Environmental Remediation of Contaminated Sites
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Lecture – 57
Case Study: Soil Vapor Extraction Part – II

Hello everyone. So welcome back to the latest lecture session. So we have obviously been looking at the relevant aspect or the case study relevant to soil vapor extraction right. So in that context, we looked at a few details.

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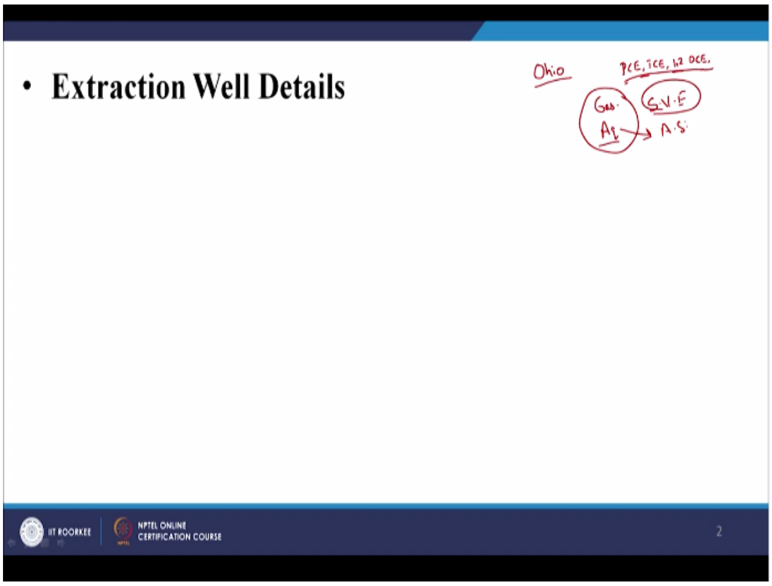

- Extraction Well Details

Ohio

PCE, TCE, 1,2 DCE.

Gas.

Aq.

S.V.E

A.S.

As in the particular site contaminant in Ohio let us say right, that is contaminated with PCE, TCE, 1, 2, DCE, benzene and so on and so forth and the contamination was both in the gaseous phase and in the aqueous phase and this was used by corporation such as this and the site was previously used by corporation such as Monsanto and they dumped their waste there and later on I believe a landfill was constructed but obviously you know the relevant site was already contaminated let us say.

And a considerable what do we say section of the area was also it seems used for burning some of the wastes. So thus obviously you have relevant aspects. So in this context gaseous and aqueous phases are contaminated. Obviously, soil also will be contaminated right. These are hydrophobic compounds too right. So obviously people looked at soil vapor extraction and to enhance it and get out the relevant contaminant from the water, they looked at air sparging let us say right. So we are looking at those aspects right.

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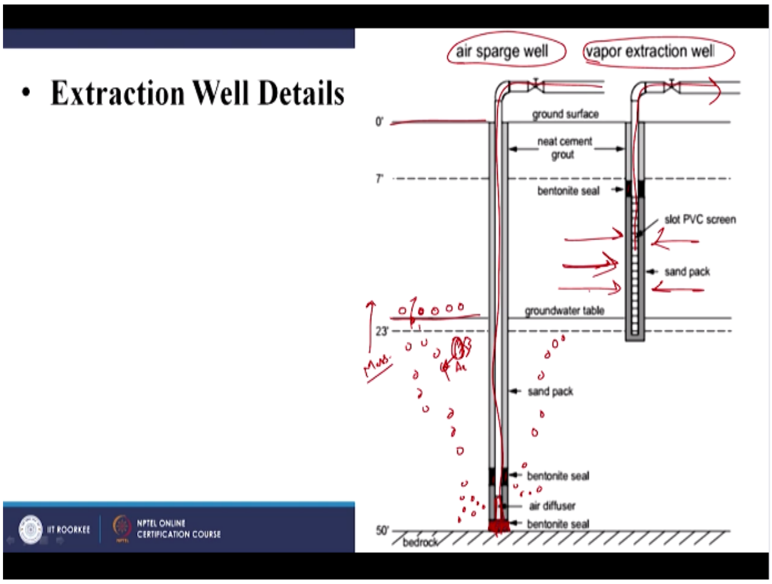

- Extraction Well Details

And let us look at the relevant details. So obviously what do we have? We saw that they constructed both the air sparge well and the vapor extraction well in close proximity to do each other. So this is the ground surface let us say right and here you have let us say the air sparging well where they are going to introduce air into the relevant system right. There looks like they almost went till the bedrock here right.

We saw that they were some particular bedrock and what do we have out here? Air diffusers. So now you have bubbles of air let us say that are going to be released let us say right. See how these bubbles of uncontaminated air that are travelling through this particular contaminated groundwater. So what is going to happen during this particular period let us say.

When you have the relevant air coming in, uncontaminated air coming in contact with this particular groundwater, you are obviously going to have let us say change in phase of the contaminant from the aqueous phase into the gaseous phase right and here you have the relevant groundwater table as we can see here. So that is what you see out here and once as this particular gas of the bubbles leave the relevant groundwater, what is happening?

You see that there is a net change in mass of the particular contaminant right from the aqueous phase or the water into the gaseous phase right. So anyway we are just trying to promote or fasten the change in mass or transfer of mass from the aqueous phase into the gaseous phase. So similarly at the same point or time let us say we are going to have relevant contaminated soil here in contact with contaminated groundwater.

So as the contaminant is removed from the groundwater let us say into the relevant gas let us say or the air bubble let us say right, you are also going to have desorption of the relevant contaminant from the soil into the groundwater right. So that is something to keep in mind. Again, they have cement grouting, bentonite seal right and so on and so forth. So sand packs and so on let us say.

Again, the primary aspect is that they are going to bubble air through this particular groundwater table and here you have the extraction well let us say right and it is relatively negative pressure let us say right or vacuum source depending upon where they have the vacuum source anyway. So they are going to pump the gas out right and thus and then treat that further I guess right. This is what we have out here.

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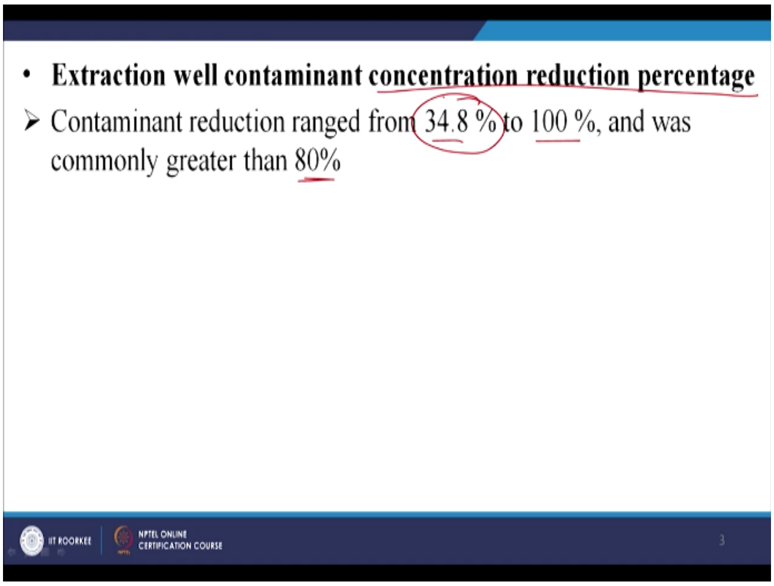

- **Extraction well contaminant concentration reduction percentage**
  - Contaminant reduction ranged from 34.8 % to 100 %, and was commonly greater than 80%

So extraction well contaminant concentration reduction percentage, obviously we are going to look at you know the amount of reduction that was noticed over these 3-year period. So range from 35% to 100% and typically >80% let us say. So I guess it would have been interesting if I was able to get more data regarding which particular contaminant and we are going to look at that particular aspect out here right.

