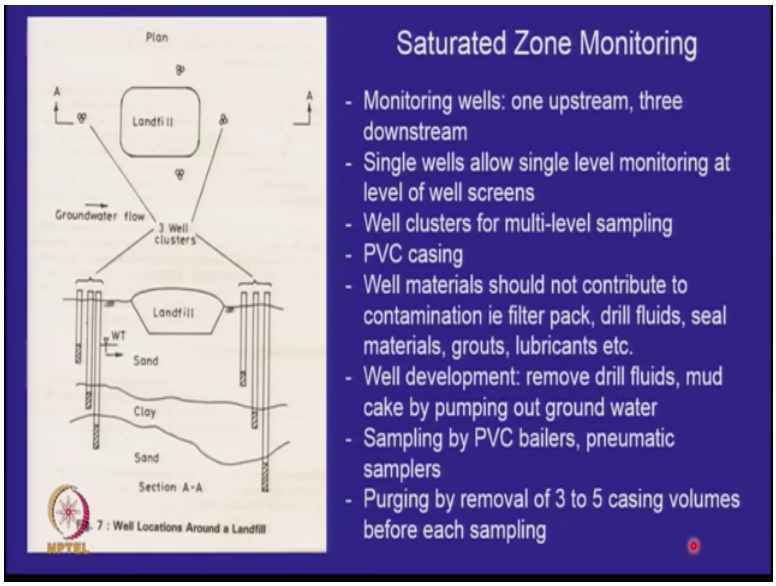

So, let us focus on saturated zone monitoring and we said last time that monitoring is done using wells, typically if ground water is flowing in a particular direction let us say from here it is flowing from this side to this side, we will have one well on the upstream side. So, that is the groundwater is coming towards the site, you know what is the quality of the groundwater we can have one well on the downstream side, but it is possible that fluid may go on some other directions. So, normally three wells are kept in plan. So, total of 4 wells are used.

Now, one well is normally good for detecting at one level, and if you want to detect at two three levels, then we can adopt a cluster of wells. So, first we have to we did this last time why cannot the same well be used for the purpose of monitoring at different levels and we will revisit this, but at the moment we recognize that wherever there is the screen that is where the water can be collected from, and you can use the cluster of wells if you want to do monitoring at different levels. So, one upstream three downstream, single wells allow single level of monitoring at the level of well screens, well clusters allow multi level monitoring, preferably for groundwater quality monitoring we should not have the cast iron casing, but PVC casings, we should avoid materials which can cause contamination of the groundwater because the drilling process itself. So, you know drill fluids, seal materials grouts that they can all cause problems and if we have inserted a lot of drill fluid, we have to remember that we have to do well development that is suck out all these for several days or weeks before we can come back to the original groundwater

which exists. So, well development means remove the drill fluid, the mud came to back pumping out to the groundwater.

To pick up the groundwater samples we would like to use PVC bailers or PVC pneumatic samplers, and in any case whenever we want to go and sample at a particular location suppose I want to pick up a sample today, then I want to come up after a month and pick up a sample, I do not just send my sampler to this level. I have to first remove the three times the volume of the water which is inside this casing why? It is a well something may have fallen on some foreign material may have fallen from the top, even if it is sealed some other algae or bacteria may start to grow. So, therefore, you would like to purge; purge means remove 3 to 5 casing volumes and then take a sample from this location.

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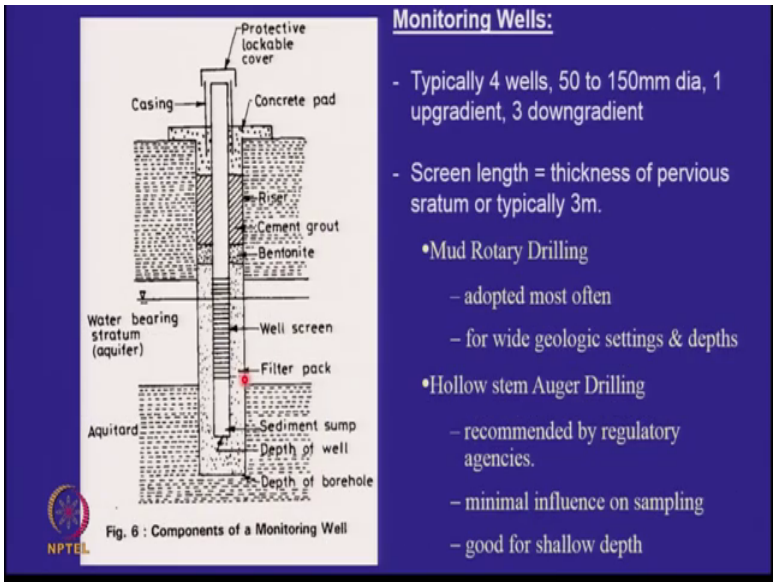

So, again just to understand if this my landfill is here, that is my groundwater.

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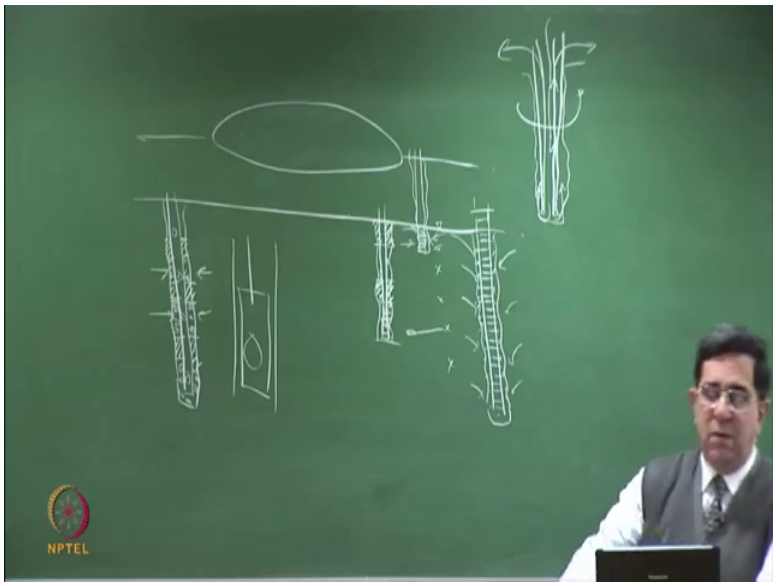

If I wants to ask you please give me the concentration of ground water at different locations. I wanted you to tell me what are the concentration of chlorides at these 5 points. Now it seems simple that I should make a well and monitor it, but just see what happens when you make the well first you make the bore hole right and during the making the bore hole your using drilling fluids, how will you make a bore hole for a tube well, what kind of boring do use do you normally use gagger boring, do you use auction wash.

