Course Name: Watershed Hydrology

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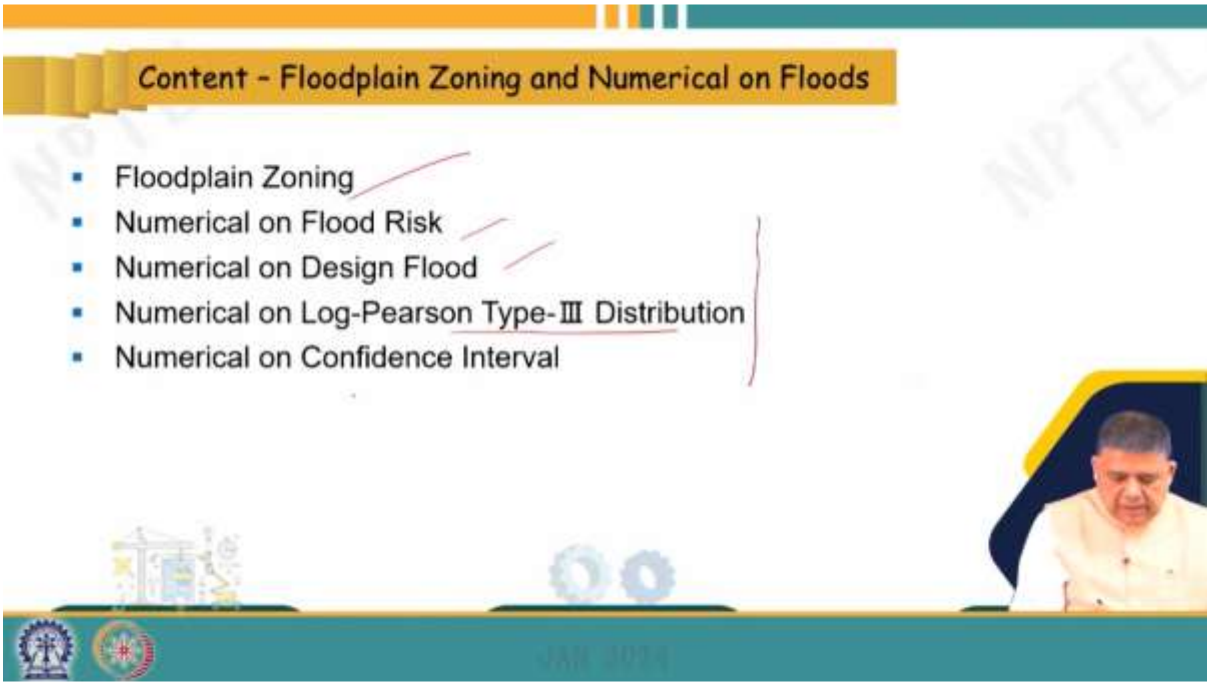
Week: 09

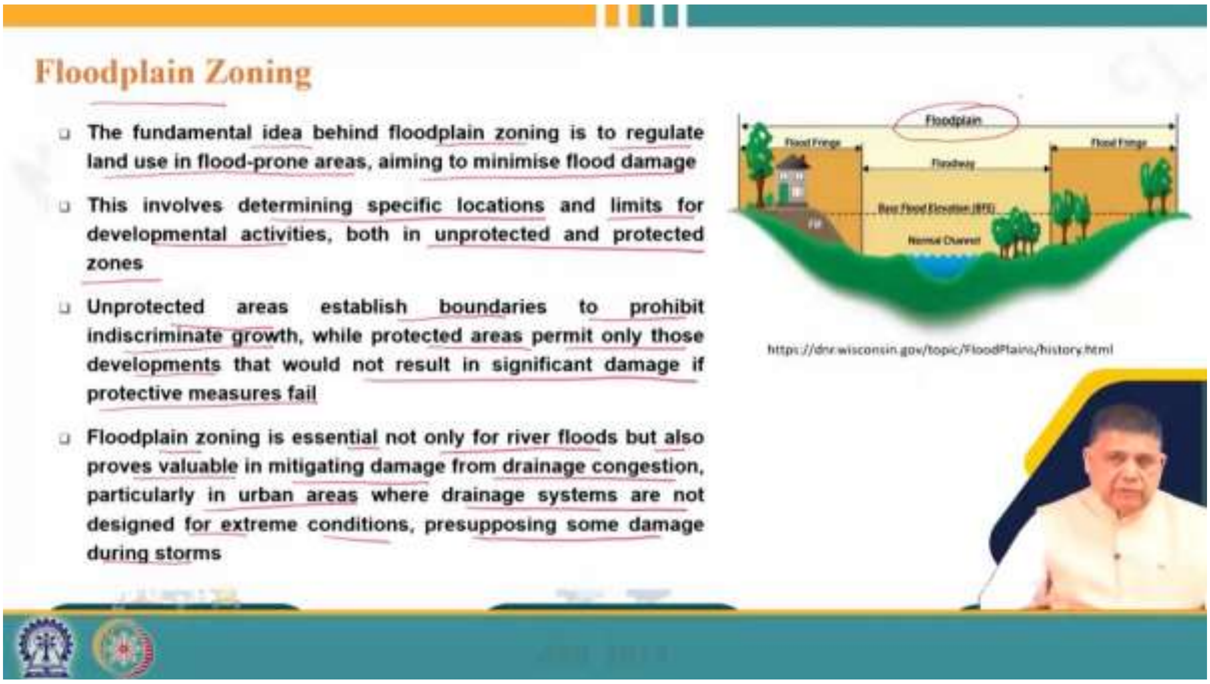
Lecture 45: Floodplain Zoning and Numerical on Floods

