Environmental Impact Assessment
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Lecture 53
EIA Methods – Risk and Risk Assessment

Welcome to the course Environmental Impact Assessments. And in today's course, we are going to cover Risk and Risk Assessment. How do we undertake that? And we will look at the methods involved in this. So, the key reference for us is chapter 18 from our textbook, which we are referring to Therivel & Wood.

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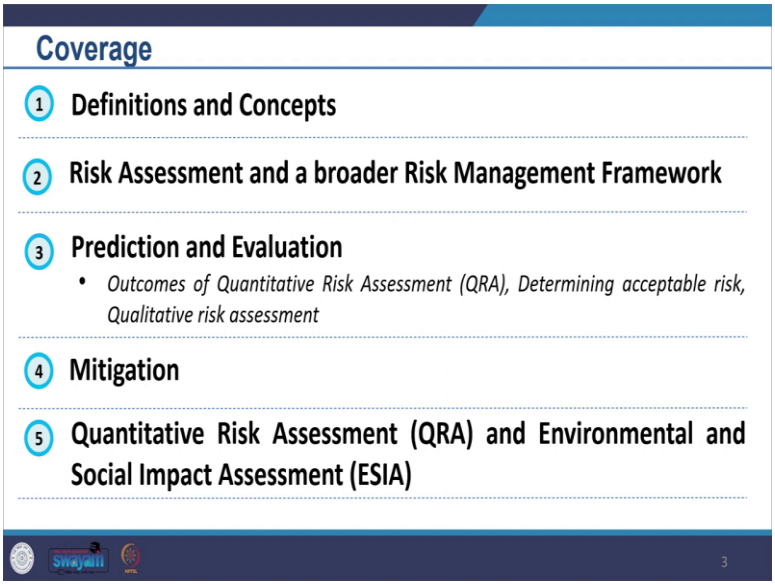

So, today's coverage includes we will look at the definitions and concepts, what are the various definitions and words about risk. And all the terminologies within that and then we will look at what are the risk assessments and what is the management framework. Further, we will look into the methods involved with prediction and evaluation, what approach we adopt in that and we will look at the mitigation aspect then we will also look into Quantitative Risk Assessment QRA and Environmental and Social Impact Assessment what relationship, and how do we deal with that.

So, accordingly, the learning outcomes expected learning outcomes is that you should be able to define and explain the involved key concepts in this particular domain and then you should be able to review the framework involved in the process, further, you should be able to identify methods and approaches involved in prediction and evaluation, and then identify the various mitigation approach, which would be would be taken in this and then also discuss the quantitative research assessment and the environmental and social impact assessment and within this domain.

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So, when we look at it, we see that risk is more an idea or a concept, what is risk, so, it involves a lot of judgments, that are perceived, like we feel the risk rather than what happens. So, it is more of a risk, which is perceived by the individual than than the fact of what takes place on the ground.

So, like, you might be afraid, you might be thinking about what might happen if you go somewhere and then the actual factors, whether that incident accident would happen or not happen. So, that is what we call risk. And when a risk is realized, then definitely the impact occurs, which in most cases, if we see the risk in a negative terminology, it relates to negative impact.

So, risk has a negative connotation, and risk is also aligned with uncertainty and probability because things may or may not happen. So, risk, if you look at the term risk means exposure to the possibility of economic or financial loss or gains. So, it can be any kind of risk and then the physical damage or injury or delay whatever might happen, because of the consequences of that particular event taking place.

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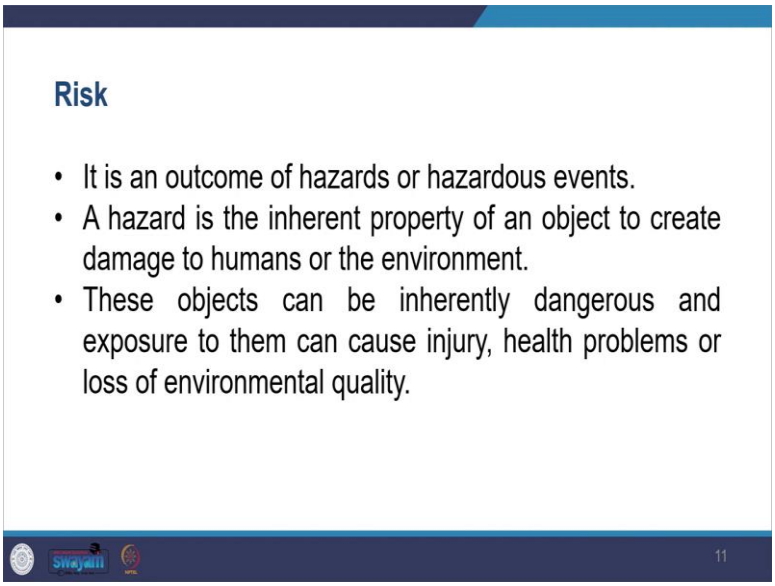

So, looking at the involved definitions and concepts a risk is an outcome of a hazard, if a hazard happens, hazards or hazardous events. So, what is the result of that is the risk? So, the hazard is the inherent property of objects. So, certain objects can be hazardous. So it is the property of the object to create damage to humans or the environment. So, if those things happen, then the results and the outcome, which happens are the risks.

And, these objects can be inherently dangerous and exposure to them can cause injury, health problems, or loss of environmental quality. So, these hazards can cause harm in one or two ways. So, if we see what the damage can happen.

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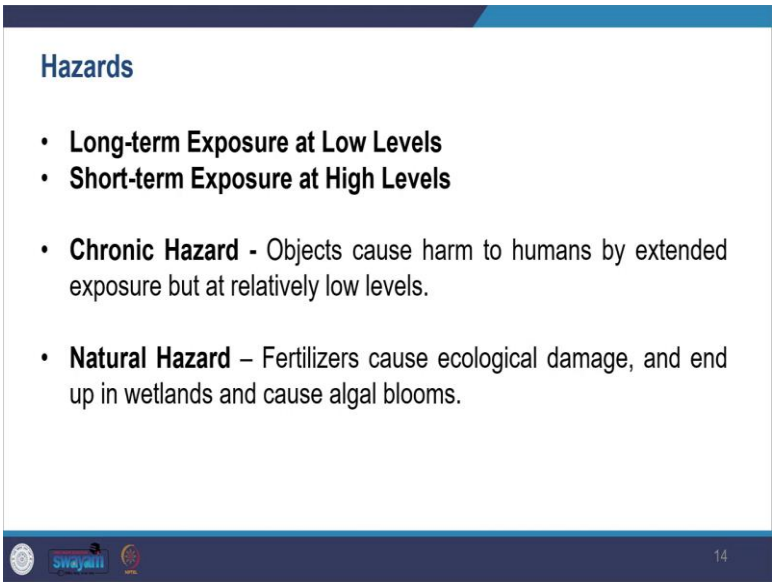

So, the damage can be long-term exposure at a low level. So you are exposed to something for the long term and the level of exposure is very low. And the other can be you can be exposed in a very short term, maybe a few seconds or an hour, but the exposure can be at a very high level. So, you see these two ways it can cause you harm.

And then the hazards that cause harm over some time through long-term exposure typically include examples include, like toxic chemicals, pesticides, radioactive material, all these X-rays and things like that, isotopes which are used in the X-rays, so, long-term exposure to all those, so, that can cause and then you and all these things are said to be a chronic hazard. So, the chronic hazard is the exposure caused to humans by extended exposure, but at relatively low levels.

And then, you also have natural hazards. So, for example, fertilizers cause ecological damage. And then you also see fertilizers that end up in wetlands and cause algal blooms, they can be slow or can be rapid with accidents. So, these natural hazards can also be slow or they can be rapid as well.

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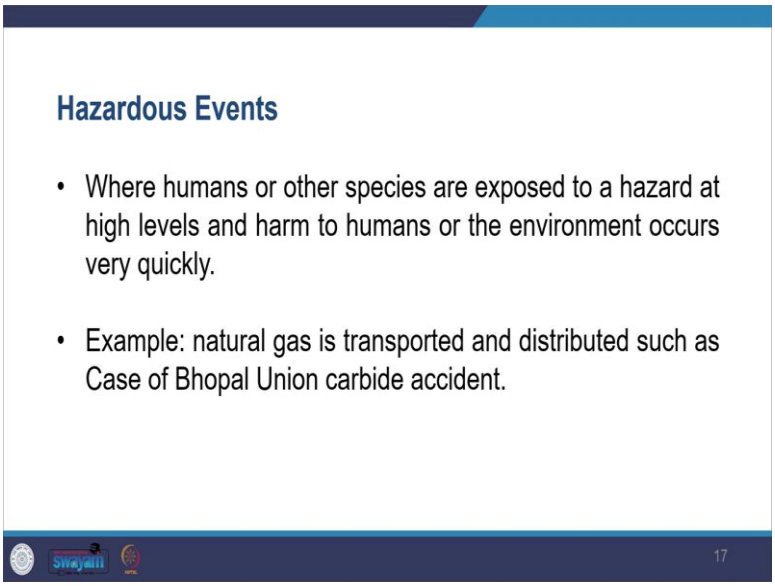

Then you also have hazardous events, where humans or other species are exposed to the hazardous levels and then you have, it causes damage harm to humans or the environment in a very quick manner. So, that is the hazardous event and in all these cases the hazards result in an accident, where very high levels of toxic chemicals or radiation are produced.