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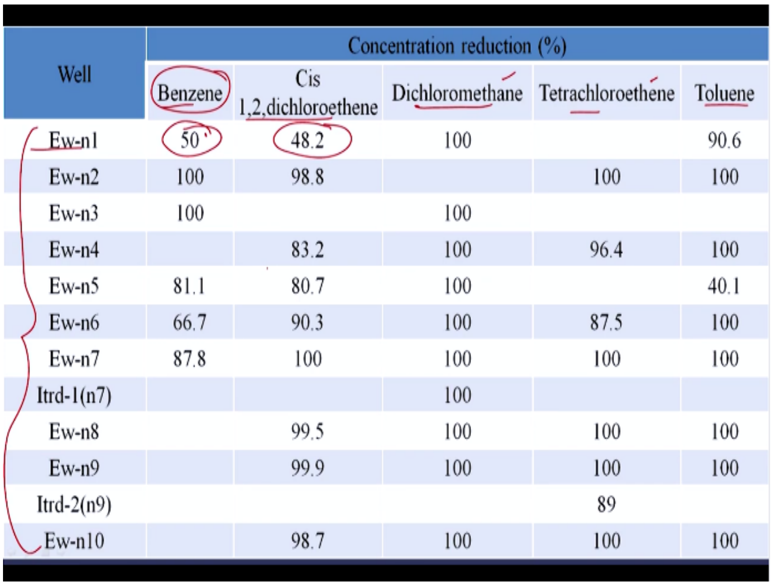

Well	Concentration reduction (%)				
	Benzene	Cis 1,2,dichloroethene	Dichloromethane	Tetrachloroethene	Toluene
Ew-n1	50	48.2	100		90.6
Ew-n2	100	98.8		100	100
Ew-n3	100		100		
Ew-n4		83.2	100	96.4	100
Ew-n5	81.1	80.7	100		40.1
Ew-n6	66.7	90.3	100	87.5	100
Ew-n7	87.8	100	100	100	100
Itrd-1(n7)			100		
Ew-n8		99.5	100	100	100
Ew-n9		99.9	100	100	100
Itrd-2(n9)				89	
Ew-n10		98.7	100	100	100

So here we have different wells right, different locations right and different what do we say compounds out here right and I believe this is the one in the gaseous phase if I am not wrong. So typically let us say benzene right for some particular reason let us say this particular well we have both 1, 2 DCE and benzene removals to be slightly lesser than expected or desired and typically let us say you know we see that dichloromethane, tetrachloroethene and toluene let us say which are considerably volatile.

You know considerable or 100% removal and maybe not as much for 1, 2 DCE and benzene let us say. So what are some of the aspects that can lead to such partial removals let us say. If you contaminant is either present as NAPL or you know present as benzene itself or as this 1, 2 DCE itself let us say or you have NAPL phase or if you have considerable fractions adsorbed onto the relevant soil let us say right.

So the compound can also change phase from the water into the relevant what do we say gas right or let us say if it is also very hydrophobic or it wants to be adsorbed onto the relevant soil too, in such a case let us say even though you are going to have desorption from the soil you know depending on the kinetics or let us say the Octanol water partitioning coefficient let us say, you might not have complete removal let us say.

Because here we are only trying to pump out the relevant air right, so but in general as you look at this particular data let us say you see that the removed percentage is pretty good let us say. Again, keep in mind that these are hydrophobic compounds and pump and treat or such mechanisms typically will not work out here right. So let us look at the total mass that was removed.

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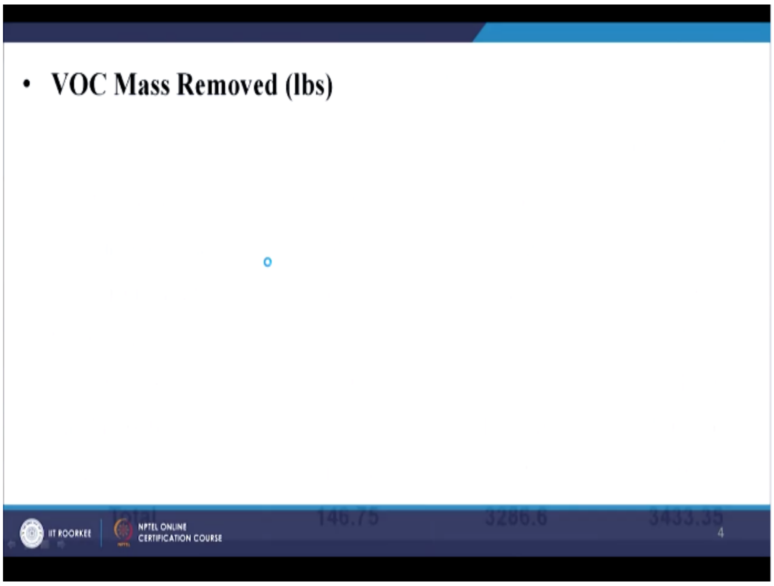

- VOC Mass Removed (lbs)

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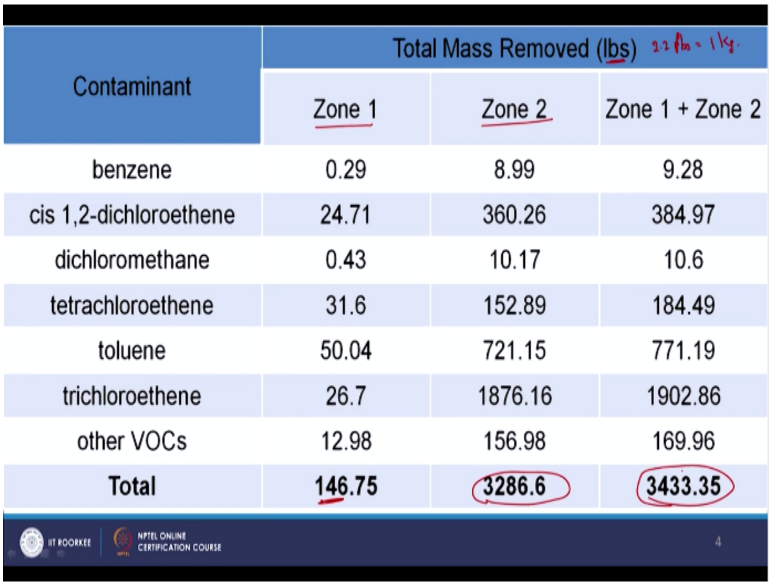

Contaminant	Total Mass Removed (lbs) 2.2 lbs = 1 kg.		
	Zone 1	Zone 2	Zone 1 + Zone 2
benzene	0.29	8.99	9.28
cis 1,2-dichloroethene	24.71	360.26	384.97
dichloromethane	0.43	10.17	10.6
tetrachloroethene	31.6	152.89	184.49
toluene	50.04	721.15	771.19
trichloroethene	26.7	1876.16	1902.86
other VOCs	12.98	156.98	169.96
Total	**146.75**	**3286.6**	**3433.35**

So two zones obviously I think south and the west zones right. So we have different contaminants here. So here in zone 1 relatively less but in zone 2 you see a considerable amount let us say and what is this? This is in lb let us say or pounds right. So typically 2.2 pounds let us say is=1 kg let us say right, so now you get an idea about the total mass of these VOCs that were removed let us say right.