Hello friends, welcome back to this online certification course on Watershed Hydrology. I am Rajendra Singh, a professor in the Department of Agriculture and Food Engineering at the Indian Institute of Technology Kharagpur. We are in module 9, and this is the last lecture of this module. The topic is Flood Plain Zoning and Numerical on Floods.

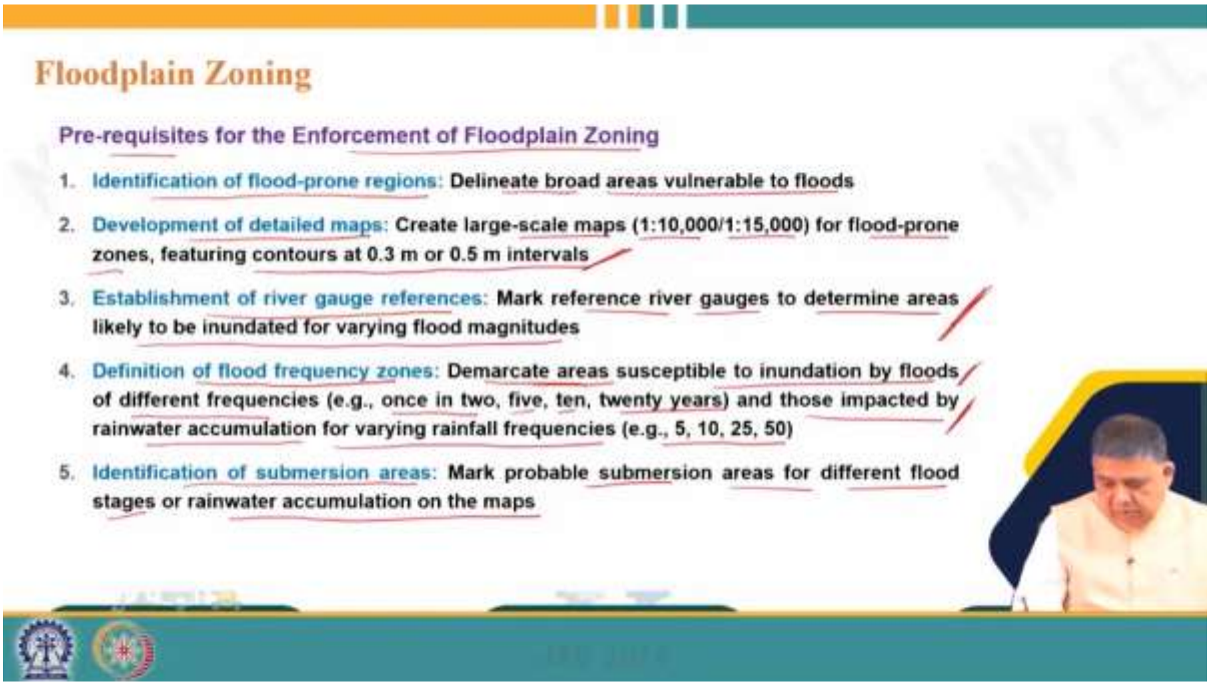
So, basically, as far as continuity goes, we will have two components. In the first part, we will talk about flood plain zoning, and then we will take up numerical on flood risk, design flood, flood distribution, and also confidence limits or intervals.