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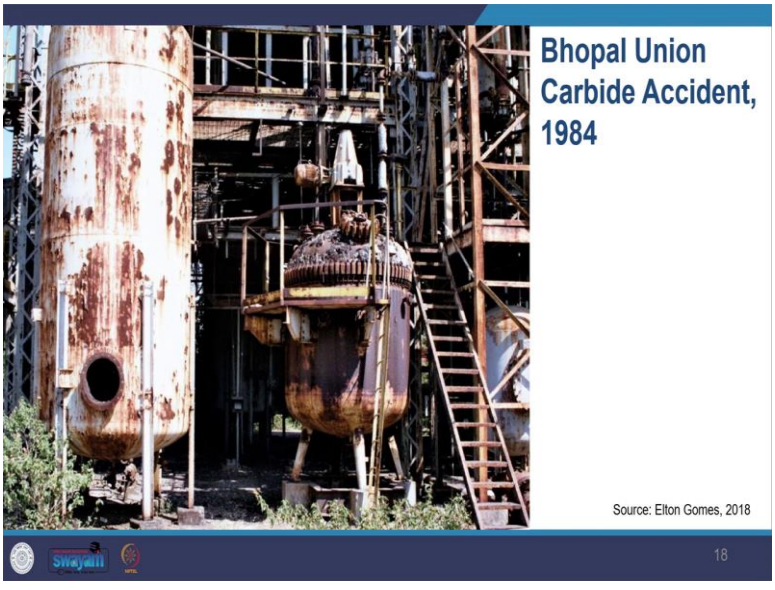

So, for example, you can see we have already seen this case before, for example case of the Bhopal gas tragedy, where we had seen a 1984 leak of methyl isocyanate gas at the Union Carbide Pesticide Plant. So, this is an extreme example of such an accident.

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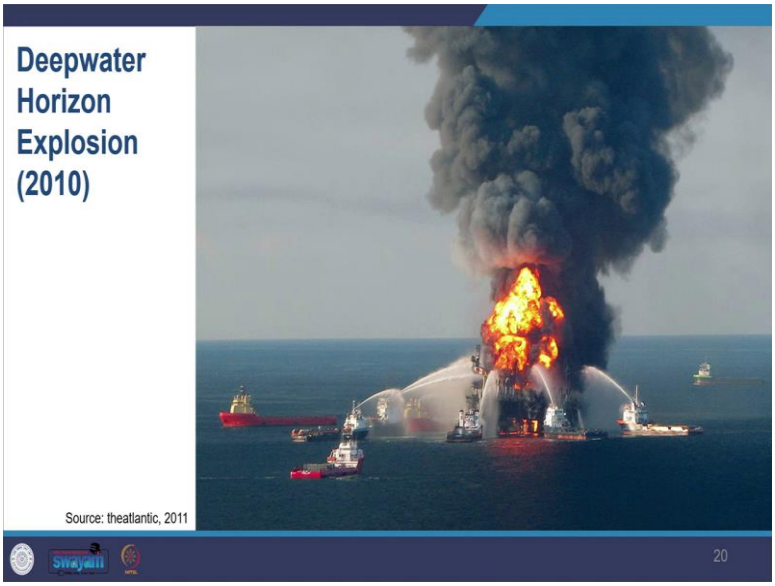

So, there have been other examples also of the 2010 explosion of the Deepwater Horizon oil platform and the Gulf of Mexico. So, that resulted in over 1000 kilometers of course, being affected directly by the mixture of oil and chemical dispersant you can see that as well. So, seeing risk, what is the risk? Is equal to the likelihood does harm to a human or the environment occurs as a result of exposure to the hazards.

So, there is a probability case and there is a hazard. So, what kind of damage will happen based on the likelihood and the hazards, so, if the human beings are exposed to that hazard, so, you will see that risk is seen as a combination of these two factors. So you will see likelihood which is frequency and hazard, which is the consequences of the interaction.

So, the frequency for chronic hazards is about the length of time, how much you are exposed to the hazardous chemicals, or the number of times that exposure occurs. So, as you will see, as the length of time increases, or the number of exposure increases, the risk also increases more to cause the damage. And you also find an acute hazard, which is like frequency is more generally about how many times a certain type of accident occurs, or how often things go wrong. So the consequence, the result in the risk refers to how serious is the harm and the risk here.

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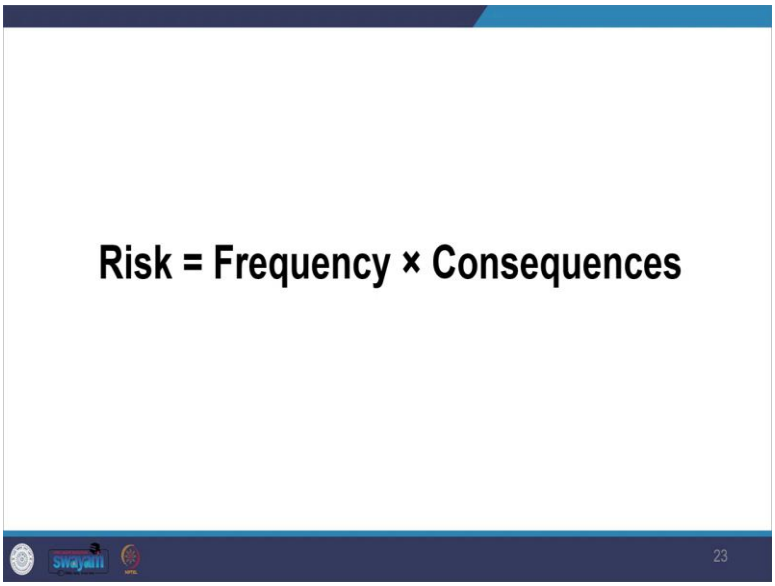

So, the risk is if we will see in a very simple term frequency conceptually multiplied by consequences.

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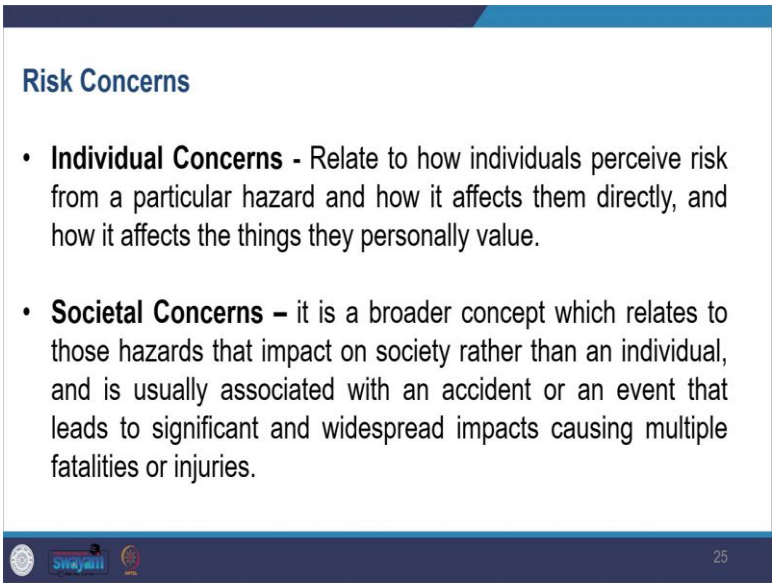

So, you will also see that these risks can be of individual concerns or societal concerns. So, individual concerns relate to how individuals see perceived risk from a particular hazard. So, how it affects them directly, how it affects things they value. So, that is like individual concerns. These concerns can be quantified also. And then there are certain societal concerns and then there are broader concerns, which relate to hazards that impact this society in larger compared to individual, and mostly our focus is on the societal concerns compared to the individual concerns.

So, now understand risk assessment what do we mean when we say risk assessment, it is the process of estimating you are going to calculate the level of risk that a hazard has which poses on the poses that calculation is called risk assessment. So, the broader risk management strategy would involve you are going to estimate the likelihood of an adverse outcome, so that you would, based on this you are going to develop the broader risk management strategy, you are going to estimate the likelihood of an adverse outcome.

And you would also evident, you will also provide useful data on which all the authorities involved authorities, which operate or make the decisions are going to try to reduce the risk. So, now, you see that these assessments are done in the quantitative format as well as qualitative format.

So, looking at the quantitative risk assessment QRA. So, here you try to quantify the risk, and the process involves evaluating and assigning a number value to the risk. So, you give a number to it, and also includes the practice of probabilistic safety assessment and probability risk analysis, as well as PRA.