So that is something to keep in mind right, more than a ton let us say ton or the relevant more than a ton right were removed out here right. So that is something to keep in mind.

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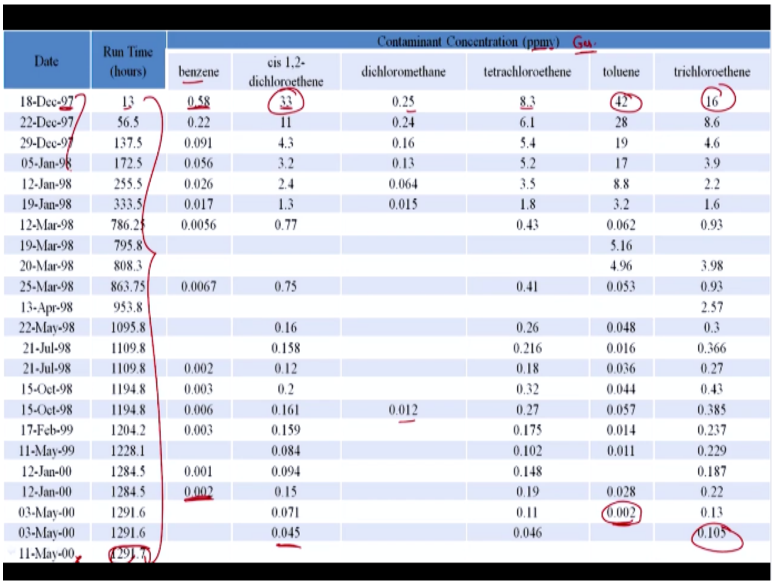

Date	Run Time (hours)	Contaminant Concentration (ppmv) Ga.					
		benzene	cis 1,2-dichloroethene	dichloromethane	tetrachloroethene	toluene	trichloroethene
18-Dec-97	13	0.58	33	0.25	8.3	42	16
22-Dec-97	56.5	0.22	11	0.24	6.1	28	8.6
29-Dec-97	137.5	0.091	4.3	0.16	5.4	19	4.6
05-Jan-98	172.5	0.056	3.2	0.13	5.2	17	3.9
12-Jan-98	255.5	0.026	2.4	0.064	3.5	8.8	2.2
19-Jan-98	333.5	0.017	1.3	0.015	1.8	3.2	1.6
12-Mar-98	786.25	0.0056	0.77		0.43	0.062	0.93
19-Mar-98	795.8					5.16	
20-Mar-98	808.3					4.96	3.98
25-Mar-98	863.75	0.0067	0.75		0.41	0.053	0.93
13-Apr-98	953.8						2.57
22-May-98	1095.8		0.16		0.26	0.048	0.3
21-Jul-98	1109.8		0.158		0.216	0.016	0.366
21-Jul-98	1109.8	0.002	0.12		0.18	0.036	0.27
15-Oct-98	1194.8	0.003	0.2		0.32	0.044	0.43
15-Oct-98	1194.8	0.006	0.161	0.012	0.27	0.057	0.385
17-Feb-99	1204.2	0.003	0.159		0.175	0.014	0.237
11-May-99	1228.1		0.084		0.102	0.011	0.229
12-Jan-00	1284.5	0.001	0.094		0.148		0.187
12-Jan-00	1284.5	0.002	0.15		0.19	0.028	0.22
03-May-00	1291.6		0.071		0.11	0.002	0.13
03-May-00	1291.6		0.045		0.046		0.105
11-May-00	1291.7						

So zone 1 let us say right let us look at that in greater detail. As I mentioned, they started pumping it out in 97 to May 2000 let us say and here you have an idea about the time it was pumped first. So looks like almost 1300 hours let us say right. So again for different what do we say contaminants, keep in mind this is PPM volume so this is in the gaseous phase right.

All these concentrations are the concentrations in the gaseous phase, so benzene we start up with 0.58 end up with 0.002. This is obviously a particular well let us say. So this 1, 2 DCE at 33 and again 0.045 and again 0.25, 0.012 and 8.3 toluene we started relatively higher concentrations, end that relatively low concentrations, trichloroethene let us say, again 0.105 again not as much removal as you would expect.

But could be due to the compound relatively more hydrophobic on to the relevant soil and such but again that is some data that you can look up let us say but try to look at the relevant aspect let us say initially let us say when the concentration is high let us say right, what is going to happen let us say?

If you introduce fresh air or contaminated air in contact with contaminated groundwater let us say then you know more of the contaminant will be released let us see but overtime what is going to happen, the concentration in the gas or the relevant water let us say, will calm down let us say right will be decreased but it is not decreased to such a level let us say that that it is safe enough let us say or you know has met the standards.

But because the concentration is relatively low right you will now need to have a lot of you know pump a lot of gas to be able to remove this, what do we say relatively little mass of the contaminant right. So again why is that? The gradient let us say or the difference in concentration let us say between the uncontaminated gas and the relevant water or the uncontaminated gas and the relevant soil let us say is relatively less let us say right.

So again we know that it is an equilibrium right, there is always going to be an equilibrium. So the lesser it is let us say right you need to obviously have more and more volumes of air to that need to be pumped out obviously let us say. If you look at let us say per time or over how much time let us say the percentage of removal let us say right. So you will see that initially let us say a great percentage of removal would have occurred.

And later on let us say over considerable fraction of time let us say or period of time pardon me relatively less what do we say fraction of the relevant or percentage of the relevant compound would have been reduced right. So let us try to look at those aspects here.

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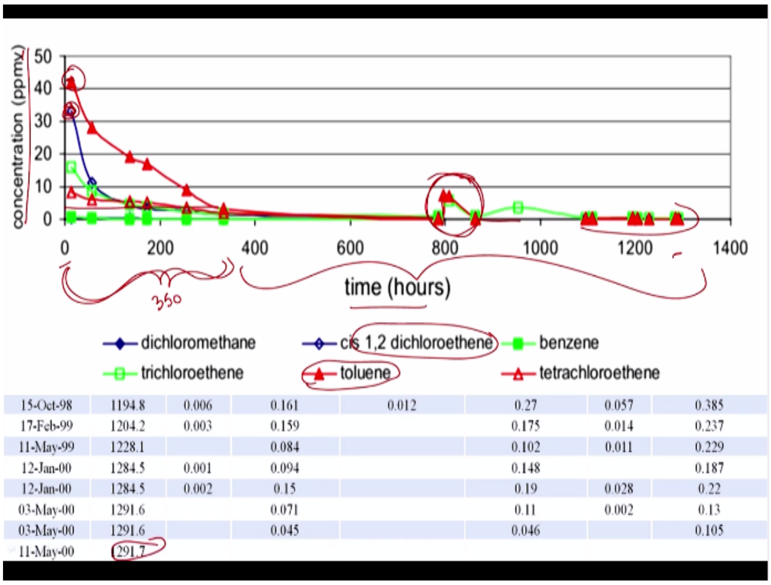

15-Oct-98	1194.8	0.006	0.161	0.012	0.27	0.057	0.385
17-Feb-99	1204.2	0.003	0.159		0.175	0.014	0.237
11-May-99	1228.1		0.084		0.102	0.011	0.229
12-Jan-00	1284.5	0.001	0.094		0.148		0.187
12-Jan-00	1284.5	0.002	0.15		0.19	0.028	0.22
03-May-00	1291.6		0.071		0.11	0.002	0.13
03-May-00	1291.6		0.045		0.046		0.105
11-May-00	1291.7						

So here we have one particular graph here and what do we have here? So this is the concentration on the y-axis and PPM volume units right volume/volume right and here time from 0 to around 1300 hours as we saw in the previous table right. So 1300 hours as we see out here and different compounds out here as we looked at it. Toluene relatively higher concentration initially and then also 1, 2 DCE let us say relatively high concentration initially right. Others may be not so high but again what were we talking about earlier?