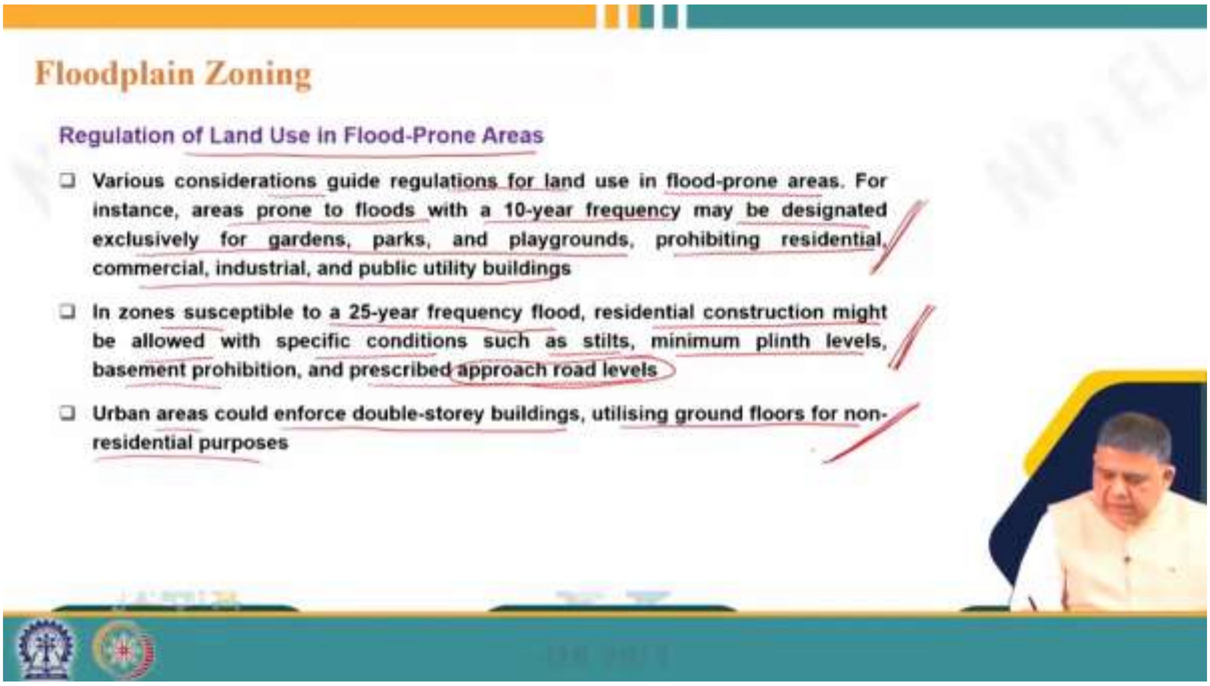
Now, beginning with flood plain zoning, we have already introduced flood plain zoning. The fundamental idea behind flood plain zoning is to regulate land use in flood-prone areas aiming to minimize flood damage. So, we say that adjoining areas beside the river stream. If this is a river, then certain areas beside the river are identified as floodplains. That means, they are likely to face floods frequently. Basically, when we say flood plain zoning, we wish to minimize flood damage in these areas. This involves determining specific locations and limits for development activities in both the unprotected and protected zones. So, there could be protected and unprotected zones in these flood plains. Obviously, our aim is to determine specific locations and limits for development activities so that flood damages are minimized. Unprotected areas establish boundaries to prohibit indiscriminate growth, while protected areas permit only those developments that would not result in significant damage if protective measures fail. Obviously, there are different approaches adopted for protected and unprotected areas. Flood plain zoning is essential not only for river floods but also proves valuable in mitigating damage from drainage conditions, particularly in urban areas where drainage systems are not designed for extreme conditions presupposing some damage during a storm. So, even in the case of heavy storms, there is likely to be high flooding. If flood plain zones are identified and activities are controlled in those areas, then obviously, not only floods but also heavy storms, especially during monsoon seasons, can be safeguarded.



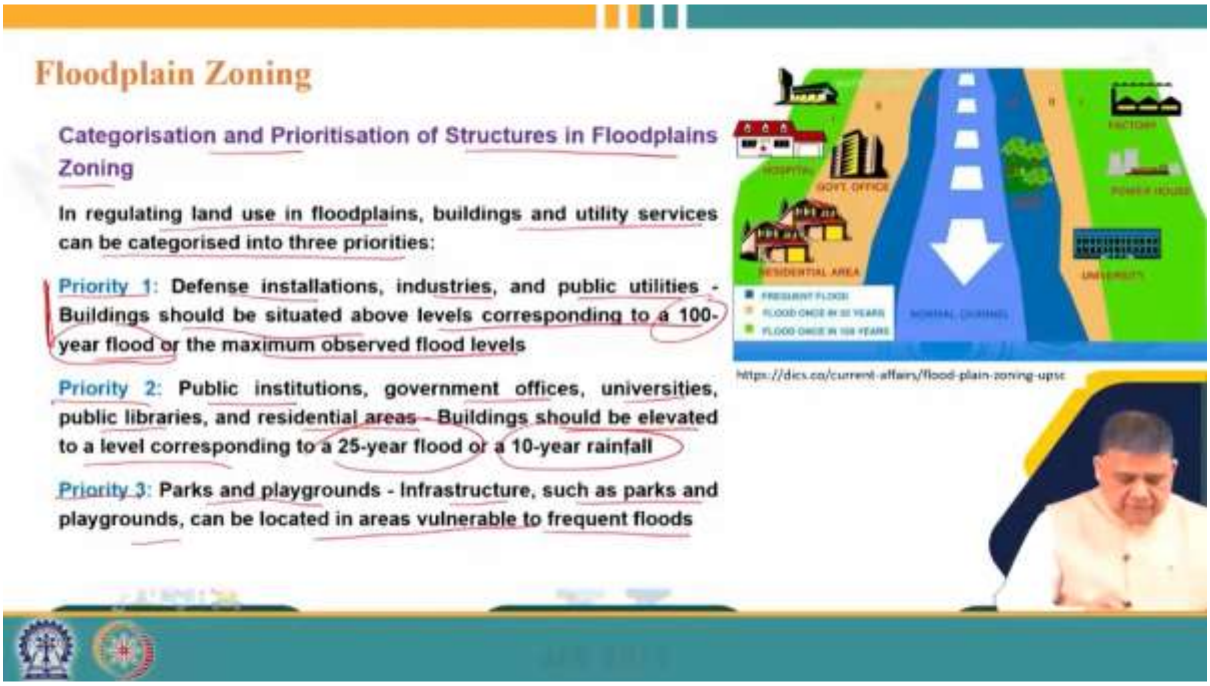
Now, there are certain prerequisites for the enforcement of flood plain zoning. The first one is the identification of flood-prone regions. So obviously, we need to delineate broad areas vulnerable to floods around streams. Then we have to develop detailed maps, such as large-scale maps or high-resolution maps, at a scale of 1:10,000 or 1:15,000 for flood-prone zones, featuring contours at 0.3 meters or 0.5 meters. That means very dense contours should be developed for such areas. Then establishment of river gauge references, mark references river gauges to determine areas likely to be inundated for varying flood magnitudes. Obviously, based on historical records, you will decide the reference Gauges, that is, these are the levels, and then accordingly the areas will be identified. Then definition of flood frequency zones, demarcate area susceptible to inundation by floods of different frequencies, say for example, once in 2 years, 5, 10, 20 years. So obviously, and those impacted by rainwater accumulation for varying rainfall frequencies, say 5, 10, 25, and 50. So obviously, both flood as well as rainfall data has to be analysed, and at different frequencies, we have to find out what is the likely likelihood of the area that will be inundated, and then accordingly those areas have to be demarcated. Then identification of submergent areas, mark problem submergent areas for different flood stages or rainwater accumulation on that map. So of course, more susceptible areas have to be also marked.