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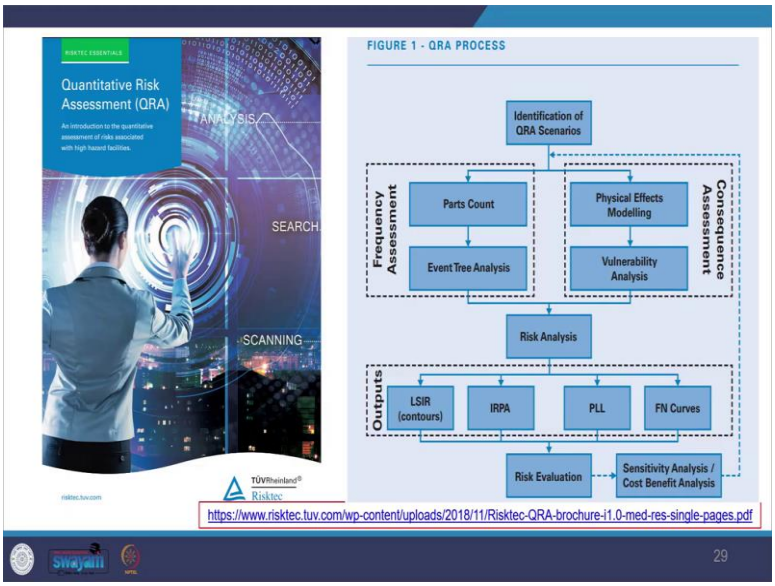

So, you are looking at the QRA process, you see how you identify the QRA scenario, you look at the frequency of assessment and what are the different outcomes. So, here you can have this guideline quantitative risk assessment, QRA guideline very detailed guideline which is there. So, I have given you the link also to that. So, it looks at what kind of how you do the frequency assessment, so, you undertake part count. So, you also draw even tree analysis or you also have physical effects modeling or vulnerability analysis.

Based on that you look at the risk analysis, where the output can be the in form of a contour, you can draw risk analysis, contour, and then all formats of IRPA, PLL, and FNB curves. So, all these are the ways how you depict the risk, and then risk evaluation shows the sensitivity analysis and then you can also link to the cost-benefit analysis. So, some of the examples here are semi-problematic presentations of QRA results.

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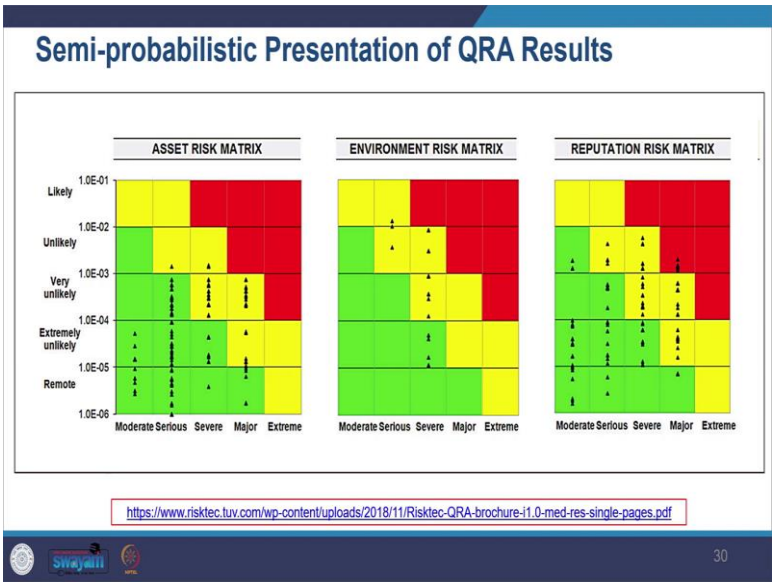

So, you can see here, asset risk matrix so, likely unlikely very unlikely, extremely remote. So, you have like how moderate, serious severe major extreme is there, so, you are drawing the matrix, you are also looking at the probability of it happening, and then what happens with if it happens in moderate or in extreme cases, what kind of things will happen.

So, semi probabilistic presentation of QRA you can see here the environmental risk matrix and reputation risk matrix, all these matrices have been given. So, what will happen to the property, what will happen to the environment and what will happen to the reputation if these kinds of things happen?

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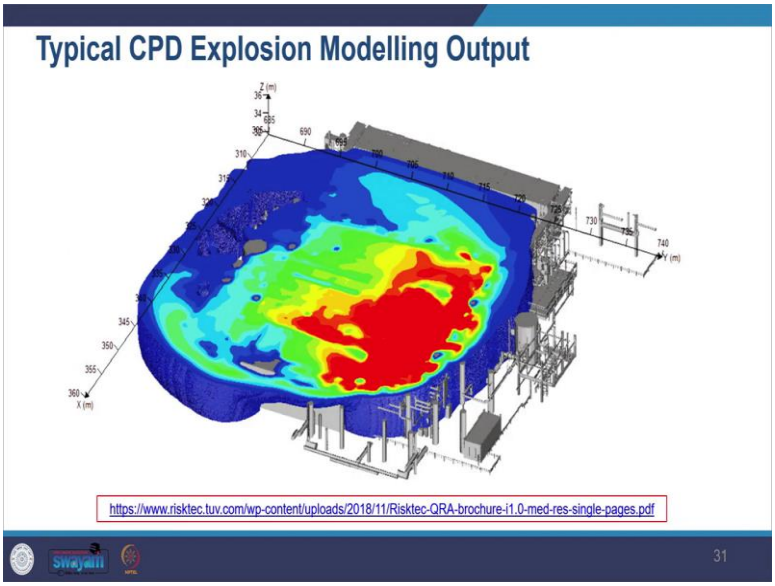

Then, you can also see this modeling output here how they are looking at how it is showing you the scenario from which the red one is the highest risk, what will happen to the outdoors and how it is along the space, how it is going to happen. So you can see this modeling output here.

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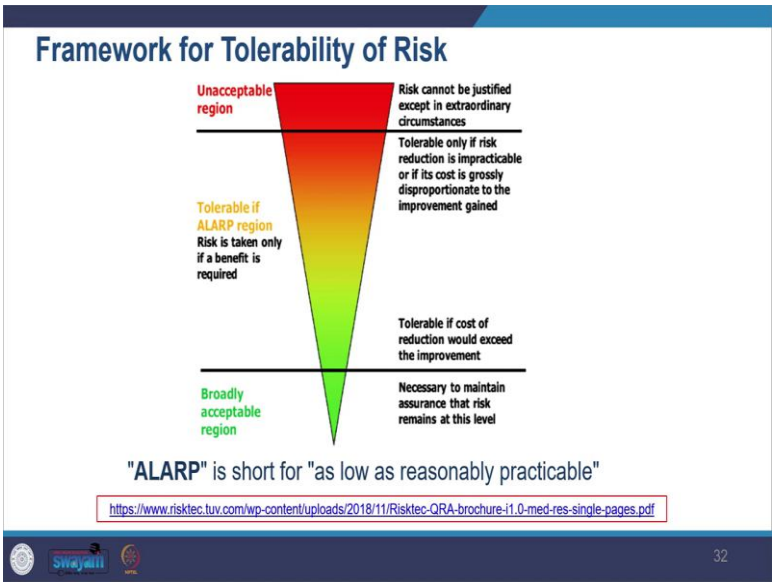

Then there is also a framework for tolerability of risk. So, you see this framework here, which is like, how do you make because it is involved, it is very perceptual and it involves a lot of judgment as well, and there are standards and guidelines for the acceptable level. So, here you see, there are certain if you look at this inverted triangle, you will see that the topmost is the unacceptable region.

Risk cannot be justified except in extraordinary circumstances. So, that is an unacceptable region, then you have this between the unacceptable region and broadly acceptable region you have, you have ALARP region risk is taken only if a benefit is required. So this region, the ALARP region, you will see the taller rebill only if the risk reduction is impracticable, or if its cost is grossly disproportionate to the improvement gained.

So if, if it is very, very expensive, then you might have that in the buffer case, and whatever mitigation you are taking, it is tolerable if the cost of reduction would exceed the improvement. So, you see how, how did these decisions are made. So, a common form of presenting risk tolerability criteria for societal risk is an FN diagram.

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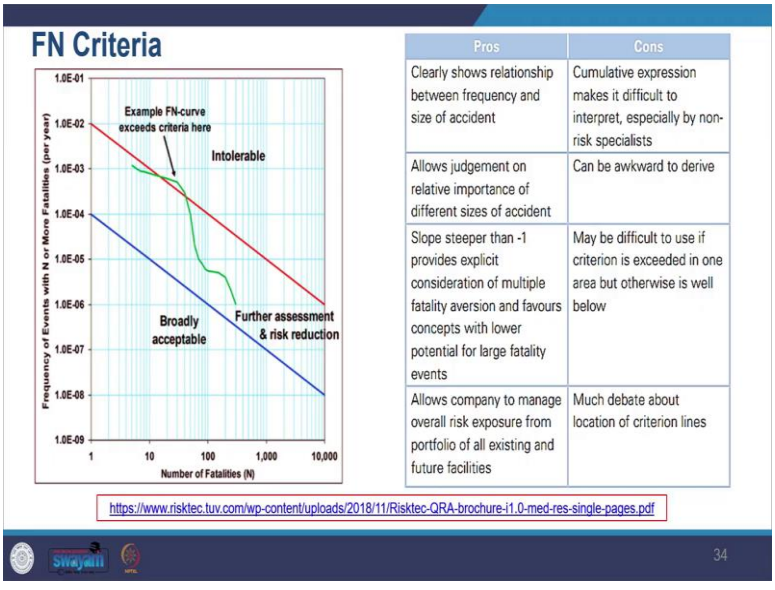

So, in that also you saw that we show it in FN curves. So where two criteria lines or divide the space into three regions, so where you have like intolerable, where it is broadly acceptable, and where it requires further assessment and risk reduction as far as reasonably practicable. So, here you can see FN curves you can see all the areas.

So, the, these line example of FN curve, here, these curves you can see, so, then, about the red zone, you will see it is intolerable within a red and blue zone, you will see further assessment and risk reduction required and then the below blue line you can see broadly acceptable things. So, the FN criteria are used and then if you look at the benefits and limitations of FN criteria is like, it shows the relationship between frequency and size of accidents.