As you see right here we started out I think 40 or so let us and within let us say 300 or 350 hours right we are almost at more than or you know almost at 90% or 80% removal let us say. We are able to capture 80% of the mass within 350 hours let us say right but as you can see you still have considerable mass and rebounds out here. This is a rebound, maybe they stopped the pumping out here.

And then you have desorption from the soil and the contaminant concentration increasing and then again pumping out and so on and so forth. You see that they have to keep pumping the relevant contaminant for you know or running the system for considerable amount of time. The same case with what is it now 1, 2 DCE 2 right. So that is what you see here. So we are starting around 32 or something and within maybe 175 or 180 hours we are almost achieving 80% removal.

But let us say again you need to keep pumping it because the lower you go let us say right again keep in mind because of the effects of equilibrium let us say right, you are still going to have to pump a lot of volume of air right. That is something that you see out here right. So let us move on.

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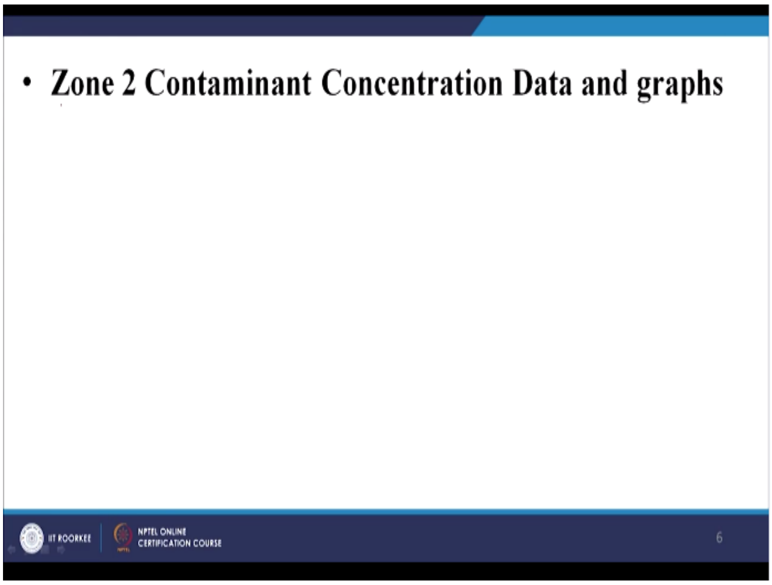

- Zone 2 Contaminant Concentration Data and graphs

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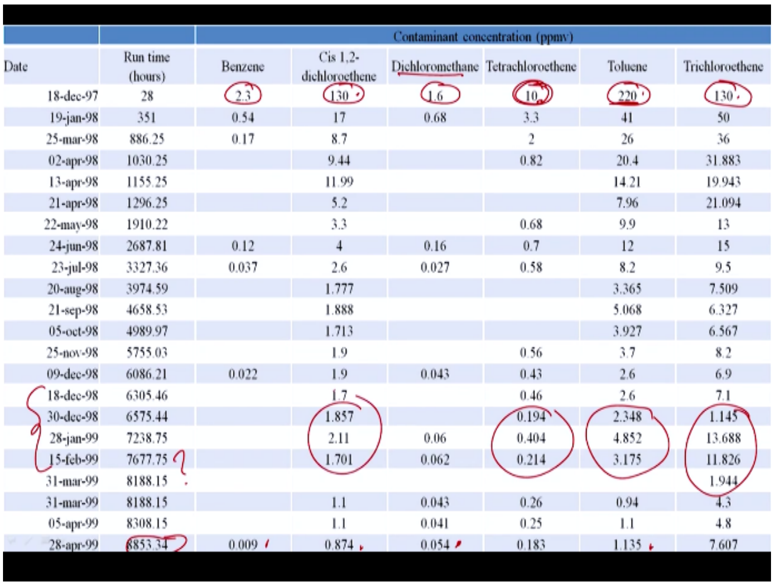

		Contaminant concentration (ppmv)					
Date	Run time (hours)	Benzene	Cis 1,2-dichloroethene	Dichloromethane	Tetrachloroethene	Toluene	Trichloroethene
18-dec-97	28	2.3	130	1.6	10	220	130
19-jan-98	351	0.54	17	0.68	3.3	41	50
25-mar-98	886.25	0.17	8.7		2	26	36
02-apr-98	1030.25		9.44		0.82	20.4	31.883
13-apr-98	1155.25		11.99			14.21	19.943
21-apr-98	1296.25		5.2			7.96	21.094
22-may-98	1910.22		3.3		0.68	9.9	13
24-jun-98	2687.81	0.12	4	0.16	0.7	12	15
23-jul-98	3327.36	0.037	2.6	0.027	0.58	8.2	9.5
20-aug-98	3974.59		1.777			3.365	7.509
21-sep-98	4658.53		1.888			5.068	6.327
05-oct-98	4989.97		1.713			3.927	6.567
25-nov-98	5755.03		1.9		0.56	3.7	8.2
09-dec-98	6086.21	0.022	1.9	0.043	0.43	2.6	6.9
18-dec-98	6305.46		1.7		0.46	2.6	7.1
30-dec-98	6575.44		1.857		0.194	2.348	1.145
28-jan-99	7238.75		2.11	0.06	0.404	4.852	13.688
15-feb-99	7677.75 ?		1.701	0.062	0.214	3.175	11.826
31-mar-99	8188.15						1.944
31-mar-99	8188.15		1.1	0.043	0.26	0.94	4.3
05-apr-99	8308.15		1.1	0.041	0.25	1.1	4.8
28-apr-99	8853.34	0.009	0.874	0.054	0.183	1.135	7.607

So zone 2 right, I believe we were able to or we saw that there was greater contamination in zone 2 right, as in zone 1 around only 150 pounds and zone 2 almost 3300 pounds right. So that is something to keep in mind. So let us look at the zone 2 data. So similar picture probably but we started with much higher concentrations for almost all the relevant compounds let us say.

Again, toluene as you see it is 220 out here, TCE is 130 out here and so on. We started 97 and so on so 28 hours here they obviously had to run it for more time let us say and why is that? Obviously, you have more what do we say, mass out there. Thus, you need to pump more volume of air through let us say right to be able to remove that particular contaminant and thus the time required is obviously going to be relatively higher let us say right.

So let us look at the relevant aspects again, 2.3 to 0.009, 130 to 0.874, 1.6 to 0.054 as you can see let us say some of the compounds right the percentage of removal is relatively less. So turn to 0.1 right 220 to 1.1 still relatively high, 130 to 7.6 and here you see rebound here right I think rebound in these particular cases maybe they stopped pumping out here right. So you see some rebound out here right.