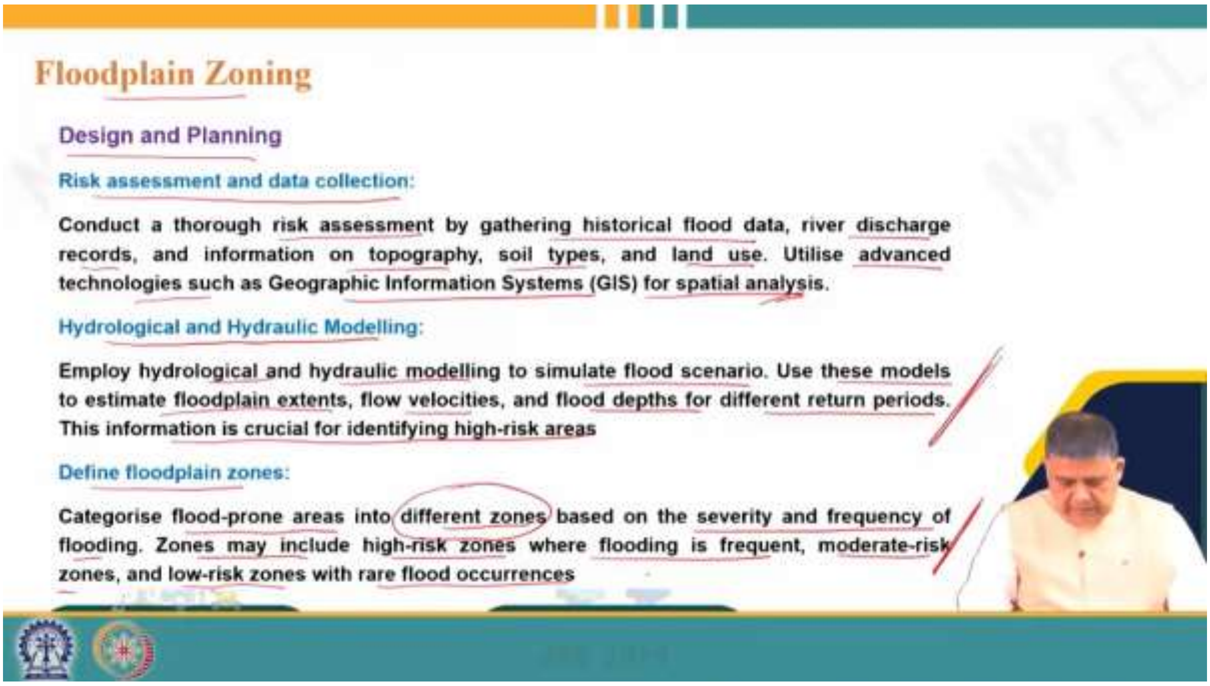
Then regulation of land use in flood-prone areas. So, various considerations guide regulations for land use in flood-prone areas. So of course, we say that both protected and unprotected areas we have certain specific land uses and that has to be regulated. For instance, areas prone to floods with a 10-year frequency may be designated exclusively for garden, parks, and playgrounds, private things, residential, commercial, industrial, and public utility buildings. So obviously, if a flood frequency of 10 years return period is there then that should not be used for any kind of residential activity or any commercial activity. Then in zone susceptible to a 24, 25-year frequency flood residential construction might be allowed with specific conditions such as stills, minimum plinth levels, basement prohibition, and prescribed approach load levels. So obviously, you would like that the minimum level at which properties and human lives are there has to have a certain level which will be above the expected floodwater. And of course, there has to have an approach road. So, in case of an emergency, people and property could be moved away quickly from those places. Urban areas could enforce double-storey buildings utilizing ground floors for non-regional purposes. This is also possible that you do not allow any residential activity on the ground floor and only first floor onwards people stay in urban areas.