And then you also allow the judgment on the relative importance of different sizes of accidents. And then, you look at the steep slope, which helps you to make further decisions on, how you can manipulate information, and it also allows the company to manage overall risks.

So, they this is this has certain advantages, but the limitations include cumulative expression makes it difficult to interpret at certain times interpretation is difficult, and it can be difficult to derive and maybe difficult to use the criteria, if we are using it in one area or more than one area. And this is also debatable about the location of lines. So, that is there are benefits as well as limitations.

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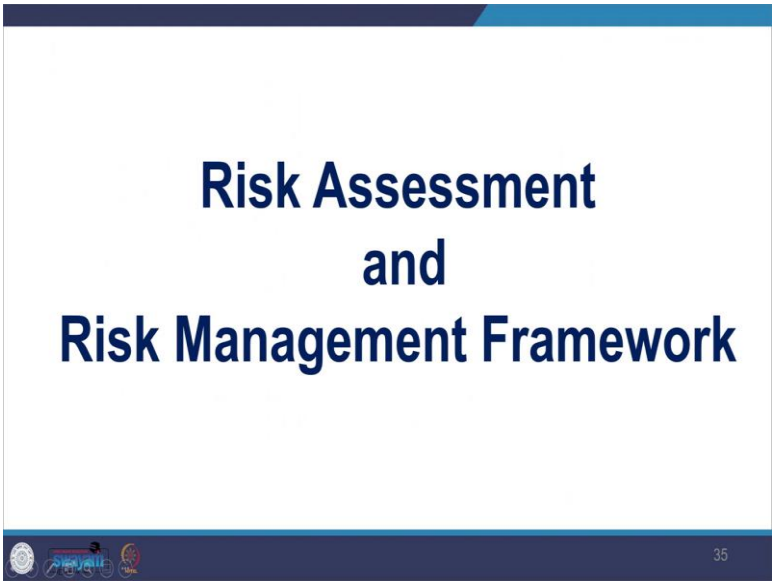

So, now moving on to look at the risk assessment and a broader risk management framework.

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So, here you see, four broad steps as you can see in this stage here. So in this risk assessment we first is that you identify the hazards, what are the hazards, what, what things can go wrong. And then if they go wrong, what consequences will happen, and then what is the likelihood that the things will go wrong, and then then you will find out what nature would be to what extent it would happen, what kind of impact would happen and how many people will how the material will be affected and then establish the acceptability of the risk level.

So, what kind of risk we can accept, and which risks we would not be able to accept that you have already seen then after this, you have a post-assessment, where you do, you see the last step in the risk assessment. So, if the risk level is found to be acceptable, then no further action may be required, if it is in the acceptable range, then the proposal can proceed especially if the risk is negligible.

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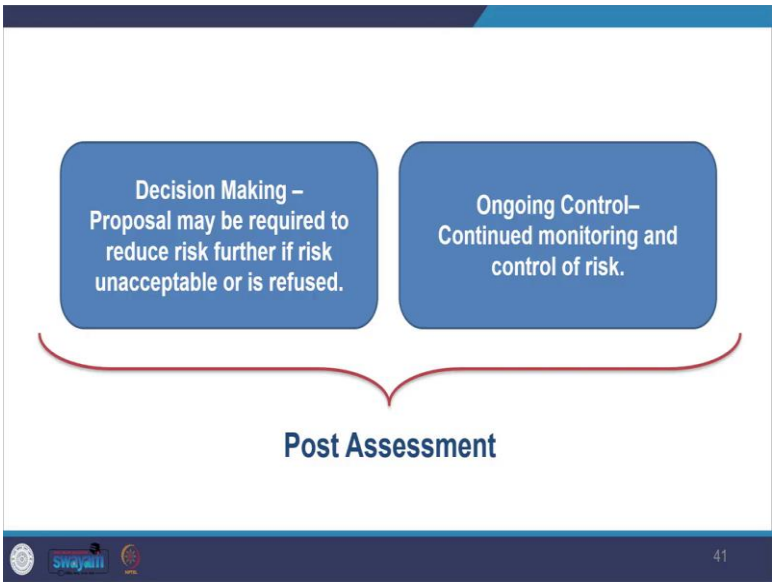

So, looking at this post-assessment here, you make the decision. So, you look at the proposal that may be required to reduce risk, further, if the risk is unacceptable or is refused you can go ongoing control is there

and then you can continue monitoring and controlling of the risk. So, this is post-assessment. So, that was about risk assessments, and the broader risk management framework, which is usually followed in a very simple manner.

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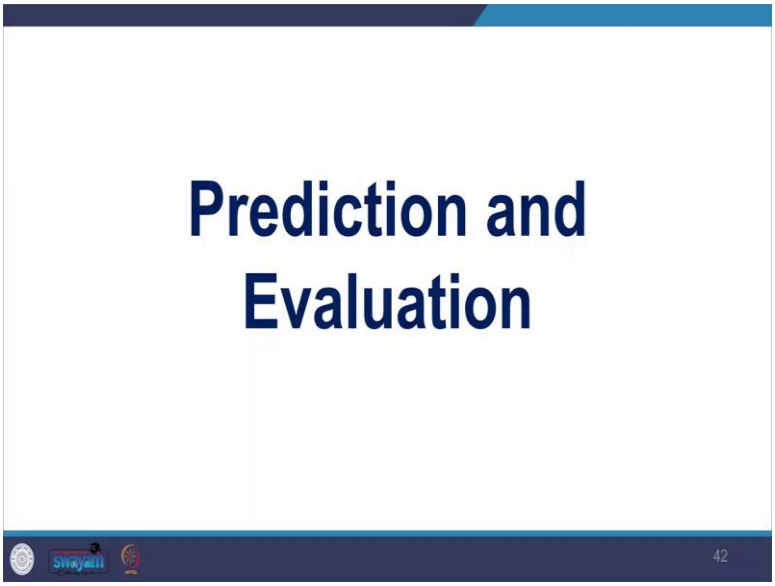

Now, looking at prediction and evaluation. So you have seen quantitative risk assessments. So, if you look at quantitative risk assessment. What is the outcome of quantitative risk assessment? So, the key outcome of quantitative risk assessments is the risk on two lines around the hazardous facility. So, you saw a range of outcome outcomes when you do this assessment, so, one is the risk contour lines. So, each contour line represents a line of equal risk of any individual standing on that line.

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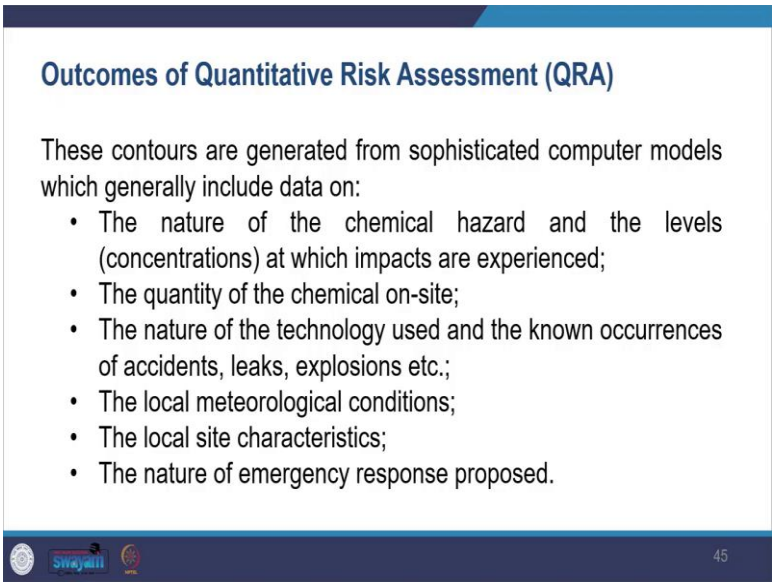

So, these contours are generated from all the sophisticated models which are used and they will include, they would show you the data, they will tell you about the nature of chemical hazard and the levels of what kind of impact would happen. Quantity of chemicals on side nature of the technology used and known like what

will like a what accidents leak, explosions would happen. So it would show that and it would also depend on the local man did a logical conditions local site characteristic and nature of emergency response proposed.

So, not just on the inside information, but also based on the external factors. So, these contour lines would the QRA will show you all these aspects, and contour lines risk contour lines will also show you.

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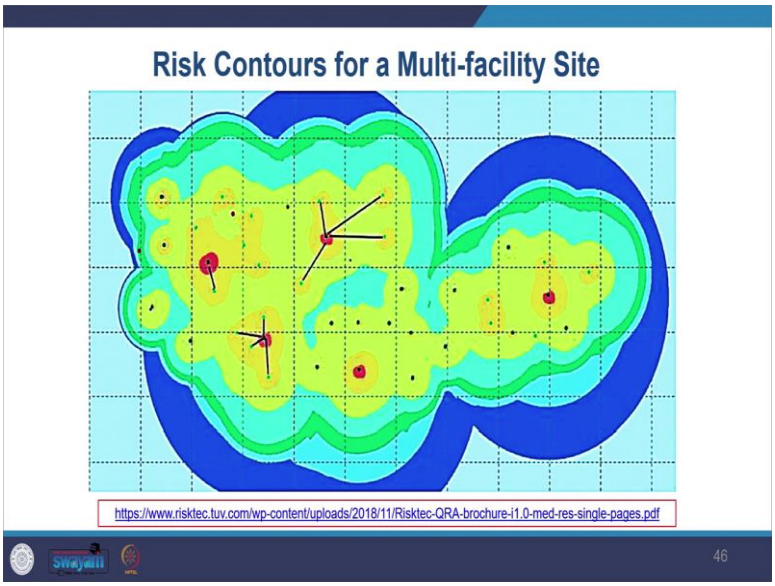

So, you can see the example of a risk contour for a multi-facility site. So, you can see all the inner polygon then you will see the yellow and then you can see the range of colors which you can see here. So, how the risk is going on reducing risk is higher at the center, and it is going on reducing. So, for undertaking all these you need certain data sources, and mostly, there are a lot of agencies that maintain accident and frequency of accident data.