So that is something to keep in mind. What is this rebound now? Say I am pumping out the relevant air and then I stopped pumping the relevant what do we say air let us say, what is going to happen now? So equilibrium is going to be reached let us say. As when I say equilibrium is going to be reached, what is going to happen? The contaminant can desorb from the relevant soil into the water and then there is again going to be an equilibrium between the water and the gaseous phase right.

So now the concentration is going to increase let us say so that is what you see out here in this particular period typically right. So let us look at the other set of data too and they continued it till again May 2000 right.

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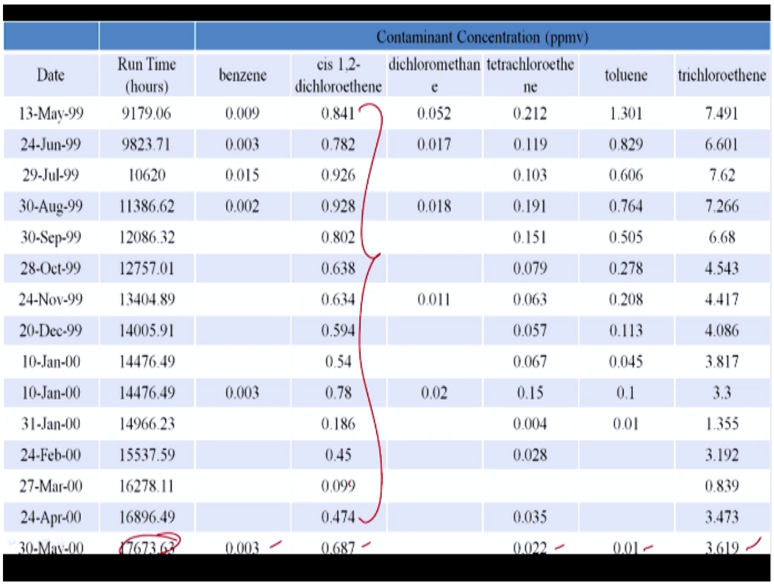

		Contaminant Concentration (ppmv)					
Date	Run Time (hours)	benzene	cis 1,2-dichloroethene	dichloromethane	tetrachloroethene	toluene	trichloroethene
13-May-99	9179.06	0.009	0.841	0.052	0.212	1.301	7.491
24-Jun-99	9823.71	0.003	0.782	0.017	0.119	0.829	6.601
29-Jul-99	10620	0.015	0.926		0.103	0.606	7.62
30-Aug-99	11386.62	0.002	0.928	0.018	0.191	0.764	7.266
30-Sep-99	12086.32		0.802		0.151	0.505	6.68
28-Oct-99	12757.01		0.638		0.079	0.278	4.543
24-Nov-99	13404.89		0.634	0.011	0.063	0.208	4.417
20-Dec-99	14005.91		0.594		0.057	0.113	4.086
10-Jan-00	14476.49		0.54		0.067	0.045	3.817
10-Jan-00	14476.49	0.003	0.78	0.02	0.15	0.1	3.3
31-Jan-00	14966.23		0.186		0.004	0.01	1.355
24-Feb-00	15537.59		0.45		0.028		3.192
27-Mar-00	16278.11		0.099				0.839
24-Apr-00	16896.49		0.474		0.035		3.473
30-May-00	17673.63	0.003 ✓	0.687 ✓		0.022 ✓	0.01 ✓	3.619 ✓

So they ran it for a total of almost 17,000 hours right, so that is something to keep in mind right and then achieved I guess the relevant standards and so on. Again, as you see the mass removed let us say is going to be decreasing, mass removed per mass of air or volume of air that you pumped out will keep decreasing with time. Why is that?

Because right now not right now let us say in the later stages I do not have as much contaminant, so when I let the system equilibrate let us say only small amount of contaminant will be removed in the gaseous phase right. So that is what we see out here. Let us look at the graphs too right.

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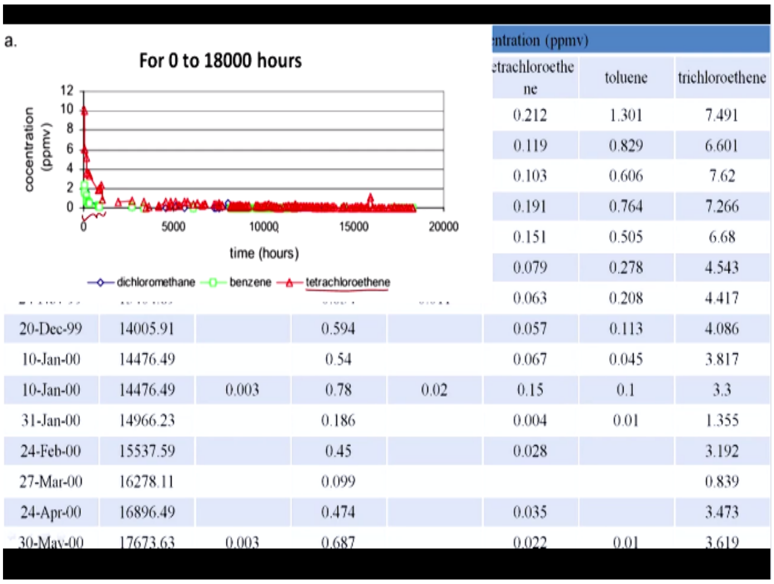

					ntration (ppmv)		
					trachloroethene	toluene	trichloroethene
					0.212	1.301	7.491
					0.119	0.829	6.601
					0.103	0.606	7.62
					0.191	0.764	7.266
					0.151	0.505	6.68
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So again as you can see we started with what is this now for tetrachloroethene let us say PCE right somewhere around here in 10 and again almost 90% removal within maybe 1000 hours let us say but we still had to keep pumping it out let us say to remove those or the relevant trace concentrations right. That is something that we see out here but I guess the picture is not greatly clear, we are going to break that down right.

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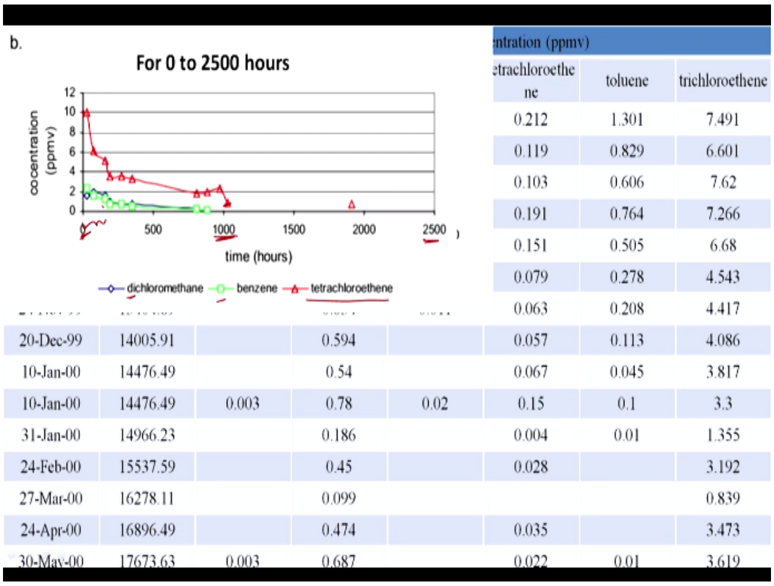

					ntration (ppmv)		
					trachloroethene	toluene	trichloroethene
					0.212	1.301	7.491
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					0.103	0.606	7.62
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27-Mar-00	16278.11		0.099				0.839
24-Apr-00	16896.49		0.474		0.035		3.473
30-May-00	17673.63	0.003	0.687		0.022	0.01	3.619

So the same picture let us say from 0 to 2500 as we mentioned earlier within 1000 hours let us say we were able to capture almost 90% of the relevant contaminant let us say right and same case with let us say you see that with benzene and dichloromethane let us say right, so relatively similar profiles.