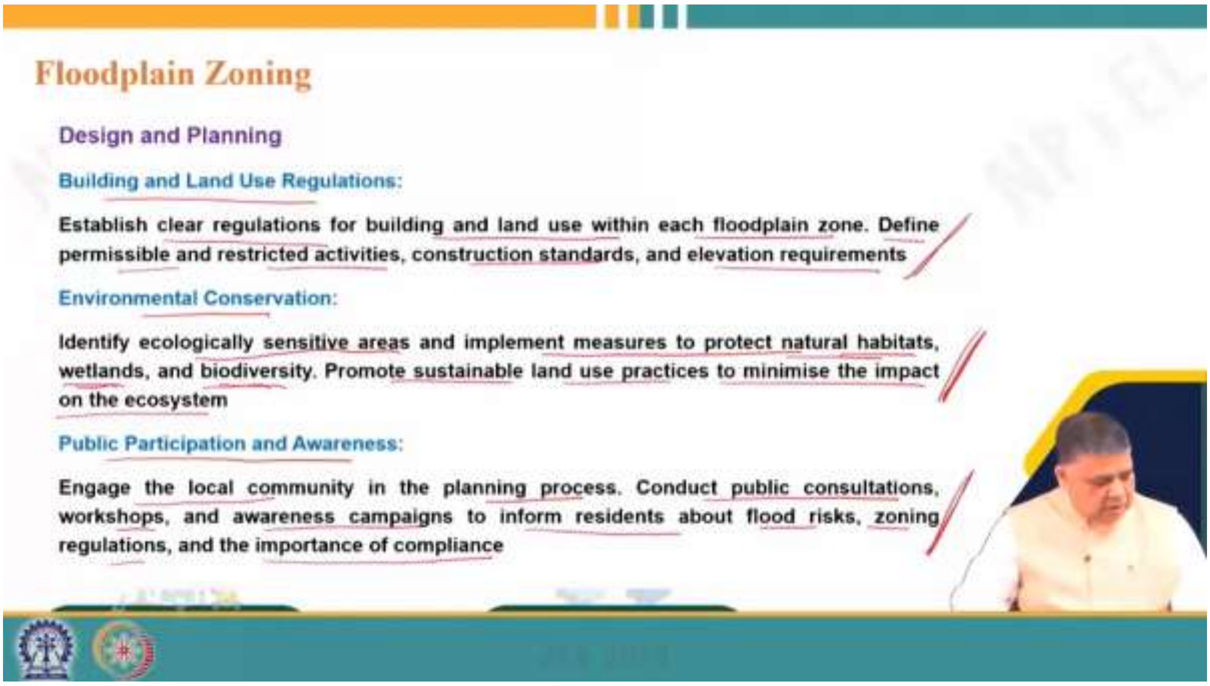
Then categorization and prioritization of structures in flood plain zoning in regulating land use in flood plains building and utility services can be categorized into 3 priorities, priority 1, priority 2, and priority 3. Priority 1 is defined installations industries and public utilities. So, buildings should be situated above levels corresponding to 100-year flood or maximum observed flood level. So obviously, all those sensitive installations have to have a high flood frequency um consideration. Then priority 2 will have public institutions, government offices, universities, public libraries, and regional areas should be elevated to a level corresponding to 25-year flood or a 10-year rainfall. So, it means these should be protected against a 25-year flood or 10-year rainfall. And priority 3 that is parks and playgrounds, in spread structures such as parks and playground can be located relevant to frequent floods. So, because they are typically people do not live in parks and playgrounds. So, even lower frequency floods can be considered for these areas.



Then for flood plain zoning, we have to have design and planning, and then of course, there are certain steps that we have to take for risk assessment and data collection. So, conduct a thorough risk assessment by gathering historical flood data, river discharge scores, and information on topography, soil type, and land use. Utilize advanced technology such as GIS for spatial analysis. So obviously, you have to collect data on all possible aspects, and then you can, of course, use remote sensing technology for gathering the data, and then, of course, one should utilize GIS for spatial analysis. So that you know exactly where what is located. Then we can adopt hydrological and hydraulic modelling. Employ hydrologic and hydraulic modelling to simulate flood scenarios. Use these models to estimate flood plain extents, flood flow velocity, and flow depth for different return periods, and this information is crucial for identifying high-risk areas. So, based on these model results, one can decide the priority 1, priority 2, and priority 3 areas which we discussed just now. Then we can define flood plain zones, categorized flood-prone areas into different zones based on severity and frequency of flooding. Zones may include high-risk zones where flooding is frequent, moderate-risk zones, and low-risk zones with rare flood occurrences. So obviously, within the flood-prone area itself, we can have different zones identified depending upon the likelihood of flood or the frequency of the flood. So obviously, high-risk zones, where flooding is frequent, and low-risk zones, where the floods are rare. So, these areas can be identified.