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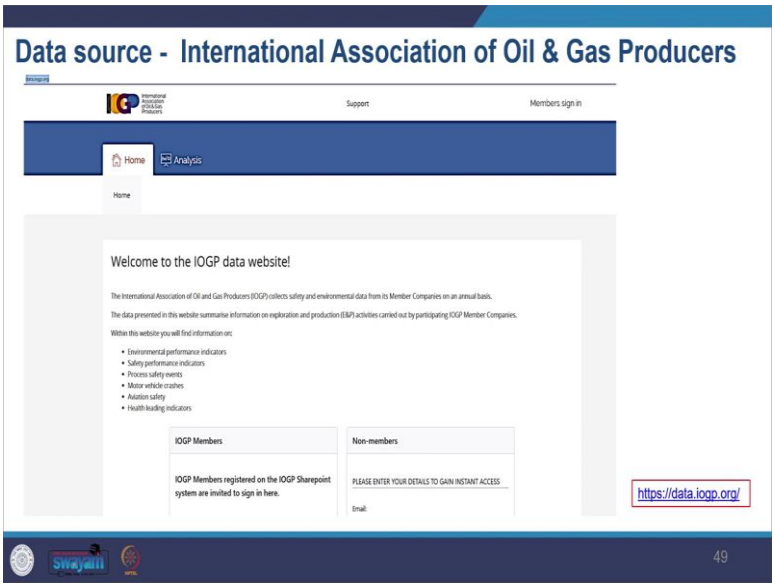

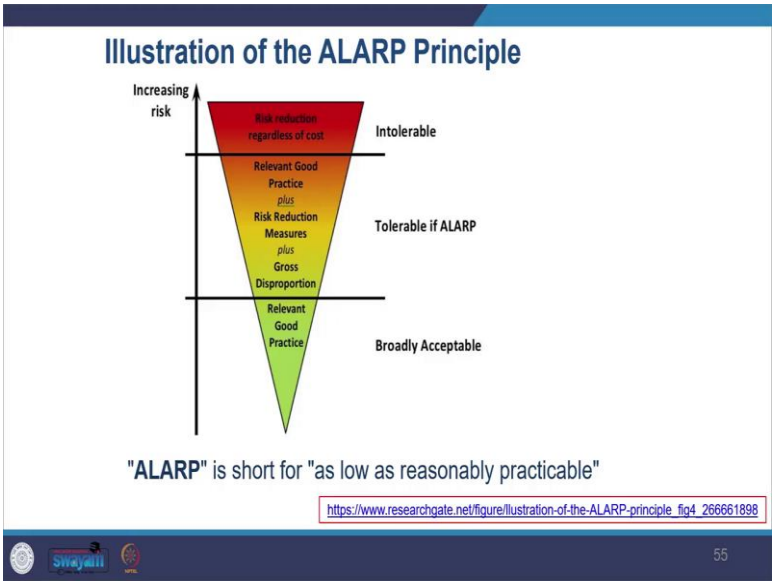

For example, we have oil and gas producer data, which you can see here, I have given you the link. So, these kinds of agencies maintain data on accidents and the possibility of accidents. The QRA has been criticized also for being very narrow, it gives very stimulated modeling results. So, there are limitations to it. And then there is also criticism about it being focused on the equipment failure, but then there can be chances of human errors like there is a discussion on the Bhopal gas tragedy, which was a combination of human and equipment failure.

So, now looking at how we determine the acceptable risk acceptable risks. So, in QRA, we see what level of risk is acceptable, and what is tolerable and acceptable. So, when we say tolerable, we mean the willingness of a society as a whole to live with the risk. So, as to like there are certain benefits you get from whatever activity you are doing.

So, you are willing to undertake that risk to gain that benefit. So, that is the tolerable level of what you mean here, and it is also guided by the political processes and then there is also like, what kind of exchange is happening between the benefits and the risk which is involved here.

So, when you say acceptable, it means risk levels lower than the tolerable level and can be considered acceptable and this does not mean that once the level of tolerable risk has been established, every individual will accept it. So, it might also vary from context to context from individual to individual as well. So, you also see there is a difference between we had seen the diagram between what is acceptable and what is not acceptable.

So, if we had seen the diagram, ALARP, so, as low as reasonably practicable. So, now, this is what philosophy we follow. So, the risk between the two values is often called an ALARP region as low as reasonably practicable. While it is preferred that the risk levels be reduced to a minimum, what minimization you can do? The risk within this range can be acceptable if reducing the risk level further is either like it is not cost-effective, or it is not practically possible to attain it or it loses the trade-off which we are making it no more is beneficial for us.

So, you can see the diagram here of ALARP as low as reasonably practicable. So here, you see increasing risk reduction, regardless of the intolerable cost, then you have tolerable if it is as low as practically possible. So that is the ALARP range you are seeing and then relevant a good practice because of good practice and standards and maintenance, which you follow broadly acceptable level. So, you will see that nations have adopted criteria for tolerable unacceptable risk levels.

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So, you have various like all these range of countries we have which have adopted criteria for tolerable and unacceptable risks. So they have these and then, you have seen quantitative risk assessment you also have qualitative risk assessment. So here you do not number but you describe the information.

So, that allows for a comparison of options. So that includes the views of the experts and sometimes like even the views of the stakeholders, experiences of the stakeholders, and then it allows you to make the assessment based on the kind of descriptions and descriptive information you have. So, in this also the same general approach adopts the risk equals to frequency into consequences. But in this case, you do not come up with a number, but you come up with a description.

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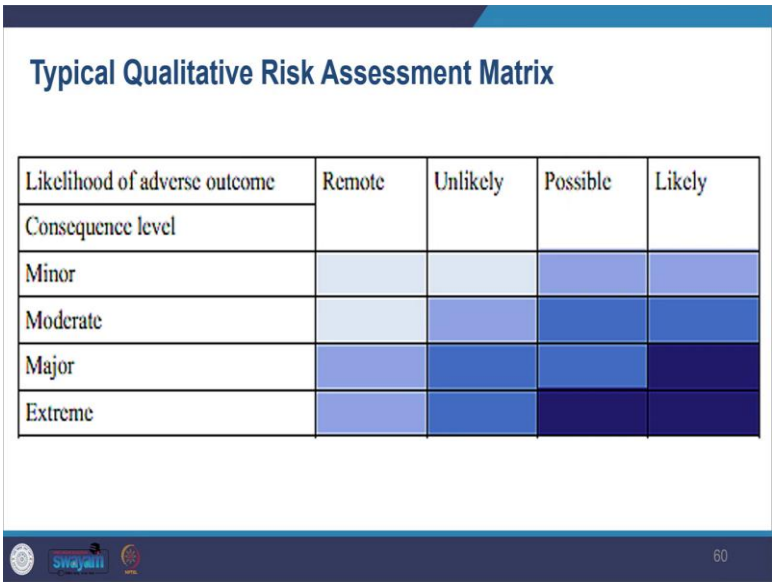

So, you can also have a risk matrix which is used here. So, this tells you the two-dimensional aspect of it as you can see here, and this matrix you can see is describing it is not giving a number so the likelihood of the adverse outcome, what is the consequence level minor, moderate major extreme. And, what are the chances of it happening remotely unlikely, likely given the cases or experts' opinions or stakeholders' experiences? So, there are a lot of methods which are available for risk analysis.

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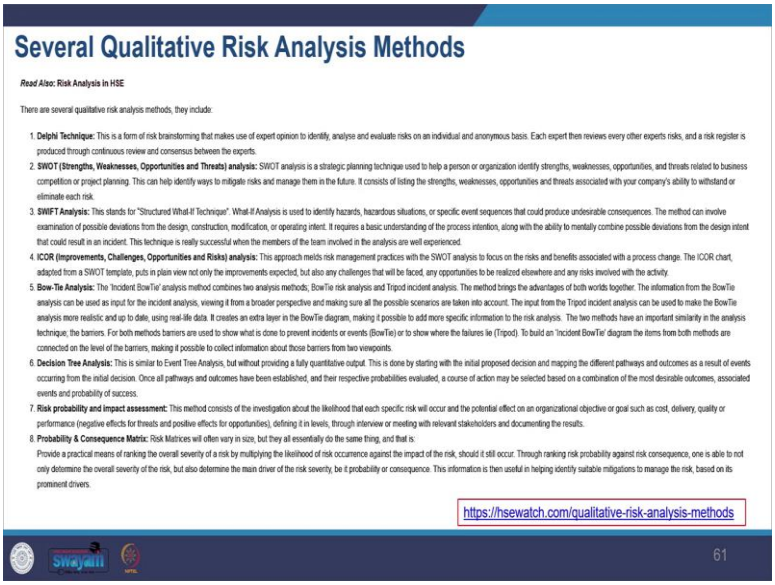

So, you can see risk analysis, which has like Delphi Technique, you can have SWOT Analysis, Swift analysis, and then you can also see ICOR, Improvement Challenges, Opportunities and Risk Analysis, Bow-Tie analysis, Decision Tree Analysis, Risk Probability and Impact Assessment, and Probability and Consequences Matrix. So, all of these are available for undertaking qualitative risk analysis methods. So, we will not get into the details of all these Delphi techniques and SWOT analysis, but for our understanding, these techniques are used.