Student: Wash

Wash boring means what. Suppose I am making a 6 inch or an 8 inch diameter well, what is the drill tool that I will use. I normally use a casing with bentonite slurry being pumped into it and I keep on rotating the casing and the bentonite slurry comes from outside, I am aggregated in this and the drill bit at the bottom you are fluids are coming in this casing is rotating and the cuttings are coming out. It keeps on cutting you do not record the casing suppose you have to go very deep the slurry which is coming from the annular space between the casing and the borehole that carries out the material which has been cut. Once you have reach the particular level then you put in your pipe with the screens and remove your casing and in the annual annular space you fill up the gravels. So, what are you seeing here? You are seeing here in this diagram though this is the straight line this is the bore hole, which has been made by the drilling equipment. The

drilling equipment is gone you have put in a casing, the casing has holes or screen and between the annular space of the bore hole and the casing your putting the gravel pack. So, do remember that when you remove your casing the whole hole is full of bentonite slurry and that bentonite slurry has nothing to do with ground water, which exists there and this bentonite slurry has also gone into the soil. So, that is why the importance of well development are moving this. So, you put the gravel, and then you put bentonite or cement gourd to seal this so that nothing from the top can come here, and this screen level is where the ground water is coming in. So, when I give you this problem that please tell me the ground water your chloride concentrations in the groundwater at these 5 levels, we are you are very tempted to put a bore whole and we have very tempted to put a. Suppose you put this screen you say I will put this screen over this entire length, and then I will take the samples from this bore hole. Please understand the gravel outside is making all these waters mix together, you know this is become a high drainage media.

So, anything you do to take out the water from here the level will go down, I have to do purging 3 to 5 casing volume more water will come in that water will be mixed to water of all this because the water will flow like that. So, I am not able to pick up the water from 5 specific points, which represents the original condition. To do that either I can use a well cluster of 5 wells. So, then I will put one well up to this point and just have the screen here. So, that the water which comes here whenever I sample comes only from this zone. If I put another well which is away from this here so, that the two things get interconnected; and when I put the sampling here please note I want to put two sampling here my screen or my puff rated pipe is this is the level of sampling is here, and suppose I seal the hole here with bentonite or cement ground, I am again making the fundamental error why the gravel pack is all over. I think I am picking up the sampler from here, but that is not the case the water is falling through the gravel into your screen. So, you have to either seal of your sealing should be here. So, that no water can come from the upper layers and meet the bottom layer.

So, there for establishing the groundwater contaminant concentration requires picking up for samples from specific points, and you should not have any interconnectivity with the other points. Now that is not what we do on normal wells and normal tube wells and nobody seems to understand that. So, you will go to any landfill site and you will find do you have a borehole for monitoring groundwater yes sir. So, there will be one bore hole

where is the water table? 15 meters deep; how deep is this? Sir this is 25 meters deep, but what are the sampling are the sampling of 15 meters or are the sampling from 25 meters or 20 meters it is all mixed, you can have even deeper. So, therefore, if you want to monitor at different depths, then you have to have either a well cluster or a multi port device a multi port device. I will show you next what will the multi port device do in a multi port device you will have openings at specific depths and you will seal of the portions between those depths. So, both I want to pick up 5 samples in one bore hole what will you do.

In if I want to pick up 5 samples from the one well, I will make my hole, I will put a pipe with my screen or a port here 1 2 3 4 then I mastery sure that water does not cross from one port to the other; that means, I will put gravel pack here, and then I will seal this then I will put gravel pack here and then I will seal this.

So, that when I come to this hole and take the water, water only comes from here, the top water cannot fall into this, this is zone of your sampling. So, a multi port device has got multiple levels of seal in it, is in the annular space between the pipe and between the bore hole, that is critical to then again you put gravel here and then you put your bentonite seal. Do you know how the seal the annular space, how do you seal an annular space between the pipe and the soil outside. You are made an 8 inch hole, you put a 6 inch pipe inside it, you will put the gravel pack around it how do you put the gravel? You just put the gravel from the top it goes into the bentonite slurry which is there. How do you seal it then? Conceptually you can sent cement slurry and seal it, but normally you get bentonite telex you know like tablets.

If you take any small bentonite tablet it is nothing, but bentonite powder which is compacted in the form of a tablet, and if you put it in the water it will fall down like gravel, but once it falls down on the gravel below, it hydrates with time. As it hydrates with time first the tablet will expand then it will it is tribal. So, the whole mass will become one hydrated bentonite gel right and that is a perfect seal you know what I can go through it. So, basically to seal the hole specially for applications like ours, you please understand in understand in a normal well you are not trying to stop water from coming in from every level, you want water drinking purposes or irrigation purposes, you want all the water to fall is that right. Here we are trying to say we want water from a specific place therefore, this sealing becomes so much more important.

So, multi port device has multiple seals and water comes from when you will say some, but still in this it can get mixed. So, your sampler goes and dogs itself on this. Shall I say it again, a sampler goes and dogs itself to the whole, then you pick up the water which comes in the sampler take it out throw it away, per get 3 to 5 times then finally, doc it and take the sample. Then if the sampler comes and docs itself if this is the pipe and this is the port and a sampling device is coming down and docking itself means it attaches itself and you can open the doc, then you are only picking up water from that zone which is coming in from here, that is what a multi port devices.

So, either you use well clusters or you use multi port. Multi port devices are very require a highly skilled operation to install that you can easily go wrong, but your drilling costs are done here you will drill 5 holes, there you have to put one device. Any questions on this, whole concept of ground water sampling?

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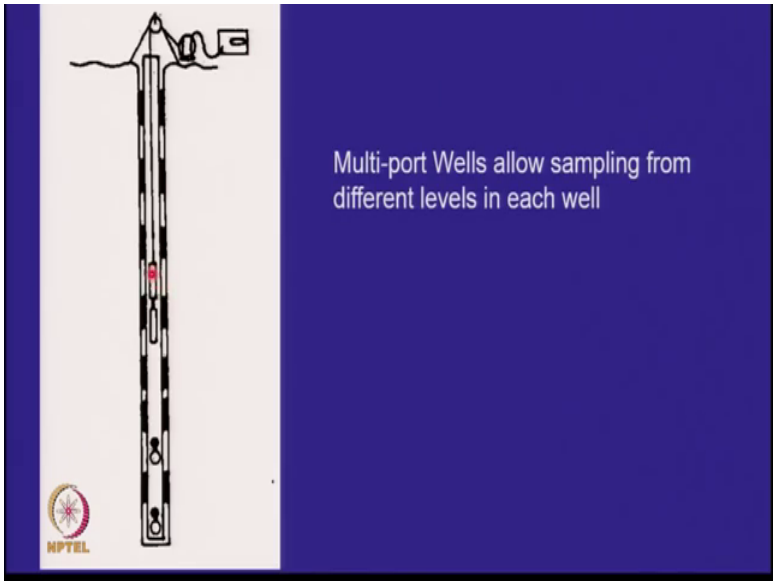

So, a multi ort device looks like this there is a particular type of sampler, we will not going to details of this, this can be a vacuum sampler or a numeric sampler.