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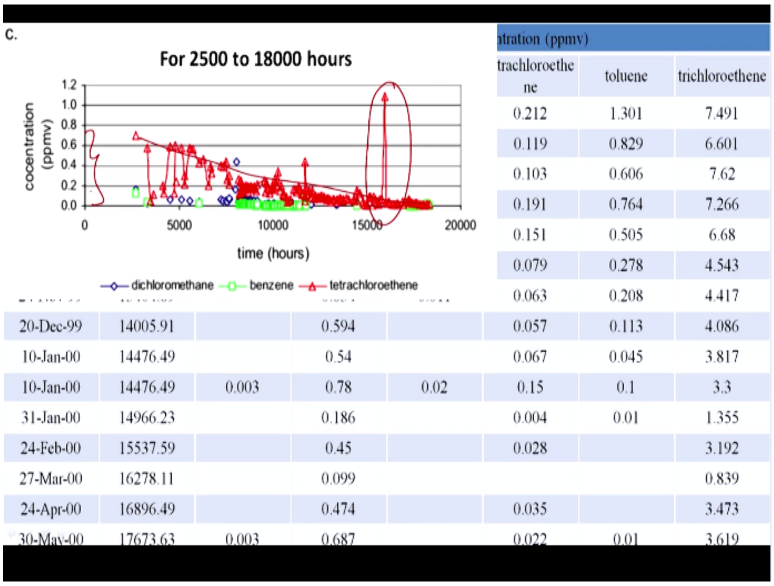

					tration (ppmv)		
					trachloroethene	toluene	trichloroethene
					0.212	1.301	7.491
					0.119	0.829	6.601
					0.103	0.606	7.62
					0.191	0.764	7.266
					0.151	0.505	6.68
					0.079	0.278	4.543
					0.063	0.208	4.417
20-Dec-99	14005.91		0.594		0.057	0.113	4.086
10-Jan-00	14476.49		0.54		0.067	0.045	3.817
10-Jan-00	14476.49	0.003	0.78	0.02	0.15	0.1	3.3
31-Jan-00	14966.23		0.186		0.004	0.01	1.355
24-Feb-00	15537.59		0.45		0.028		3.192
27-Mar-00	16278.11		0.099				0.839
24-Apr-00	16896.49		0.474		0.035		3.473
30-May-00	17673.63	0.003	0.687		0.022	0.01	3.619

So the next fraction let us say as you can see, here you can see the effects of rebound let us say you know here you see increase here from time to time so that means that they have not obviously you know pump the system out or gas out continuously right. They let the system rebound right. As in let us say there is this mass of contaminant in gaseous phase I remove this and then if I keep pumping it what is going to happen, I am only going to keep pump out relatively less contaminated air.

So the efficiency of my system is relatively less, so what would I do? I will stop pumping for some time and then let the system reach equilibrium between the soil, gas and the aqueous phase or at least try to you know have more contaminant now in the gaseous phase and then I will pump out that particular contaminated gas.

So that is why you see this particular rebounds and I guess they stopped pumping or there was some particular reason why there was considerable rebound out here right and you see though right. You need to pump for considerable amount of time for you know net removal let us ay at when you have concentrations at relatively low levels let us say right. So that is something that we have out here.

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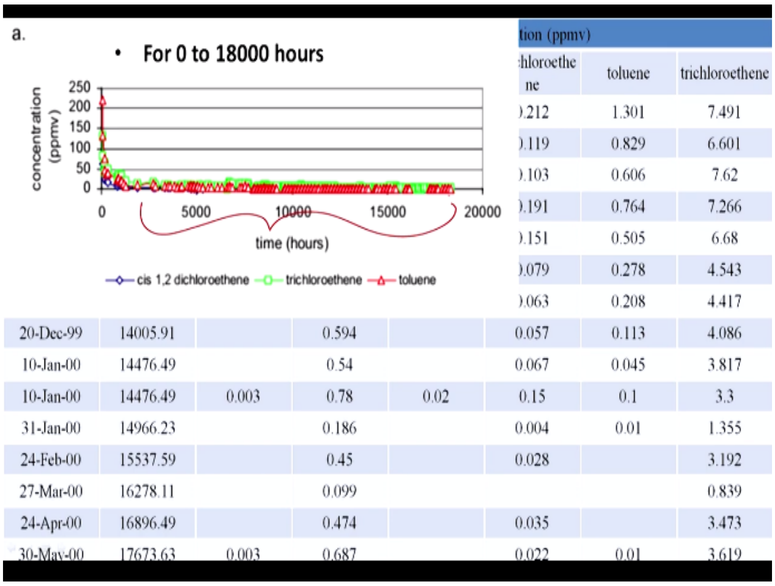

					tion (ppmv)		
					hloroethe ne	toluene	trichloroethene
					)212	1.301	7.491
					)119	0.829	6.601
					)103	0.606	7.62
					)191	0.764	7.266
					)151	0.505	6.68
					)079	0.278	4.543
					)063	0.208	4.417
20-Dec-99	14005.91		0.594		0.057	0.113	4.086
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24-Apr-00	16896.49		0.474		0.035		3.473
30-May-00	17673.63	0.003	0.687		0.022	0.01	3.619

Again, this is the bigger picture we looked at this particular case I believe until now and then looked at this particular case but as we looked at in this particular set of data we saw that they let the system rebound and then pump at the relevant contaminant out let us say right. So that is something to keep in mind.

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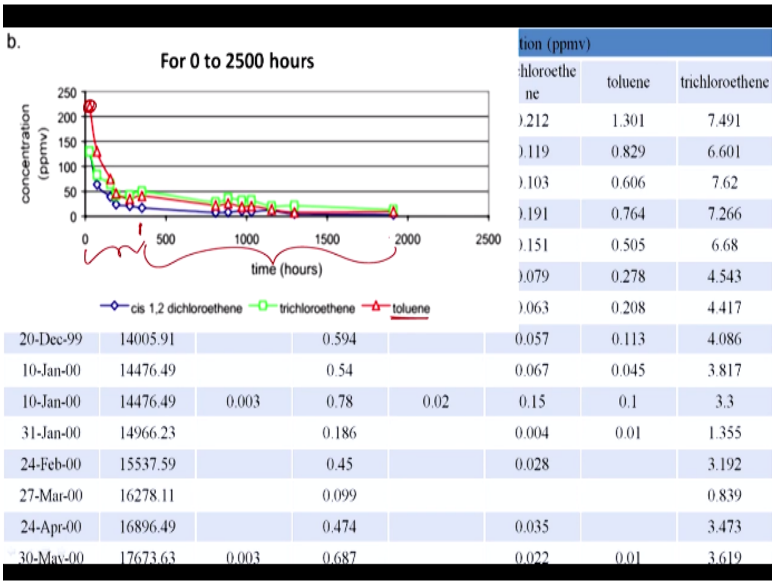

					tion (ppmv)		
					hloroethe ne	toluene	trichloroethene
					)212	1.301	7.491
					)119	0.829	6.601
					)103	0.606	7.62
					)191	0.764	7.266
					)151	0.505	6.68
					)079	0.278	4.543
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20-Dec-99	14005.91		0.594		0.057	0.113	4.086
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27-Mar-00	16278.11		0.099				0.839
24-Apr-00	16896.49		0.474		0.035		3.473
30-May-00	17673.63	0.003	0.687		0.022	0.01	3.619

So for the other sets of contaminants if you remember toluene was at relatively high concentrations 220 or something that is what we see out here. Again, same picture let us say almost 90% to 80% within a fraction of the time let us say or fraction of the total volume of air and for relatively less removal let us say less than 10%. Again, you have to pump for considerable amount of time let us say right.