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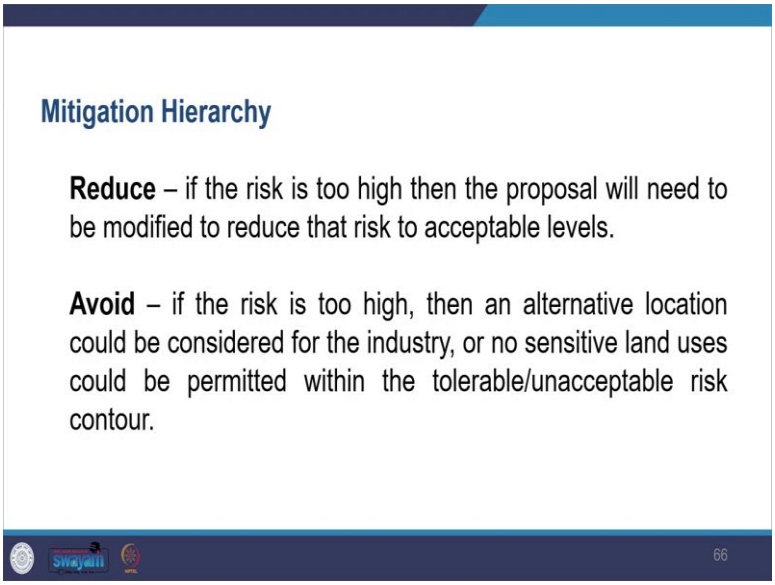

So, now looking into the mitigation aspect. So, once you do the assessment, risk assessment, especially when you undertake QRA, quantitative risk assessment, or qualitative risk assessment, the purpose is to inform the decision-makers of both policymakers and the people who are going to be affected. So, you inform them, the purpose is to inform.

So, and then if your mitigation can be informed of land use planning decisions, where you to locate what kind of things and also what kind of standards you are going to follow as per the acceptability of the risk to human health and safety. So, what you try to do is you have a certain mitigation hierarchy.

So, first, you try to reduce if the risk is too high, then the proposal will be required to be modified to reduce the risk to an acceptable level. And there is a if that cannot be done, then you need to avoid it if the risk is too high, then an alternative location can be considered for the industry or no sense or no sensitive land use could be permitted within the tolerable unacceptable risk contours. So if any sensitive land is used there, you have to avoid it. So, you follow this mitigation hierarchy.

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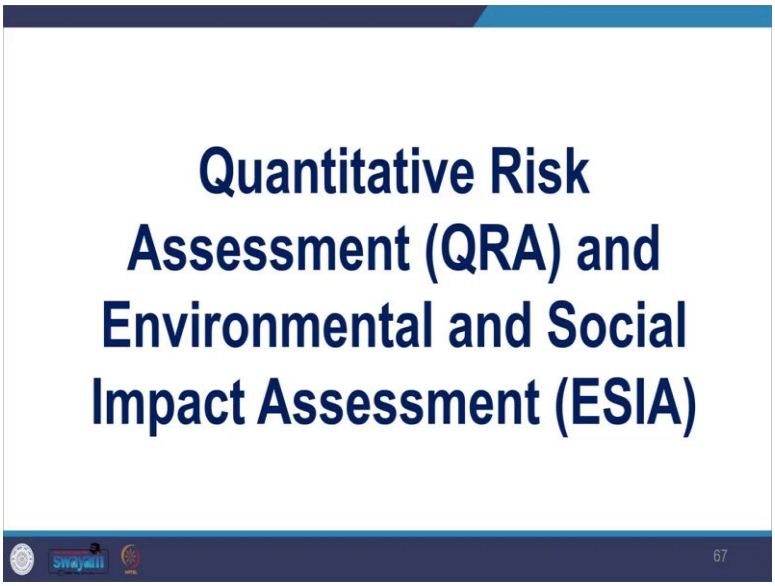

Now, looking at quantitative risk assessment and environmental social impact assessment. So you are dealing with quantitative risk assessment and EIA. There is a link between that. So, you see that both the QRA and EIA are about like you are looking at the impact of new or any kind of proposals, which is coming up and you look, but what you do in QRA focuses on human health and the safety aspect of the proposal.

So, when you are looking at the risk, we are looking at the human health and safety aspect of the proposal, while when we are looking at EIA, we look at the broad range of environmental impacts. So, if you want to understand the difference between the two you when we do the risk assessment and when we do the environmental impact assessment? So, then we are looking at the impact on the environment and here we are looking at the impact on human beings. So QRA can be seen as a tool that allows a which, which is within the EIA process. And though it has a similar theory, it is looking it is for the focus is different in QRA you are looking at human beings, and in EIA, you are looking at humans as well as the environment altogether.

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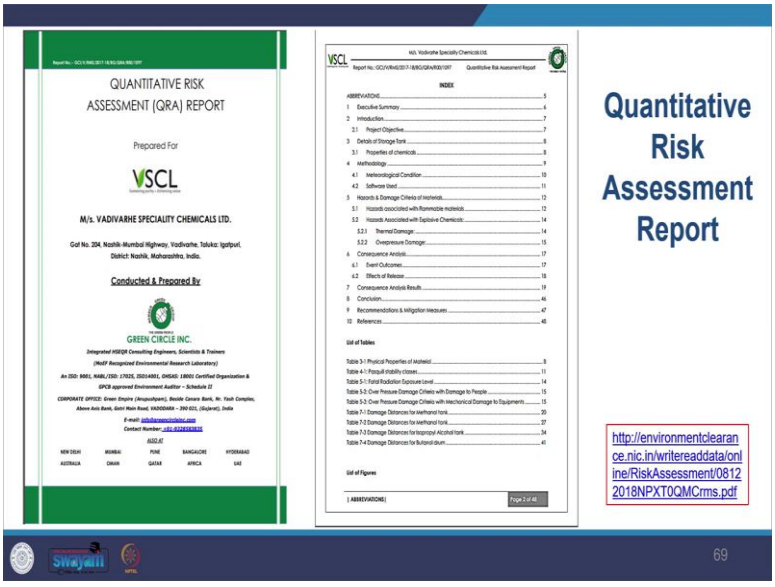

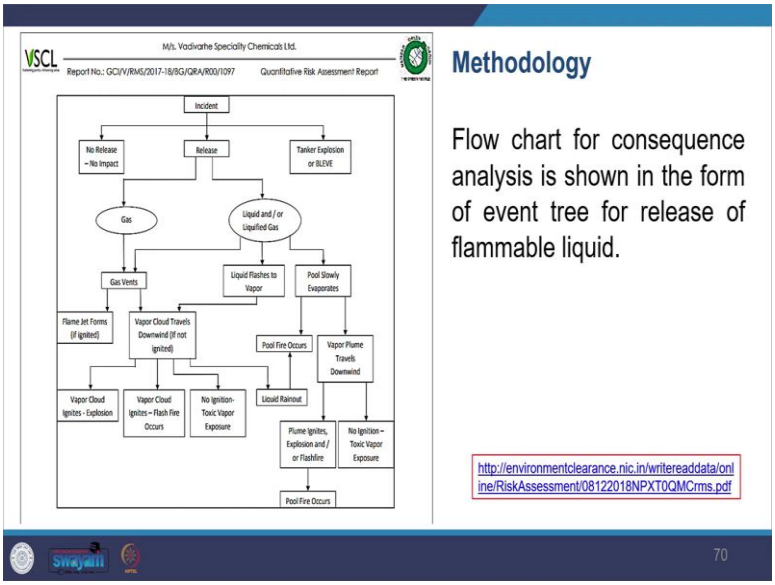

So, there is a certain quantity quantitative risk assessment report, I have given you the link here, you can see here how they are analyzing, where, what kind of accident, incident, or release tanker explosion or release will happen then what kind of scenario will happen, so, these kinds of flowcharts for consequences are built. So, these are some of the techniques and tools which I use to analyze.

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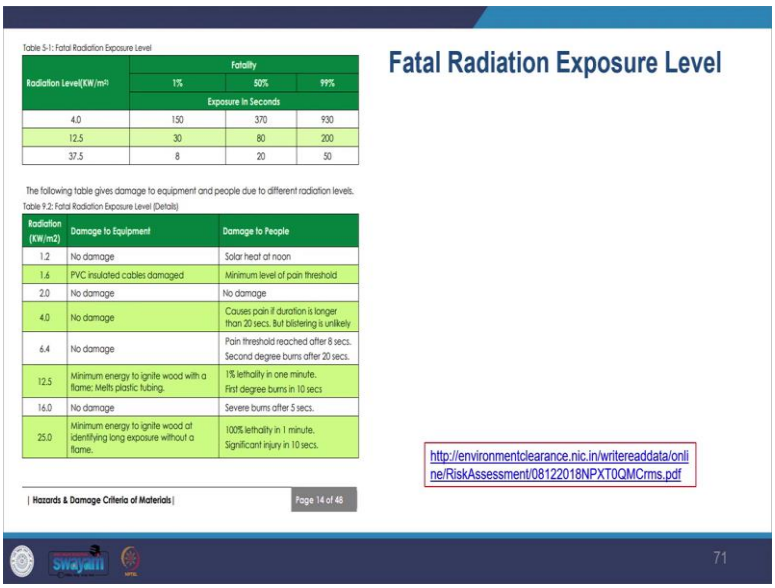

You can also see here from this example of fatal radiation exposure level, how they are creating different scenarios with radiation level and then fatality. If it happens, then what will be the percentage of damage which will happen?