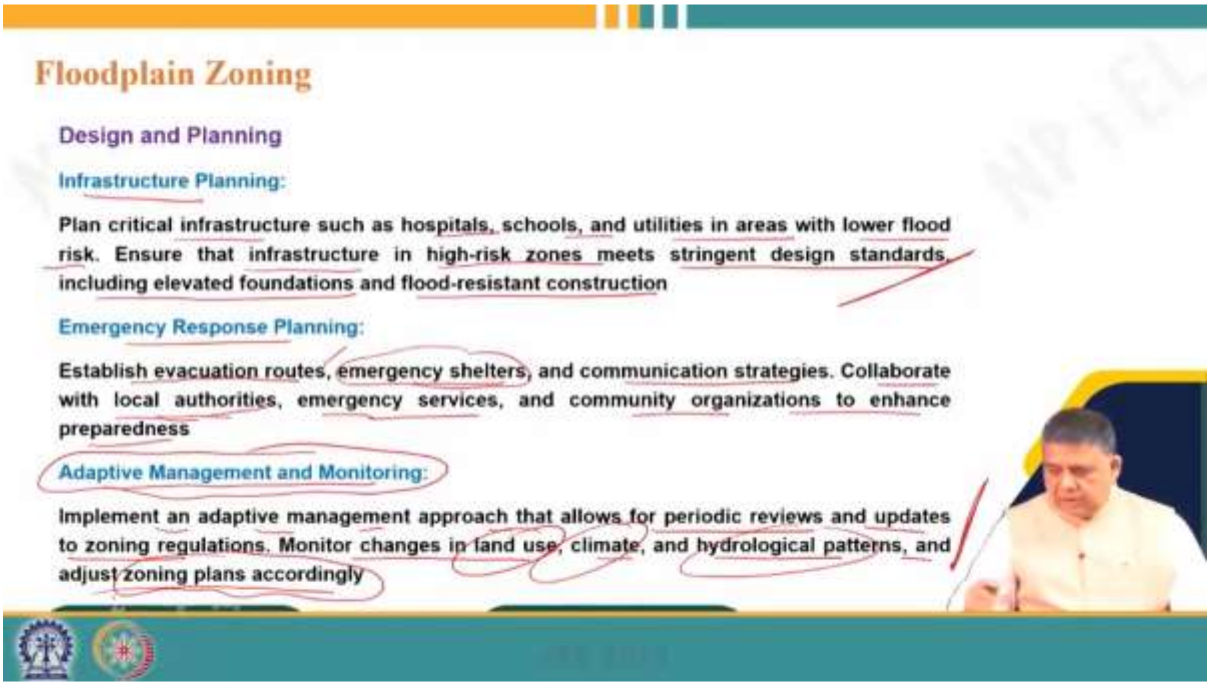


Then we can have building and land use regulations like establish clear regulations for building and land use within each flood zone, define permissible and restricted activities, construction standards, and elevation requirements. Just now we discussed that different priority areas have to be assigned, and then only typical areas have to be assigned for different priority levels. So, that is what basically it means in building and land regulations. Then environmental conservation identifies ecologically sensitive areas and implements measures to protect natural habitats, wetlands, and biodiversity, promotes sustainable land use practices to minimize the impact on the ecosystem. So, while making all these plans, we do not focus only on human beings, but we have to also take care of the natural habitats of various other birds and animals and wetlands, and of course, the biodiversity of the area has to be protected. Then public participation and awareness are very important things that is engaged up local community in the planning process, conduct public consultations, workshops, and awareness campaigns to inform residents about flood risk zoning regulations and the importance of compliance. So basically, you have to include people, involve people in various stages of planning and organizing. So, that they are well aware of regulations, they are well aware of the dangers, and then they are ready to face any untoward incidences.