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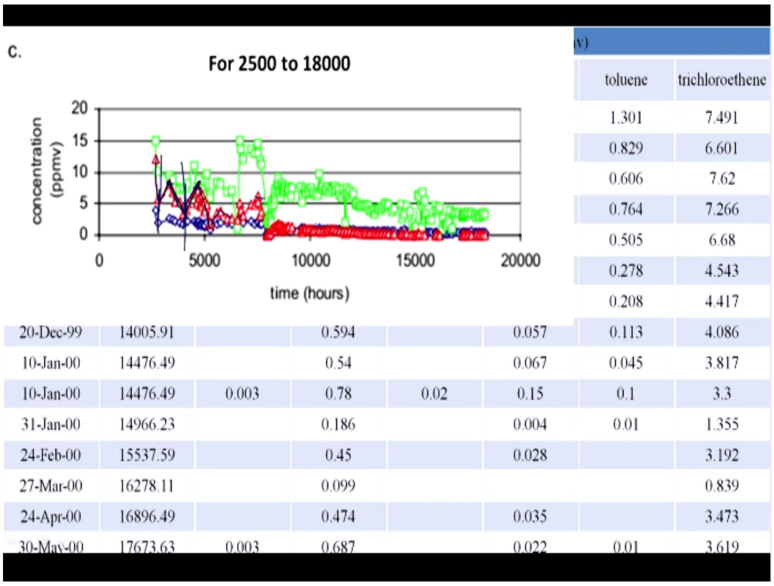

v)

						toluene	trichloroethene
						1.301	7.491
						0.829	6.601
						0.606	7.62
						0.764	7.266
						0.505	6.68
						0.278	4.543
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20-Dec-99	14005.91		0.594		0.057	0.113	4.086
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24-Apr-00	16896.49		0.474		0.035		3.473
30-May-00	17673.63	0.003	0.687		0.022	0.01	3.619

So again this is from 2500 to 18,000. Again, what do we see here, we see that the relevant people let the system rebound or equilibrate they stop pumping, so the system equilibrates, then they kept pumping, again they pump it up again; let me try to change the color here. So here you see that there is a decrease and then increase why is that, that typically means they stop pumping at this particular case and then again kept pumping.

So decreased it as in concentration of the contaminant in the gaseous phase decreased and then again stopped pumping. So again you see an increase, again kept pumping right. So it goes in phases but you see that typically the maximums will keep decreasing over time let us say right. So that is what you see out here right. So that is something to keep in mind.

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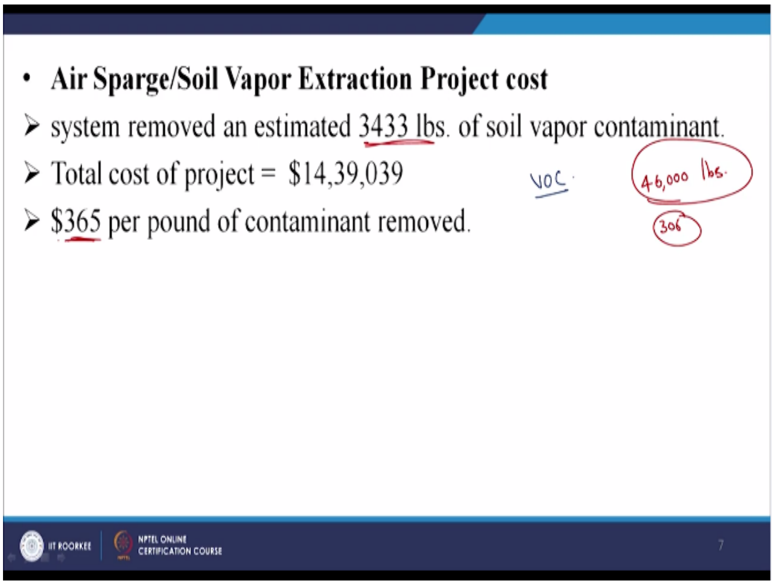

- **Air Sparge/Soil Vapor Extraction Project cost**
  - system removed an estimated 3433 lbs. of soil vapor contaminant.
  - Total cost of project = $14,39,039
  - $365 per pound of contaminant removed.

VOC

46,000 lbs.

306

So obviously you know we need to understand the relevant aspects as in the relevant costs and such let us say. What are the relevant factors or variables that add to the relevant costs let us say? Typically, what do we need as you know where do you need to spend considerable amount of money, certainly let us say when you are looking at monitoring the relevant locations and estimating the relevant concentrations of the contaminants initially that is one particular aspect right.

Or even monitoring the relevant locations with time so that is the major aspect out here or considerable aspect. Obviously, your air sparging and extraction system let us say is also going to take up considerable amount of money and resources and certainly let us say you need to put in lot of considerable fraction of the resources into extraction let us say right. As in not extraction pardon me into your relevant what is it now? Site characterization right.

So let us look at these aspects. So they removed almost 3400 pounds let us say right, more than a ton let us say or one and a half ton I guess right or you know 1.25 tons of soil vapor contaminants that is a considerable mass and they believe they ran the system for 2.5 years right and again it was not continuous operation so from time to time let us say so total project cost was around I believe what is this now, 14 million is it, no it is 1 million right or 14 lakh 39 thousand dollars or 1.4 million dollars let us say right.

And keeping in mind the type of contaminant that we have right which is VOCs let us say which are VOCs right. This project cost is very much reasonable right, typically maybe we looked at some of the other examples let us say and you might have seen cases where they went into 10s of millions of dollars, obviously here we looked at relatively smaller area let us say I think lb area or soil area or such and only a fraction of 306 acre site right.

But again you know keep in mind that they pumped out considerable mass of the contaminant let us say and for around 1.4 million dollars let us say right. So cost per pound turn out to be 365 dollars let us say that is typically reasonable.