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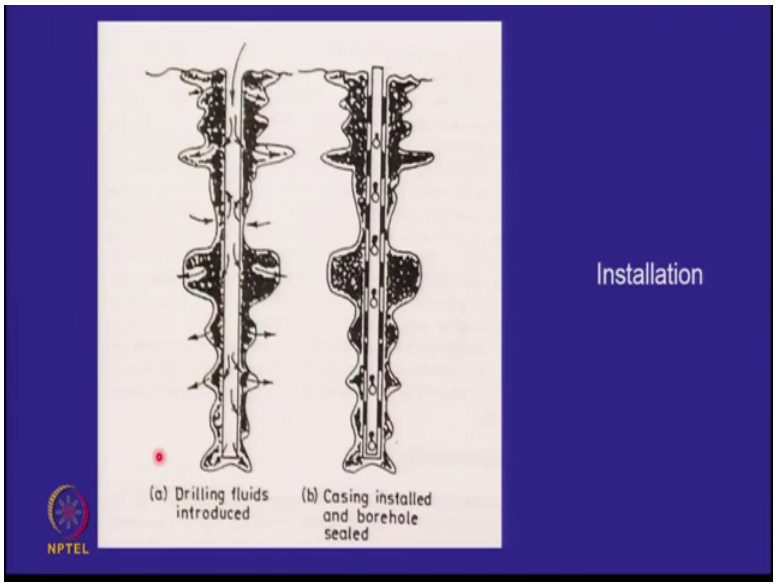

Which goes down and goes and stops at a particular location, attaches itself it mechanically or magnetically, and it will get the water sample. Just to understand first I am making the bore hole, when I am making the bore hole I am using this bentonite slurry. So, all this black black black is the bentonite slurry or whatever slurry that you are using then. I am putting in this pipe with this ports can you see this 1 2 3 4 5 6 ports right and then I have to seal, can you see this black seals 1, 2, 3, 4, 5, 6 this means these holes are only going to get water from here, from this white portion ok.

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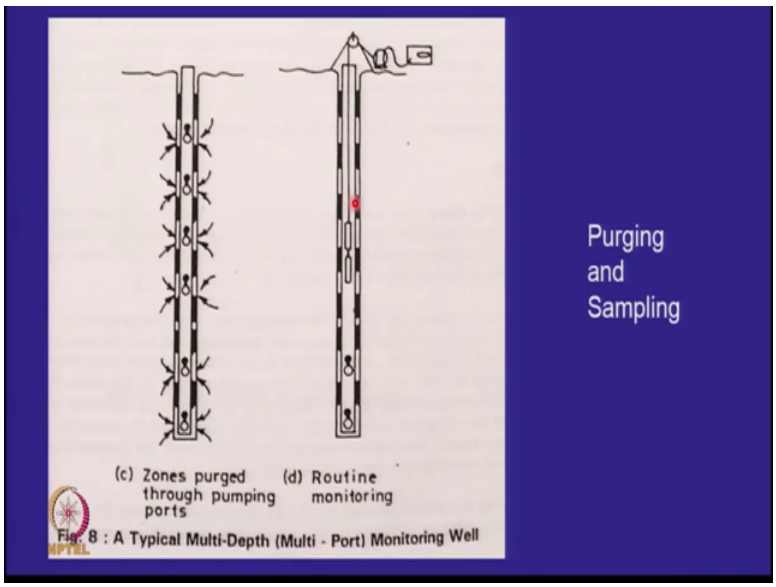

Install my device then I do the purging well development, I keep all the ports open and suck out the water what is the idea of doing this? All the bentonite slurry or drill fluid which we have put into the soil, first that will come out; well development takes weeks it does not get developed in a day.

So, you allow the water to come out, you are disturbing the groundwater. So, after the purging has taken place through the ports you close all the ports. Then only that port will open where you want to sample and when you want to sample right and then with this sample when you pick up a sample say from here or from here, you can tell me sir that this is the concentration of chlorides in this sample and this is the concentration of chlorides in this sample. Otherwise your giving me an average concentration of the chlorides, which will sometime the high them in nature level high [FL]. So, this is the typical multi port monitoring well. We do not use multi port monitoring wells so for in India, we basically are still using single wells, but we can use cluster of wells for which we have the expertise.

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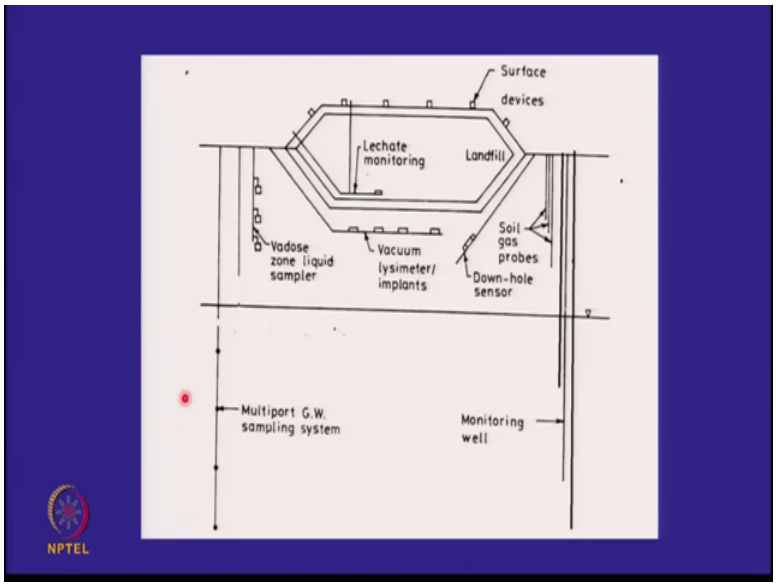

In the end I mean after all the discusses that we have done, if I am only look at sub surface contamination, please understand I am I can in the Vadose zone put a lot of sampling devices. A Vadose zone liquid, sampler vacuum lysimeter, soil gas probe all kinds of things down hole sensors and in the saturated zone I can use multi port ground water sampling or well clusters of different lengths. So, you know this looks very nice,

but I can still miss a leakage with close from here. So, which brings us back to the basic concept that I want to monitor everywhere, how do I monitor everywhere beneaths a landfill by putting a leakage detection system.

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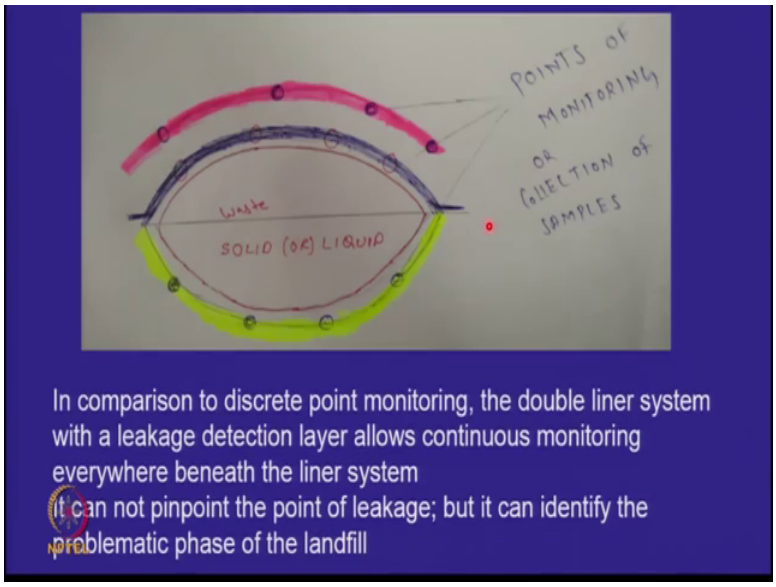

So, all this is rarely done, all that we do is put a double liner. When I put a double liner; that means, I am monitoring this entire yellow area.