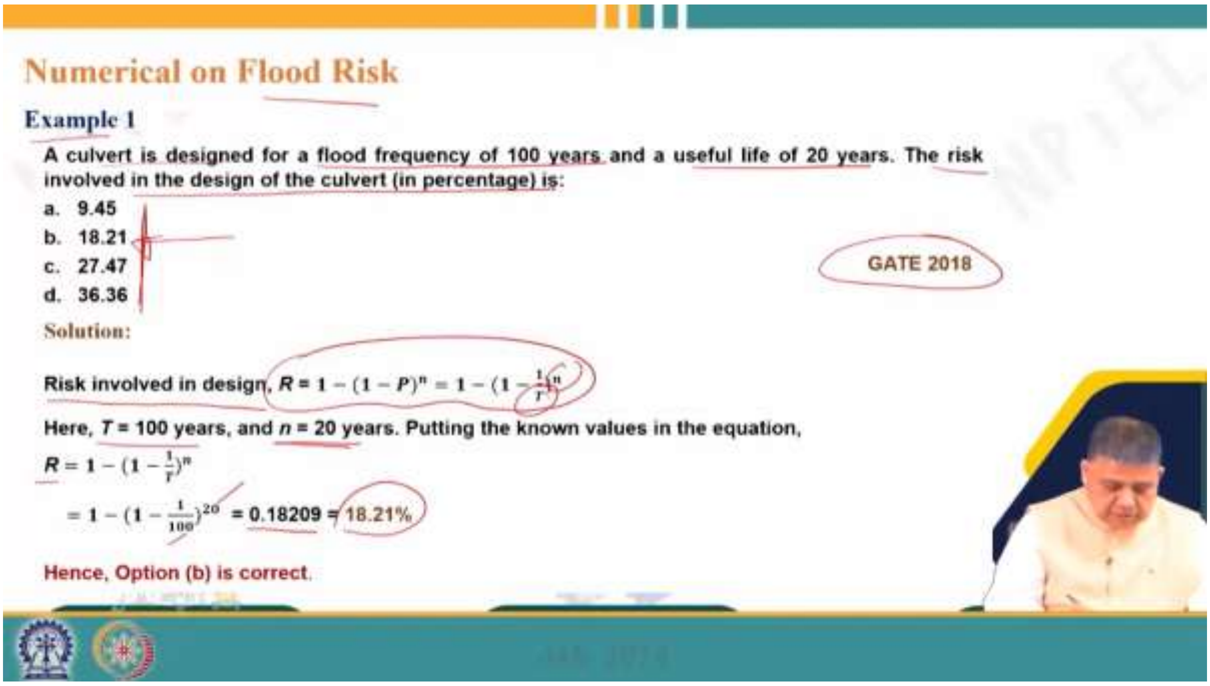


Then we have to have infrastructure planning like plan critical infrastructure such as hospitals, schools, and utilities in areas with lower flood risk. Ensure the infrastructure in high-risk zones meets stringent design standards including elevated foundation and flood resistance constraints. So obviously, all these things have to be considered. Then of course, we have to have emergency response planning, we have to do and that means, establish evacuation routes, emergency shelters, communication strategies, collaborate with local authorities, emergency services, and community organizations to enhance preparedness. Of course, if certain areas, as we discussed also in the previous lecture, are likely to have floods quite often or almost on a yearly basis, then you have to have evacuation and management plans in place and of course, you have to have emergency shelter. So that people can be quickly taken or people and valuables could be quickly taken from the problem areas to these shelters and of course, you have to have communication strategies and of course, local authorities have to play a major role besides, we saw that there are certain things like the NDMA there which are funded by the central government and they could also help provide the emergency services. Then of course, you have to have adaptive management and monitoring. Management and adaptive management approach that allows for periodic review and updates to zoning regulations, monitor changes in land use, climate, and hydrological patterns, and adjust zoning plans accordingly. So obviously, in today's time when we are facing climate change and of course, there is frequent land use change because of the overgrowth of urban areas. So, obviously, we have to our whatever plans we develop or monitoring we do that has to be adaptive in nature that means, we have to have a quick review system in place and then we have to quickly review and correction also possibility. So that you can, in the case of any land use change or any climate change or change in the hydrological pattern, we can adjust our zoning plans accordingly. So, with this, we come to the end of the first part of the lecture we have discussed and get the detail about the flood plain zoning one of the non-structural measures of flood management and then we will

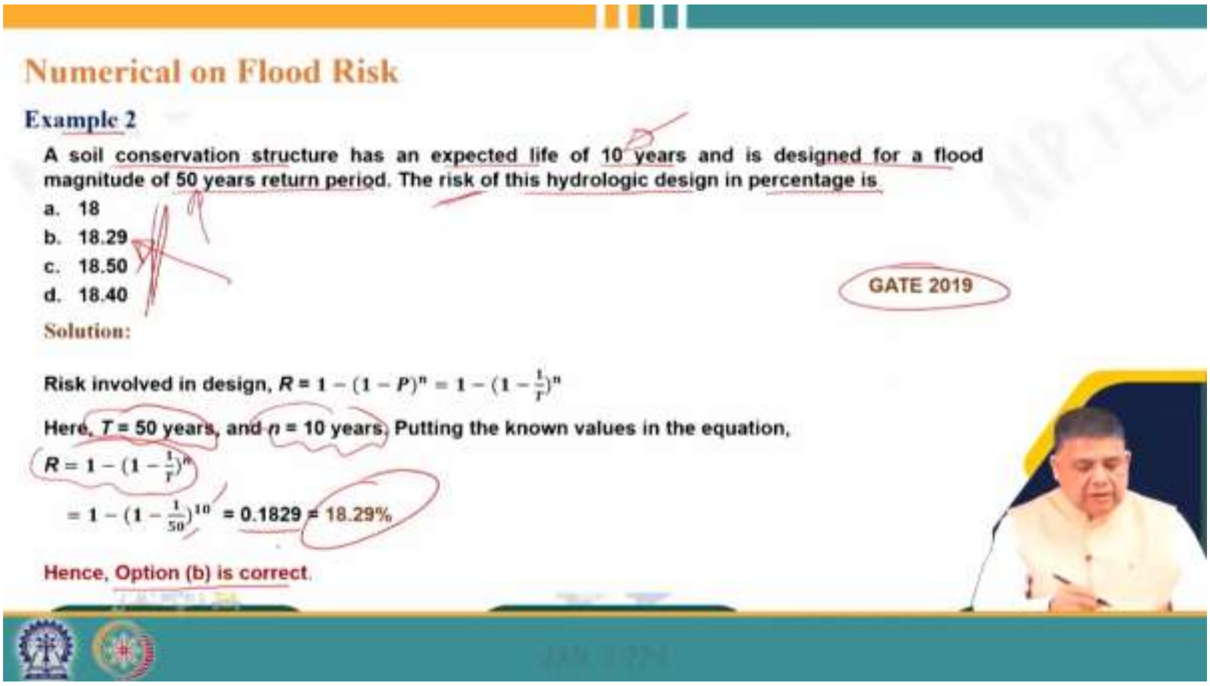
move to as I mentioned earlier that we will take up numerical on various aspects of the flood which we discussed in the previous lectures.