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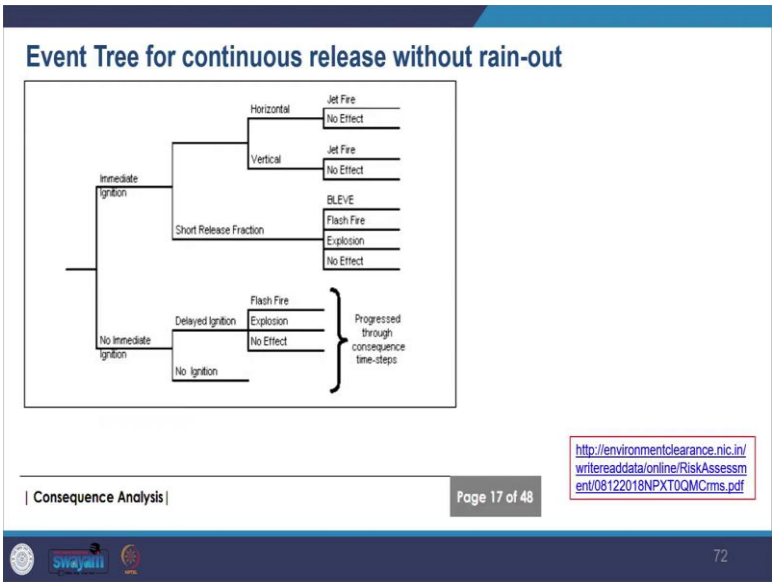

So, you can see here, that this is even true for continuous release. So, what I want to show here is the event tree. So, how do you analyze what kind of event if any accident happens then what will happen here?

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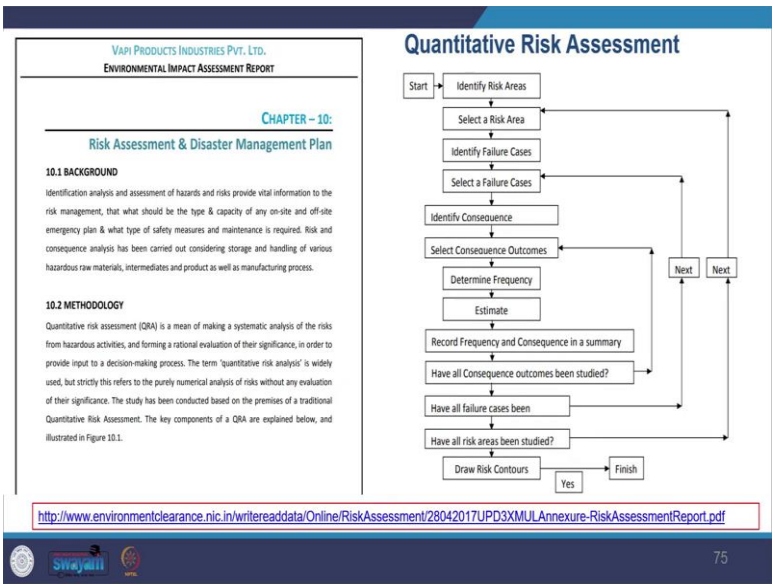

And then, you can also see here in from their report, this report I have taken from the very Re-specialty Chemicals, this is from Bombay Nasik Mumbai Highway. This example is from Bombay. So, you can see how they have done modeling stimulated the scenario in the sea pool, select pool fire results if the fire occurs, and how it will happen.

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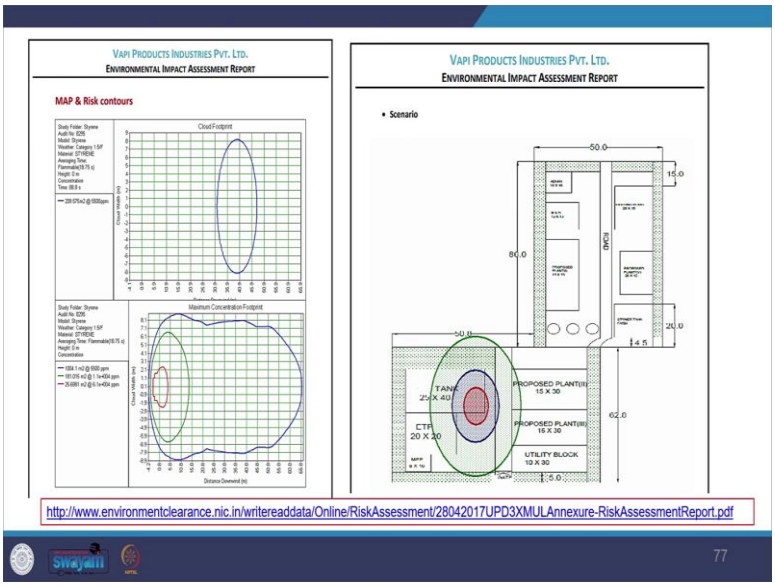

And then, there is another example in which you can see the Vapi Production Industry so, they are taking risk assessment and disaster management plans I have given you all these case studies which you can see, you can see the quantitative risk assessment, and the methodology that they have followed here.

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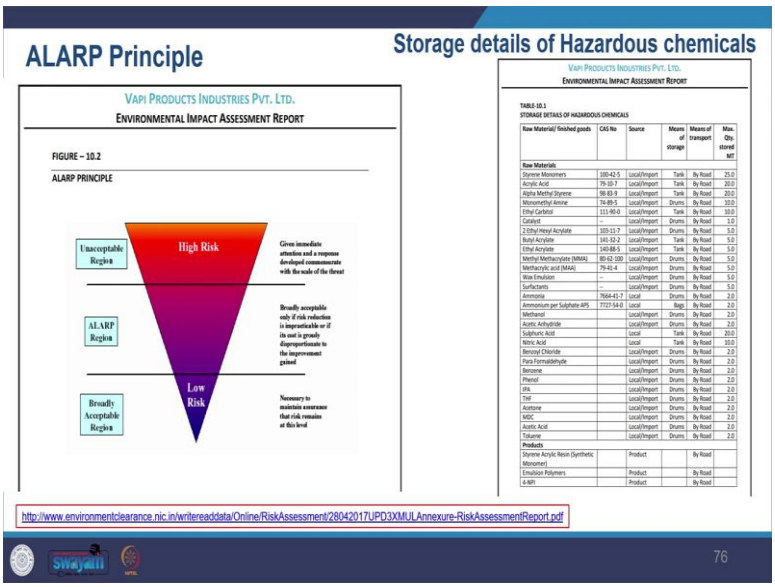

And then how they have addressed the allowed principle and then what kind of hazardous chemicals are there, then all the modeling map and risk contour. So, here you can see the example of risk contour again. So, how they have drawn the risk contour? So, what kind of exposure will happen at the blue line, green line, and red line?

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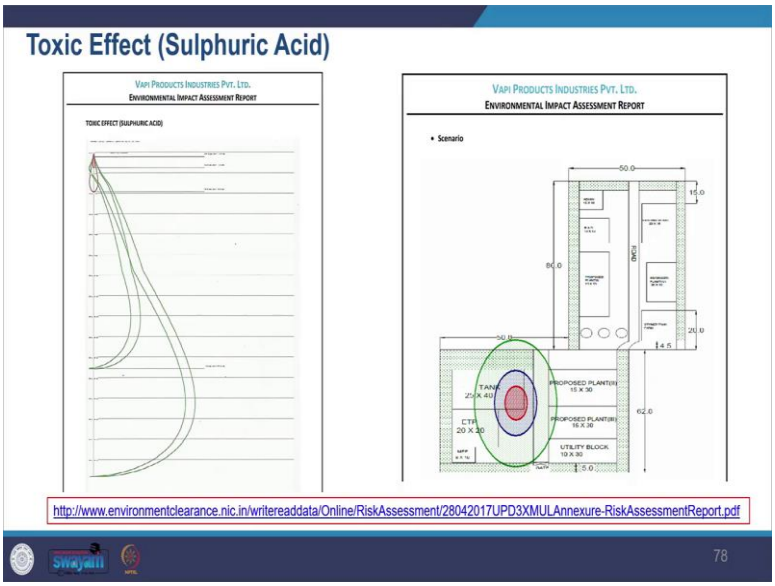

And different scenarios you can see what they have done in the talk like how the toxic effect would be for different chemicals and then they have also created scenarios for that.