If something leaks it will come into this and it will reach the side, I will not be able to tell you from where it is leaking, but I will tell you that leakage is taking place. So, I can identify the quantity of leakage and I can also have the alarm because ita has given us some values if it exceeds then we know we have a problem. But in continuous suppose I was tool not have the double liner, but I was to have 100 samplers here installed, when I could tell you it came in this sampler discreet I sampler. But what happens is just go back lest go back to a landfill; the landfill has several phases in plan. Suppose you are doing 16 years 16 phases each phase will have a well, a sump and a pump to take out the leachate. So, we will be able tell you that look this leakage is coming from this phase, but we will not be able to tell you whether what is the action by coordinate of the point which is leaking.

So, still double liner system is the best way to monitor everywhere under in the ground. So, in comparison to discrete point monitoring, the double liners system with the leakage detection layer allows continuous monitoring everywhere beneath the liner system.

Remember if you have a municipality which says oh you have got a very big municipal solid waste landfill, please monitor. Then you tell please allow a double liner system the cost is much higher because if you are going to just put a few discreet point monitors in planned you may just miss the leakage which is taking place. The double liner cannot pin point the point of leakage, but it can definitely identify the problematic phase of the landfill, because it will it will be different sumps to which all these leakage will go.

So, this by large puts us in the correct perspective for new landfills, when you have new landfill I will still have the wells, because I do not want anything to go beyond the parameter I will have a double liner system if it is a hazardous waste, but I do a single liner system if it is a municipal solid waste because that is what the law requires. Here in the new landfill it is simple for me to decide where to put my monitors, but what about the old landfill you know in India has got several 100 old waste dumps all across the country, when I have to monitor a cross an old dump then the first question is where to monitor and that is only possible to answer if I find the nature and extent of contamination.

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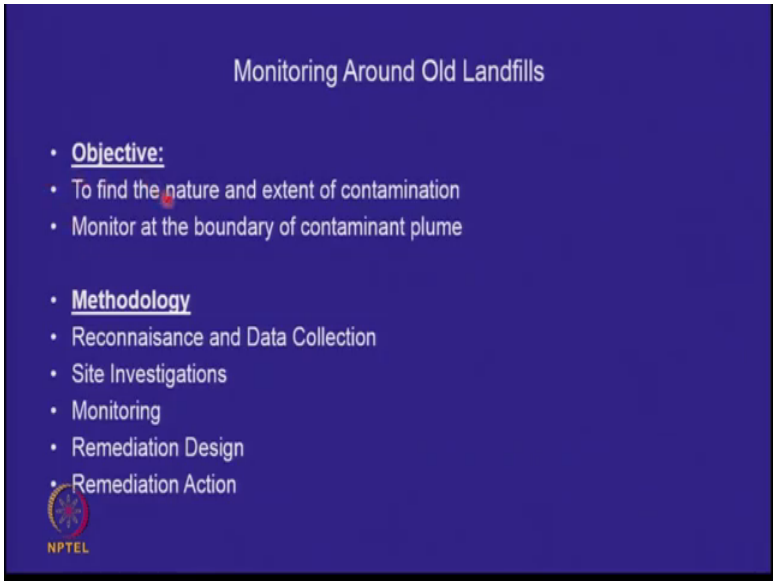

So, here the problem becomes totally different; in the case of a new landfill the sources known, in the case of an old landfill the problem becomes different in the sense that we know as a dump is, we know where the dump is, it is not that the we do not know the sources.

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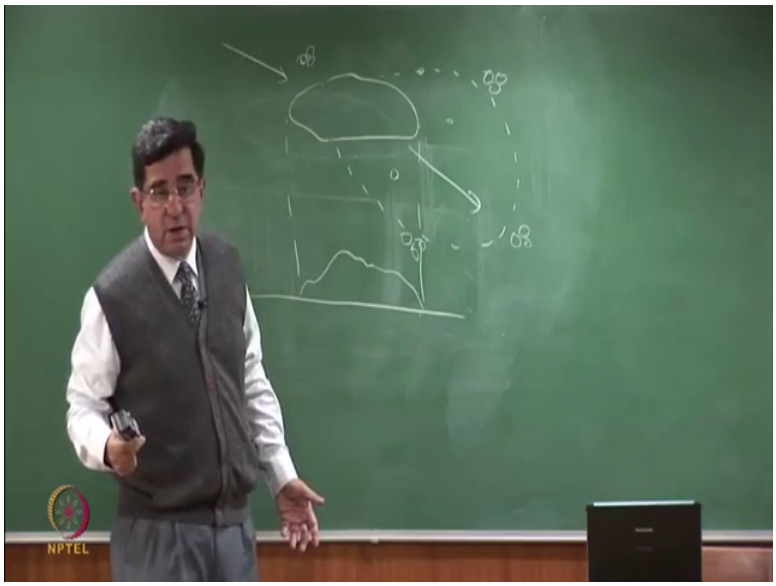

So, if I look at in plan, let us say that is my old based term in section let me see that is my old waste. This is the section of old dump this is the planned view of old waste dump, I also know from I site investigation that ground water flows like that. So, I do know where the source is, but I do not know where to put the wells because if the contamination has traveled, then no point putting the monitoring well inside the where the contamination is traveled, all that it will tell you that it is contaminated after that it will serve no powers. If you put it outside the boundary, then you can tell whether the contamination has reached or not reached. So, unless I know what the ground water contamination do already is if it is there, then I can decide is that one stream well cluster here and 3 here, and I can say that I will take some steps and ensure that it does not go beyond, but to do this location I mean in contrast if I put these here it would serve purpose, but to decide this I have got to discover the boundary of the extent of contamination that becomes an exercise in detection.

So, now, you actually need a bore a well which can move around you know [FL] let us check here is not right? If you have to find the extent of contamination in a lake, let us say we find some contamination as started taking place in the lake. So, you know that some pipe line is bring in a contaminate a lake is let us say 5 kilometers by 5 kilometers you know the source, but you now want to know how far the contamination is traveled into the lake. So, you will take a sampler and go putting plunging the sampler

everywhere and taking out sample and then say sir if it a contamination we will start from the farthest point, no contamination and come closer along some grid pattern.