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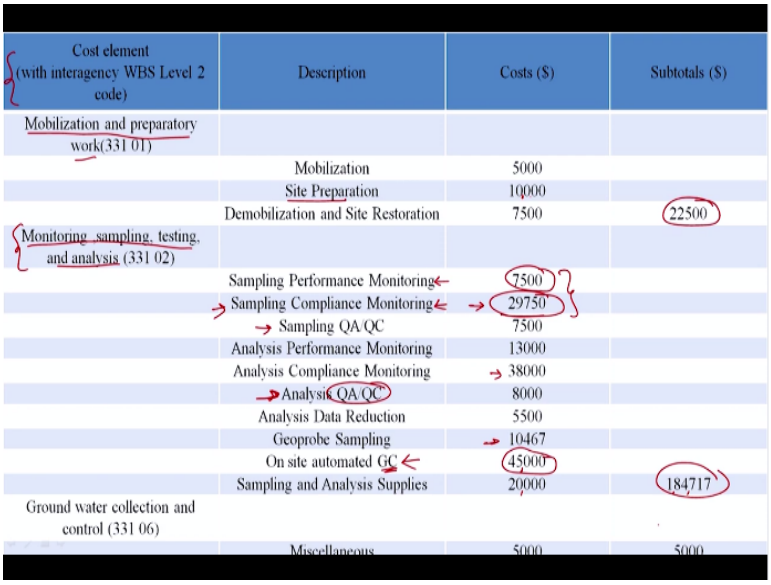

Cost element (with interagency WBS Level 2 code)	Description	Costs ($)	Subtotals ($)
Mobilization and preparatory work(331 01)			
	Mobilization	5000	
	Site Preparation	10000	
	Demobilization and Site Restoration	7500	22500
Monitoring ,sampling, testing, and analysis (331 02)			
	Sampling Performance Monitoring	7500	
	Sampling Compliance Monitoring	29750	
	Sampling QA/QC	7500	
	Analysis Performance Monitoring	13000	
	Analysis Compliance Monitoring	38000	
	Analysis QA/QC	8000	
	Analysis Data Reduction	5500	
	Geoprobe Sampling	10467	
	On site automated GC	45000	
	Sampling and Analysis Supplies	20000	184717
Ground water collection and control (331 06)			
	Miscellaneous	5000	5000

Let us look at the breakdown now right. So initially let us say again cost element, description, costs and subtotal let us say right. So we are going to look at let us say the initial phases, mobilization and preparatory work right. So site preparation, considerable what do we say amount let us say and demobilization and site restoration let us say so that is fraction of the relevant aspects.

So as we mentioned earlier monitoring, sampling, testing and analysis will take considerable or will require considerable resources. So let us look at that, so sampling performance monitoring right, sampling compliance monitoring, so as you see typically let us say you are not there to just spend money let us say on trying to get data, you will also spend considerable data as you will see in out here.

And especially in compliance monitoring let us say also let us say to be able to understand let us say the quality let us say required to maintain that particular data. As in sampling quality assurance and quality control analysis quality assurance and quality control and so on and such right and why is that obviously you need to have confidence in the data that you are generating right.

If the data that you are generating let us say is erroneous due to let us say different aspects, analytical error, human error or so on and so forth let us say or if errors kept in overtime let us say right, your system is going to you know seem as if it failed but it is that your underlying data let us say or assumptions were erroneous right. So obviously to look at those aspects you obviously need to look at you know the quality assurance and quality control which is a very important aspect let us say.

And here again for them let us say sampling compliance monitoring let us say right, even for sampling compliance as in to meet the relevant regulations I guess during monitoring let us say and sampling let us say you know looks like they had to pay considerable amount of money. Analysis compliance monitoring again right, geoprobe sampling may be not a cost, onsite automated GC.

GC is a gas chromatograph so looks like that cost you know they rather than taking it off site it as in the contaminant somewhere else and analyzing it, so that might add up to considerable fraction of money. They place the analytical equipment on site itself and that is the gas chromatograph let us say right and sampling and analysis supplies right. So more or less almost 10% of the project cost is within or you know is due to monitoring, sampling, testing and relevant analysis let us say right.

So groundwater collection and control and so on and so forth right, you know we have the relevant data out here right and that is I guess for groundwater maybe not as much let us say right.

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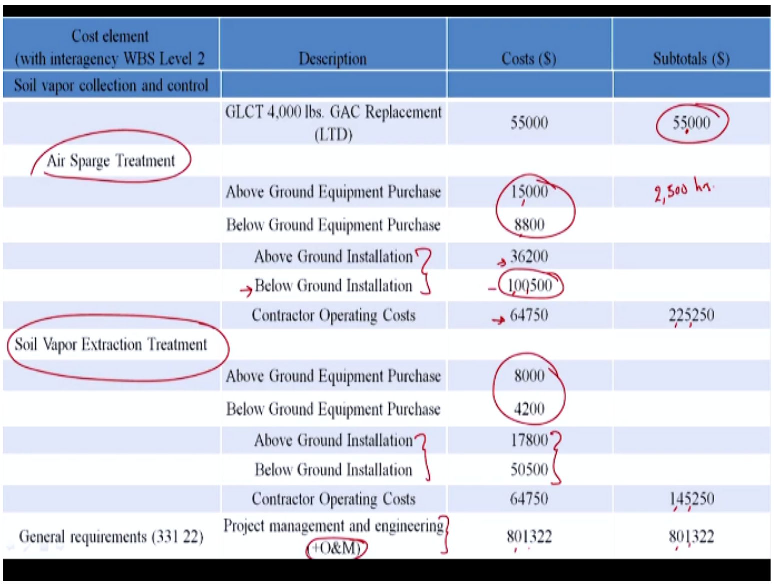

Cost element (with interagency WBS Level 2	Description	Costs ($)	Subtotals ($)
Soil vapor collection and control			
	GLCT 4,000 lbs. GAC Replacement (LTD)	55000	55000
Air Sparge Treatment			
	Above Ground Equipment Purchase	15000	2,500 hr.
	Below Ground Equipment Purchase	8800	
	Above Ground Installation	36200	
	Below Ground Installation	100500	
	Contractor Operating Costs	64750	225250
Soil Vapor Extraction Treatment			
	Above Ground Equipment Purchase	8000	
	Below Ground Equipment Purchase	4200	
	Above Ground Installation	17800	
	Below Ground Installation	50500	
	Contractor Operating Costs	64750	145250
General requirements (331 22)	Project management and engineering (+O&M)	801322	801322

So that is something out here 55000 dollars, obviously air sparging and soil vapor extraction will take up considerable what do we say amounts let us say and let us see what we have. So above ground equipment purchase, below ground and above ground installation, below ground installation costs are obviously considerably high let us say right. Obviously, contract operating costs but obviously below ground installation costs.

And you see that this is almost let us say 15% to 20% of the total costs let us say right and then soil vapor extraction let us say. Let us look at the major aspects here. Again, above and below the ground installation right is quite costly compared to the actual purchase of the relevant equipment and again keep in mind that if you do not get the locations right or the placements right let us say right, you are going to be able to you know mess up the relevant system.

So as you see a considerable fraction of the money is spent on in installation let us say right rather than actually capital costs right. Again, 10% or 15% of your relevant costs let us say and then again project management and engineering, general requirements that obviously took up what do we say I guess we do not have a great deal of background here, not background permanent data here.

But again it is for operation and maintenance, as you see they ran it for 1000s of hours I think 2500 hours in one particular zone and then greater than 10,000 and or around 10,000 hours in another particular zone. So obviously you are going to have relevant bills to pay right, both the utility bills for the labor and so on and so forth. So I guess these are the relevant aspects and that they end up almost around 70% let us say of the relevant costs let us say right.

So I guess with that I am going to end my particular what you say case study for soil vapor extraction but again the key aspect is that let us say right we need to obviously look at let us say relatively permeable soil or the relevant site needs to be relatively permeable right and even though the contamination has taken over long period of time let us say you are still going to have concentrations present as in considerable concentrations in the relevant soil.

Why is it? Because they are remarkably hydrophobic let us say right and some of them are very toxic to the microbes as in the site was used from 1947 to 1997 and even in 1997 let us say 50 years down the line they still absorb very high concentrations of the relevant contaminants let us say right. So I guess with that I am going to end today’s session and thank you.