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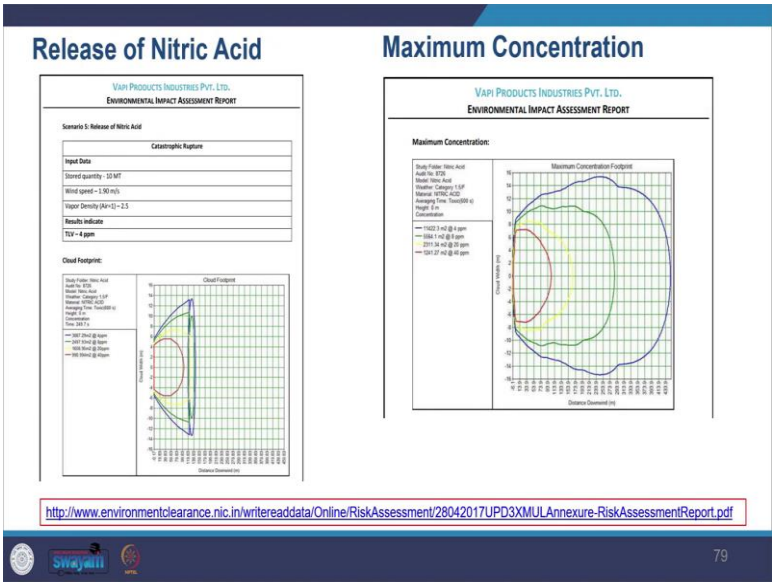

Then also you can see the again different nitric acid, and acid scenarios they have created and then the contours they have created, you can see the cloud footprint and then how they are showing the maximum concentration here.

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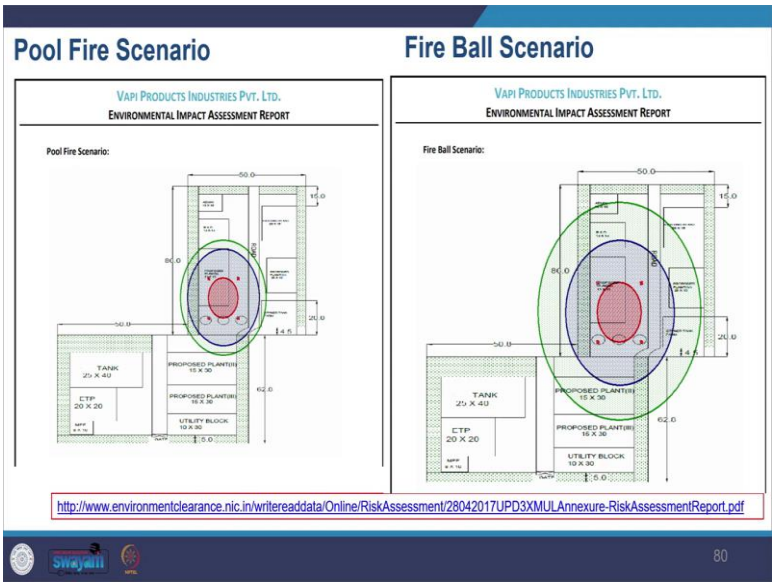

Then you can see the pool fire scenario and fireball scenario. So, different scenarios have been built here. So, it will not get into the details of it, but just to understand what all are the ways they depict and how information is communicated. So, that is what we have in this particular session.

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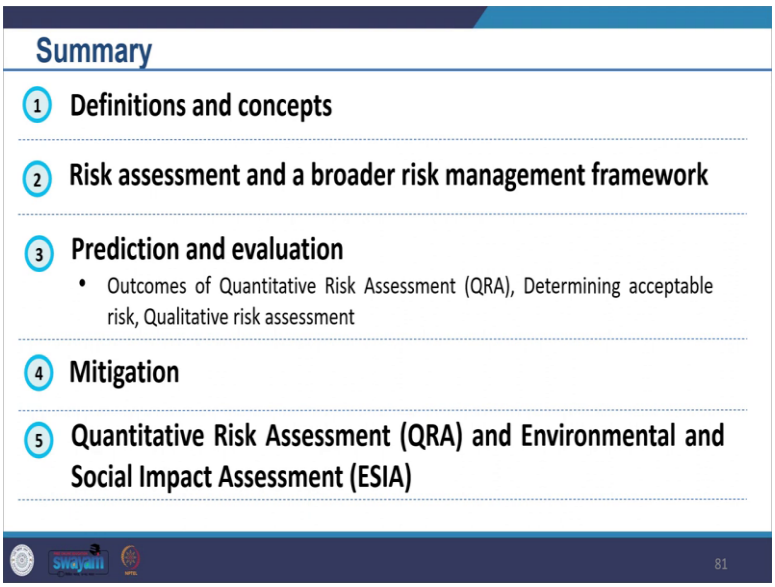

So, summarizing, we looked into the definitions and concepts then we looked into risk assessment and broader risk management framework. Then, we looked into how we predict and evaluate we looked at certain few limited examples, and then what approach we take for mitigation what are the mitigation hierarchy, and then we tried to differentiate between quantitative risk assessment and environmental impact assessment.

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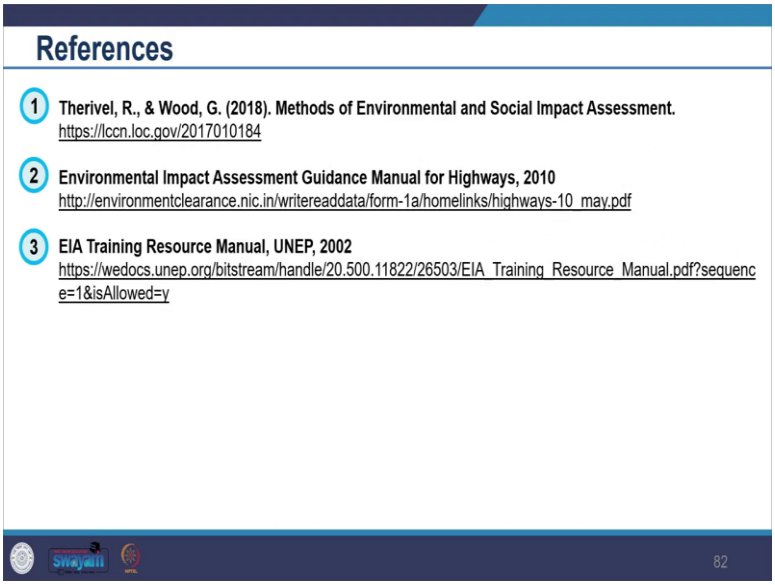

So that was all for today. These were our key references for this particular session.

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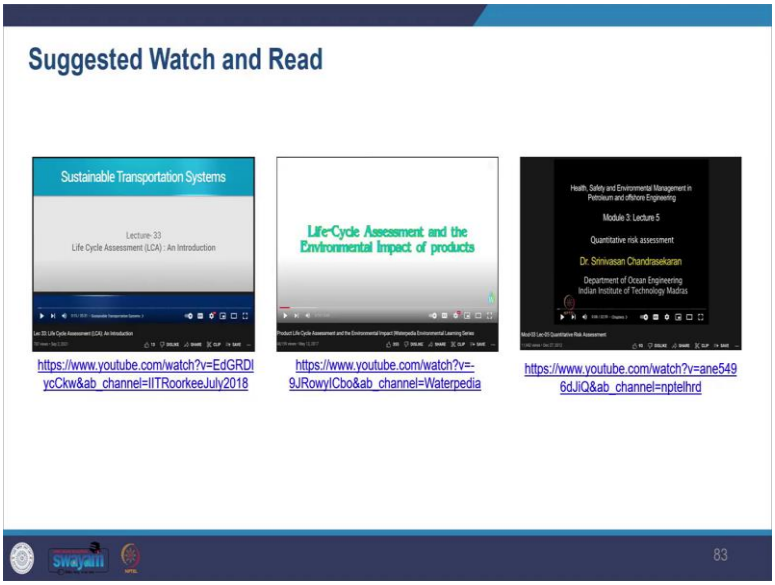

These are the suggested watch and read. I am winding up. I extend my thanks to you.

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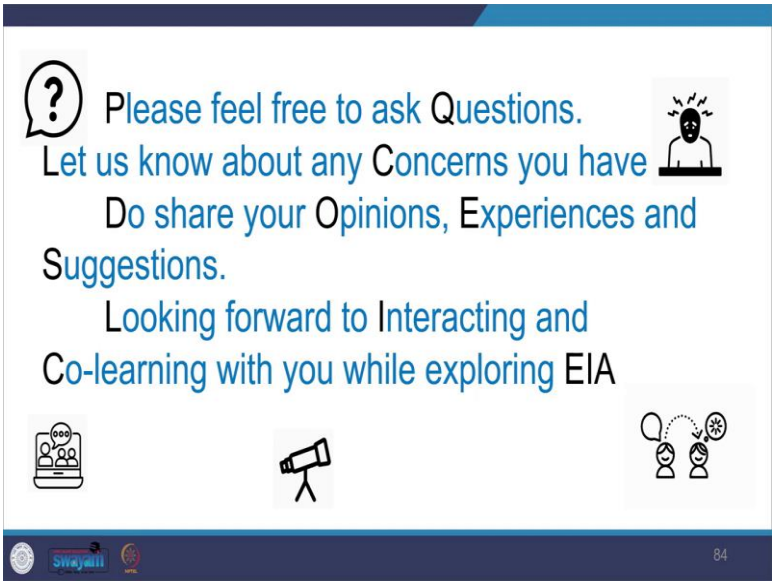

Please feel free to ask questions. Let us know about any concerns you have. Do share your opinions, experiences, and suggestions. Looking forward to interacting and co-learning with you, while exploring EIA. Thank you.