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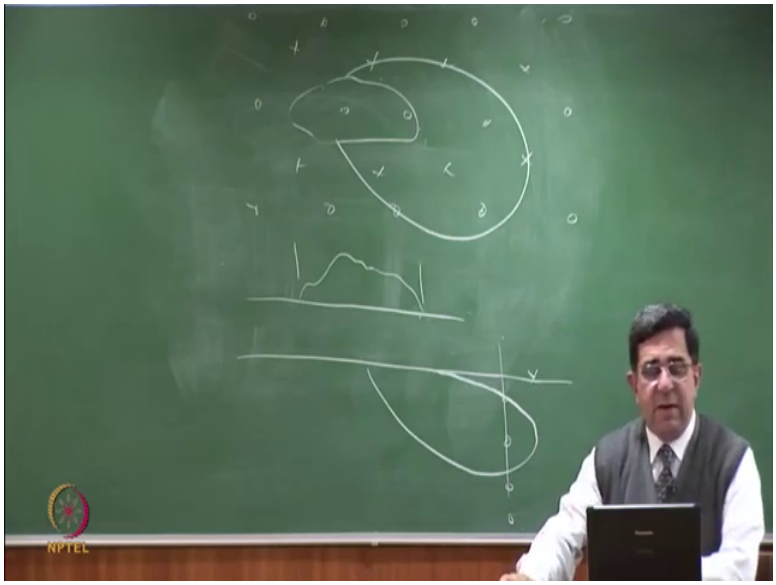

So, the detection exercise is actually different. So, in the detection exercise you have to do some studies in a grid like manner, what will you do? If say this is the few hundred meters I will first say let me go and for check the 4 corners right, and then I will make a little grid and if I detects something and we says this has gone beyond, then I will make a coarse sergeant agreed it. I want to find you in it I will make a first I will do the boundary, I know that it is not reached here and I am getting a reading here then I will do the final grade. I might do the final grade so that I can. And then on the basis of this final grade I should be able to give you all contaminate where is in plane, still I will not be able to give you how it varies in depth.

So, if I have to give you how it varies in depth and let us this is the groundwater table, then what I am trying to say? I am trying to say how does the fluid how deep is the fluid. So, then again the issues comes that one point here means what? It means that you will sample. So, that you can tell me that look my contamination is like this, and it is like this in it is not here, it is not it is here. So, basically detection is a different exercise than monitoring. Monitoring the source is known the original ground water is 16 whatever is the local background level we are just monetary.

Around old landfills you will first have to detect the extent of contamination. You are still looking at some surface contamination. So, to detect you should be able to do a lot of things in plan, first along a coarse grade and then along a finite grade, and then you should be able to do something in section. At all these locations you should be able to pick up discreet samples from different depths. Think so, if there is any other way of doing it fine. So, we need to find the nature and extent of the contamination, then we have to monitor at the boundary of the contaminant plume. So, that it does not extend beyond where it has gone, and then we have to take steps to bring the plume back or to do remediation and to improve the quality of the contaminated zone.

So, typically we will do reconnaissance and data collection if there are some tube wells which are already there or is there some hand pumps in that area, you will go and pick up samples from all those areas because that is their a natural source of information for you, will do not have to drill holes, then you will conduct site investigations and after you have conducted the site investigation you would do monitoring; that means, setup your monitoring legion and then you will do a remediation design. How are you going to remediate, what has to be removed, what is the kind of treatment system you want are you going to pump out the water, are you going to inject good water, are you going to do (Refer Time: 30:04) bioremediation and then you have to take remediation action.

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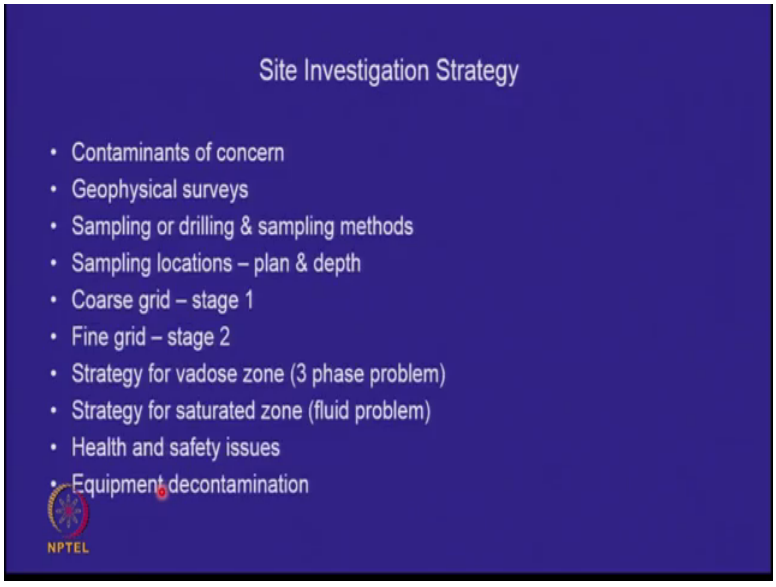

So, normally it takes the shape from your leachate of the old dump, please find out the contaminants of concern. Analyze the leachate and tell us which are the contaminants are aware which are above the prescribed limits or in the background of the compare the contaminants or the constituent of the leachate, with the constituents of the groundwater which is on the upstream side. Those which will cause the groundwater to have elevated levels, those constitutes of interest to you. Amongst those constituents the reactive ones are not of interest to you why because the soil will attenuate them the non reactive will go through. So, you will really be looking at your contaminant of which is non reactive because it will lead the plume right and therefore, you can detect it. So, contaminant of concern do some geophysical surveys, then you have to do sampling or drilling and sampling, both and plan and depth course grade stage 1, fine grid stage 2 you can have strategy for the Vadose zone and strategy for the saturated zone.

Normally you attack the saturated zone first; if it is not contaminated then you are very happy that the contaminators are still in the vadose zone they have not reached below. Then of course, you have to there are very stringent manuals on health and safety issues especially if you are monitoring around hazardous waste dump. Now the advantage of geophysics or geo physical or indirect equipment is, that it can be done very fast. So, you may do some geophysical investigations for example, you would just do a electrical resistivity or electromagnetic induction survey, write down the ground surface. You will have devices which can be rolled on the ground surface, you can have where like to electrodes can be put, a reading can be taken in 10 minutes and then they can be put forward and then they can be put forward or you also have the electromagnetic devices which you can carry in your hand, you have a meter in front you move u and down.

All that you are doing is looking for an anomaly does the reading change. If it does you will find out why it changes later, it may have nothing to do with the contamination there may be a buried pipe line there may be a water, buried underground storage tank does not get into that, let us look at into anomalies.

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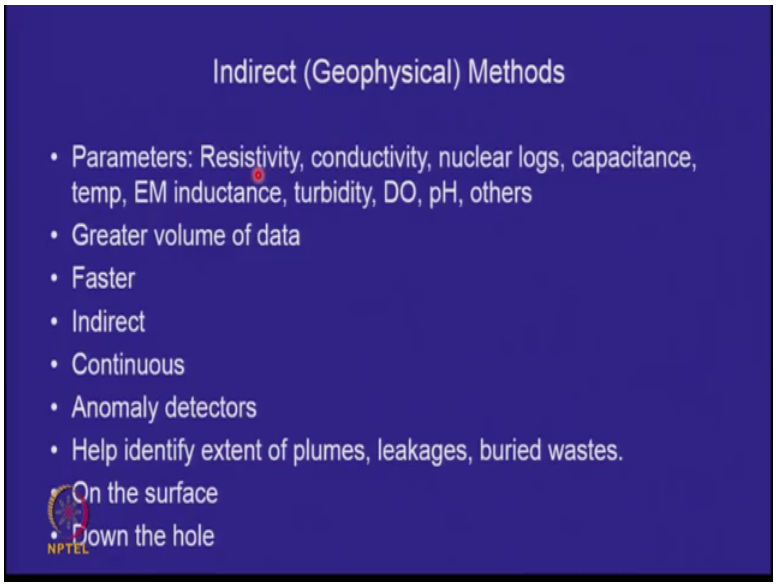

So, we look at data about resistivity, conductivity, nuclear log, capacitance whatever we can get through geophysical methods, there is a greater volume of data they are in direct, their continues and they are anomaly detectors.

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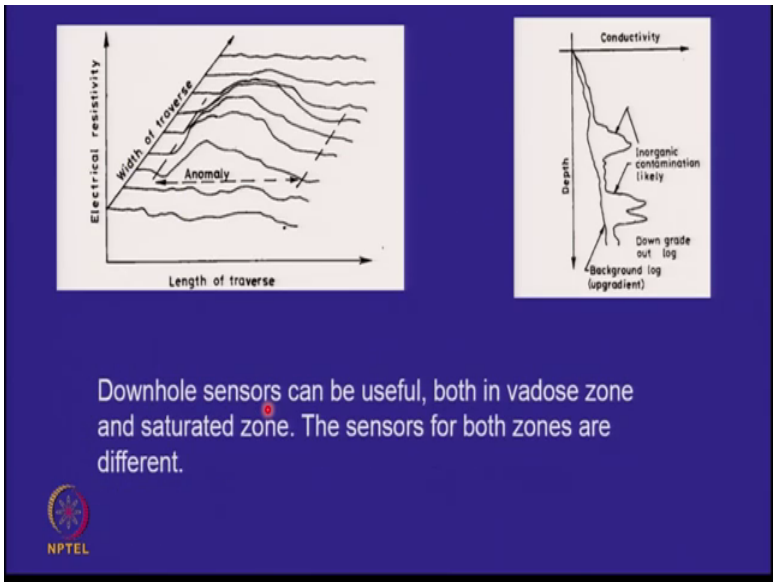

So, if you have an anomaly you have everything is going like this, but in an area something is going up or down; that means, you have an issue. And in depth if there are some if there are some tube wells already existing, please send down the bore hole

probes. These are also multi parameter probes you can measure electrical conductivity of the water, you can measure dissolved oxygen you can measure p H.

If you get an anomalies you have an idea that at some depth some anomalies are taking place, but do understand one is above the ground sensors geophysical methods and the other is down the hole sensor. Down the hole will require you either make a bore hole and look at it or go down existing wells the sensors are different. The next option is to try and do whole sampling; this is purely liker site investigation we do understand sampling the undisturbed sampling is a whole sampling method, but the only problem is in undisturbed sampling we have to make a bore hole, to make a bore hole we have to use a drilling mud to stabilize the hole that is not allowed.

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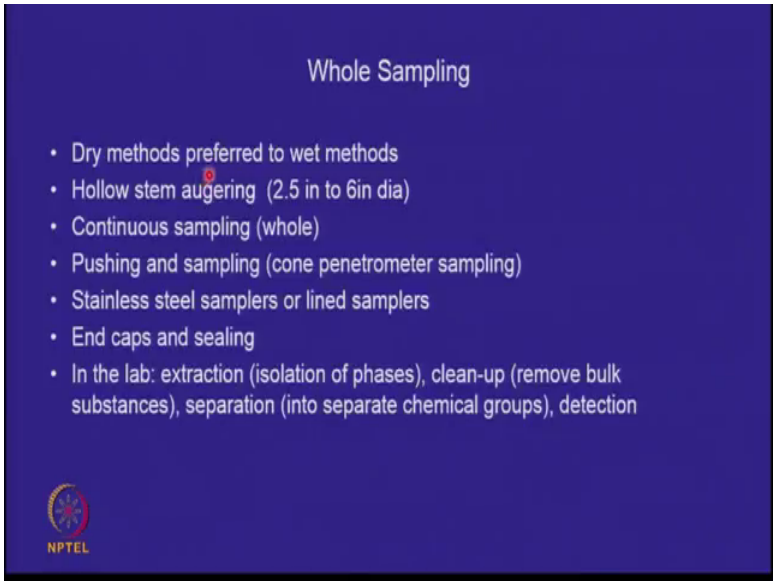

So, typically dry methods are offered do site investigations along coarse grades for hole samples using dry methods, hollow stem auguring. In soil mechanics we do SVT values, want once every 1.5 meter depth every 5 feet interval. Here instead go for continuous sampling that keep on just taking out samples, you do not have to measure any values you take what I say sample and you take out another sample, drill forward take another sampler.

So, you can do continues sampling, pushing and sampling, mostly you use stainless steel samplers and caps and sealing is important and once you bring these samples into the laboratory, you will extract the sample, you will isolate the phases, you will take out the

gas phase the whole sample will come from the Vadose zone may not have too much liquid in it you will struck out the vapor or whatever is the gas, you will do the analysis of the gases phase in the liquid phase in the solid phase separately. You will send them to a chemist or a chemistry person to do the analysis, but your job is to give them the whole sample and to make the phases come apart. So, you do isolation of phases removal of bulk substances which are not important you are not going to analyze the quartz of the sand you are only interested in analyzing the material which is sitting on the quartz. So, separate into separate chemical groups and do detection, all that you got to know is a whole sample is a good way of doing detection, but really what everybody wants to do is to be able to go down into the earth, pick up a sample go deeper pick up a sample without drilling a bore hole right and the one of the ways to do that is to use a cone penetration.

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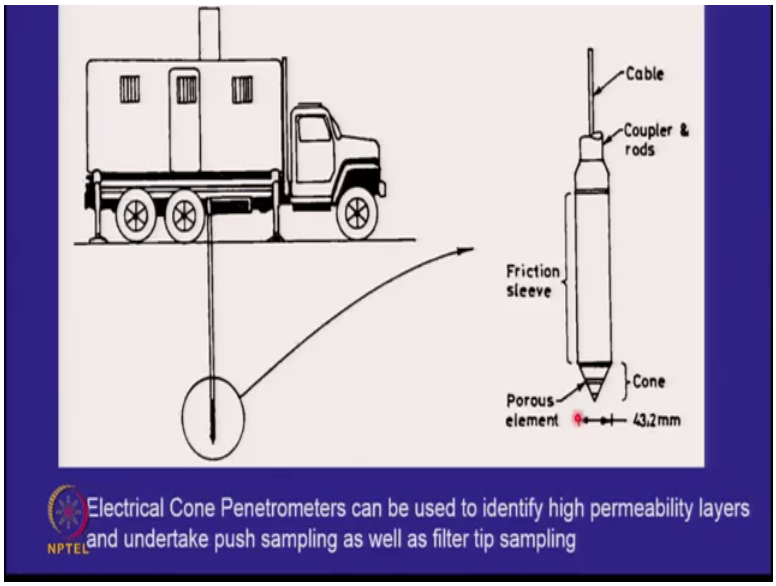

So, I will come back to this, but this is our traditional electrical cone penetration device, where a cone can be push down hydraulically into the soil.

So, two things happen I am using an electrical cone electrical cone can have a frictions sleeve or cone depresses and it can also measure the pore water pressure. So, the first idea is as the cone is pushed in, you measure the friction ratio and the pore pressure ratio in the soil. Because you are looking at high permeability zones, high permeability zones will have water will travel faster, you can contamination can travel faster. So, the

electrical cone penetrometer if you do the pore pressure ratio and the friction ratio you will get plots like this.

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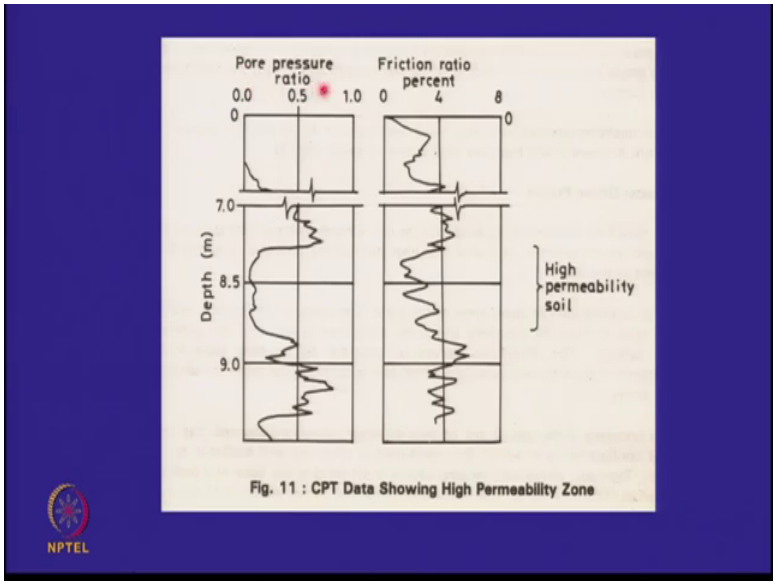

Whenever the pore pressure ratio is low or the friction ratio is low, indicates to you here higher permeability zone. And from this high permeability zone, you will pick up a sampler and how is the sampling is done?

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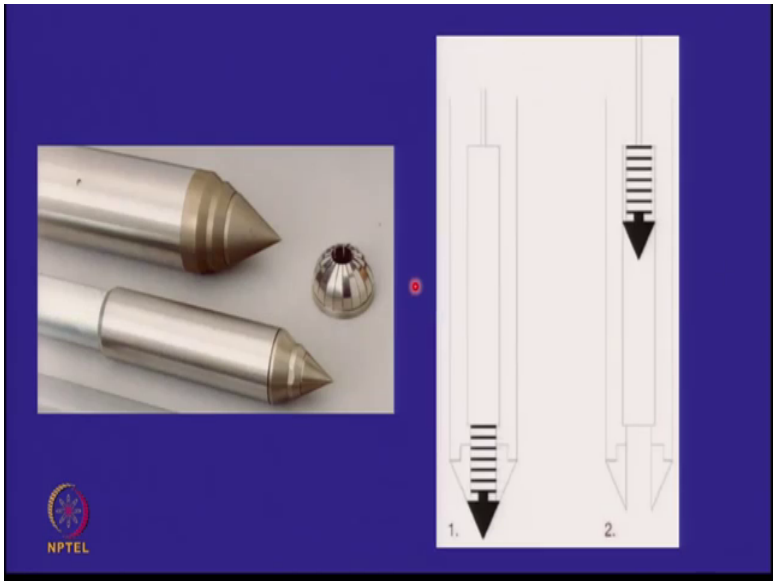

This is your traditional cone electrical cone, this a cone with the sampler, this outer sleep becomes a piston sampler. You when you go end the cone is there the sampler is around;

when you have reached the depth of sampling, you can retract a piston and push this sampler into the soil and get the sample in this space. So, the cone penetrometer which is normally without a sampler has to be now use with a sampler and becomes a more expensive equipment.

So, first do the cone penetration tests to identify the high permeability zones, then go to the high permeability zones and pick up the samples.

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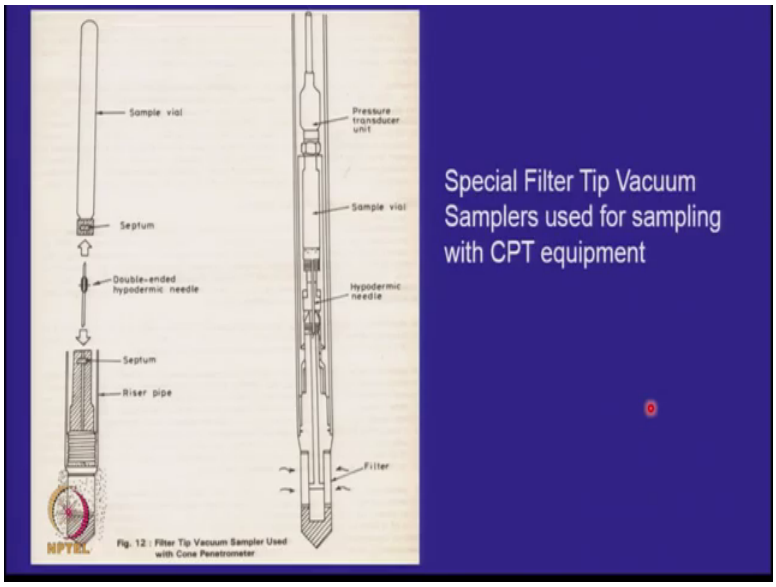

even better let me show you the next, this is called filter tip vacuum sampling; it is a beautiful device, all of you have seen you seen a siring with the needle everybody is had an injection put in the life I hope or is this is this the new world where like you know mister spoke he come and put a gun in put, they give it a blast and everything goes in without siring. Well when they when the use siring in that injection bottle of the old type there used to be a rubber top, and you could put the needle through this rubber top apply section and the material would come due to vacuum, and when you take out the siring that rubber top seals itself again. It so designed, that you know nothing comes out of that again is that part of the injection can be even used again, and that top of the bottle is called the septum a rubber septum. So, in this device which I am showing you here, this device is used with the starting cone penetrometer which has a filter tip that is the peso cone; that is the cone that is the filter. So, here is a thinker think of a test tube right think of a test tube with a rubber septum at the top; like that in the top of an injection bottle

and it is evacuated; that means, it has a vacuum inside it, this is the basic sampler what do they do? There is a septum here and there is a septum here, when the cone is being pushed this needle is not there and this sample vial is not there it is outside and the rod is hollow; you push the cone and take your readings of the cone penetration resistance, and the friction ration friction skin infection and the pore pressures.

When you reach the high permeability zone, what you do? You send in a needle, the same needle as you have in an injection, but it is pointing to both sides. This needle is lower and it comes and touches this septum. On top of it you send your test tube with the septum, now what is it? This needle is touching this septum and this part of the needle is touching this septum, then on top of that sample vial you put some weights or a pressure transducer and you make the needle under the weight go into the first it will go into the lower septum in here and then it is punctured of septum.

This vacuum will get transferred to this filter tip and what will come in, whatever water is here will get sucked into this wire and here is the water coming in. And when you are finished just pick up the thing, the lower septum will get sealed and the upper vacuum while will be full of water and it will also become sealed. Suppose your sampling in the vadose zone what will come in.

Student: (Refer Time: 41:47).

Yeah or suppose you are looking for petroleum vapors, if you are underground tank has leaked then petroleum volatile organic vapors will be there in the white space. With the filter tip you can get pore water samples or pore gas samples, and when the while comes out to you it is also no human being has touch it, no end cap sealing is required with wax or with stainless steel cap it is self sealed. So, ford fluids the filter tip vacuums sampling is the ultimate in cutting edge technology for the purpose of sampling fluids when the gas is or with the liquids. But you have to use it in conjunction with a electrical cone penetrometer and do you remember how much electrical cone penetrometer costs? I had discussed this you with in class with site investigation some idea.

Student: (Refer Time: 42:49).

20 lakhs? I thinks it is more multiply that by 5 times, a full pressure no no I just showed you the electrical cone penetrometer here is truck mounted, you have going to put the

samples in this laboratory which will have constant temperature 22 or 25 whatever is the prescribed temperature, this truck itself will cost how much.

Student: (Refer Time: 43:20).

So, whatever. So, the whole device will cost you about 100 lakhs or more, but the quality of samples that you will get from each depth you can get a sample, and you can analyze it and get. So, such are the devices which are used for taking samples from different depths. If you want the whole samples then you have to have the cone penetrometer with the sampler the piston sampler which I showed you, but if you just want the fluid samplers. So, this is for the hole sample, the whole sample will come in this, but if you want the fluid sampler you will use this ok.

So, the cone penetration device can typically work up to 20 25 meters depth 30 meter depth, it cannot work up to 100 meters depth why? Very difficult to push the cone in then you have to go back to your bore holes.

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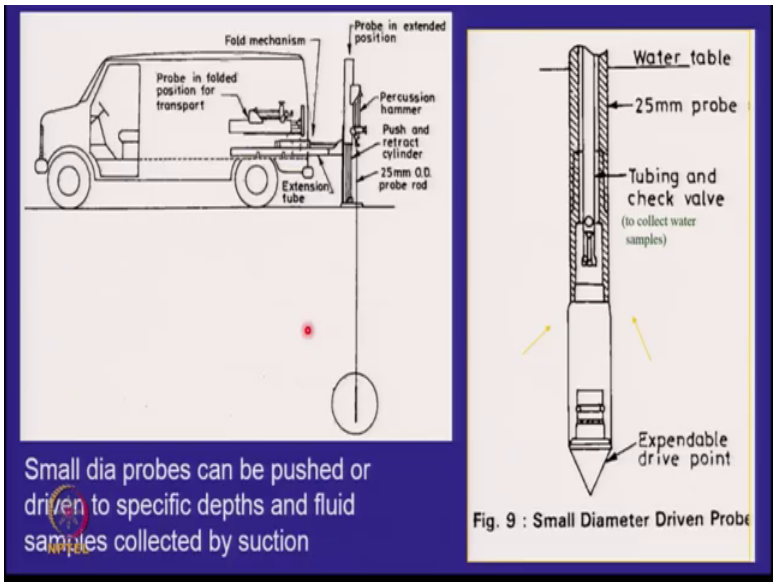

But also there is one more device which is the much smaller device suppose you have water table is say in the top 5 to 10 meters, this is not a sophisticated device this is just a one inch diameter drill rod which is hollow from inside, and it is inserted into the ground with a percussion hammer, what is the precaution hammer? The same hammer which

you see with by which you also to demolition, it goes up and down up and down up and down up and down it is nomadically activated.

So, this percussion hammer is able to send this rod down into the ground by few meters 5 to 7 meters. If you look inside this rod what is happening? I just wanted you to see this 5 to 7 meter the sample can be picked up by applying suction, beyond ten meters you cannot pick up by applying suction you to send in the sampler to retrieve.

So, what happens is this has a conical tip when you reach the depth that you want, this tip can either be discarded or it can open a port and you can suck out the water and through this tubing the water will come into a sampler at the top. So, these are small diameter probes at a site, they can do sampling for you and every one meter of the liquid only. But the advantages they can go down very fast, you are not bothered here about whether you are destroying the structure of the soil, weather the strength has change, whether you are getting undisturbed sample no what are you bothered about? You would be able to reach a particular depth and pick up the liquid sample of the gaseous sample by suction. So, for small depths we have special probes, which can be pushed or driven into the ground to collect the samples by suction.

So, both these devices which have talked about this small dialer probes or. So, this whole thing is actually mounted behind a wan, when you are travelling it just fold into the wan and both these devices is either the small probe or this, they are used for detecting the extent of contamination, they are not being used to monitor a fixed source. To monitor a fixed source you need a device which is there embedded inside all the time which is a well, a multiport well or a well cluster. But if you want to find out how much contamination has already occurred, you need a device which is mobile which can go into the ground, pick up the samples for you so that you can analyze them in the laboratory and you can then tell the extent of contamination. And these devices are used in conjunction with the geophysical results. Is the geo physics show you that there are anomalies here and there are anomalies here, then you will target this location for getting the sample to prove whether they normally is due to contamination or whether the anomaly is due to something else which is underground which we do not know.

So, in this manner in all landfill sites first we detect the extent of contamination, and then we monitor them just the same way as your monitoring new landfill sites. So, with this I

have covered for you the entire spectrum of environmental monitoring below the ground. The vacuum filter tip sampler is by far the most sophisticated technique, in which you can get the liquid and the gases and you can do the analysis in the laboratory. The multi ort ground water well is the cutting edge for taking samples in one bore hole from different depths, for whether you monitor it once a month; you say ground water doesnt travel very fast I have already told you.

So, you may monitor ground only once a month, but at least you are able to pick up the sampler from the different apps, and you know there is no contamination of the top, but no you are getting a slight increase in reading at mid depth and there is no contamination at the bottom. And with these devices you can monitor your old and new landfills. It is stuff it is expensive, it is very easy to miss contamination please understand. I can go to a site and say oh I did two bore holes there was no contamination, hence here it will by it is certified that the landfill is not leaking. What you have to actually do is to hunt and sniff around for the contamination and after you have done enough then say there is no leakage or it is not causing underground contamination.

Any questions which come to your mind? No questions wonderful, but I do wish that you read up upon how we are how normal well is so different from a monitoring well or a monitoring well cluster, and how screen length is not important in the normal well, where the ceiling is done is not important in a normal well and how it is so important in a groundwater monitoring program quality monitoring program. We will stop here have a good day.