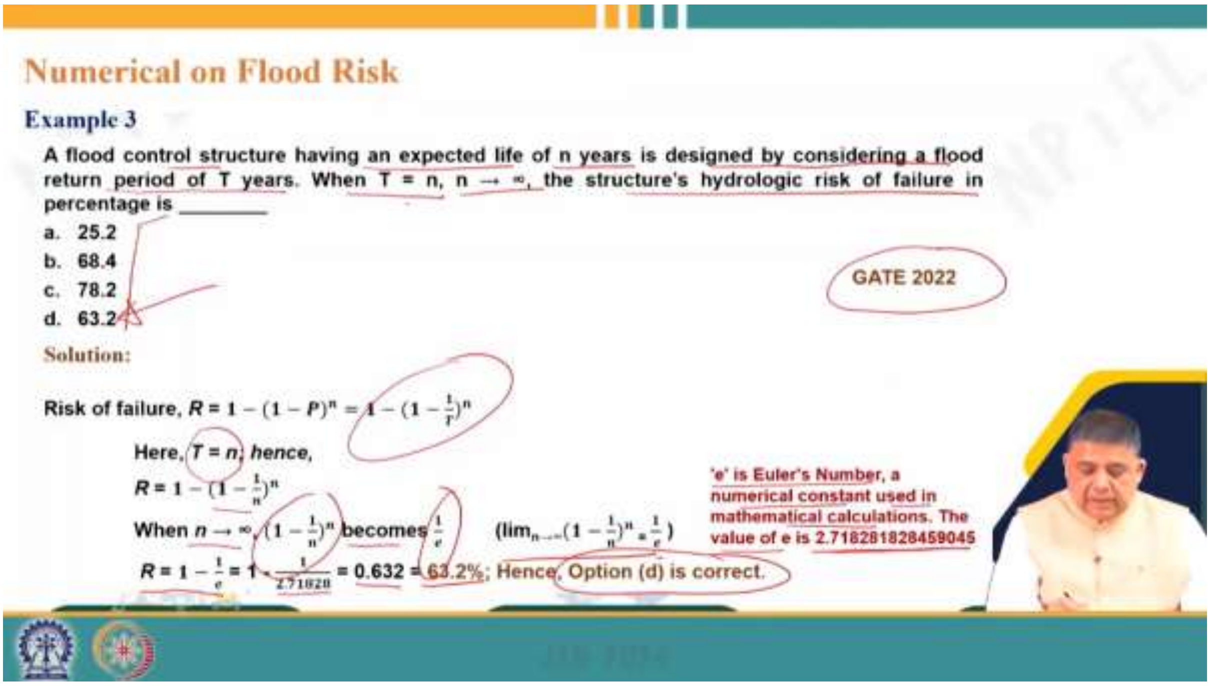
So let us take a certain numerical on flood risk to start with. So, this is example 1 a culvert is designed for a flood frequency of 100 years and a useful life of 20 years. The risk involved in the design of the culvert in percentage is we have it is a multiple-choice question we have 4 options given and this question has been taken from gate 2018 examination. So obviously, for given data we have to calculate risk and we know that we discussed in an earlier lecture that risk involved in the design is given by this relationship that is R or $\bar{R}$ both terms we use. So, it is $(1-P)^n$or 1-$(1-\frac{1}{T})^n$where T is the recurrence interval and n is the Useful life of the planned structure. So, in this particular problem, the recurrence interval or return period is given as 100 years and the useful life of the structure is given as 20 years. So, the 2 unknowns T and n are known to us. So, putting these values in the equation, that is R = 1-$(1-\frac{1}{T})^n$. So, T equals to 100 and n equals to 20, we get 0.1829 or 18.21 % and there is an option B which corresponds to this. So, option B is the correct answer to this particular question.



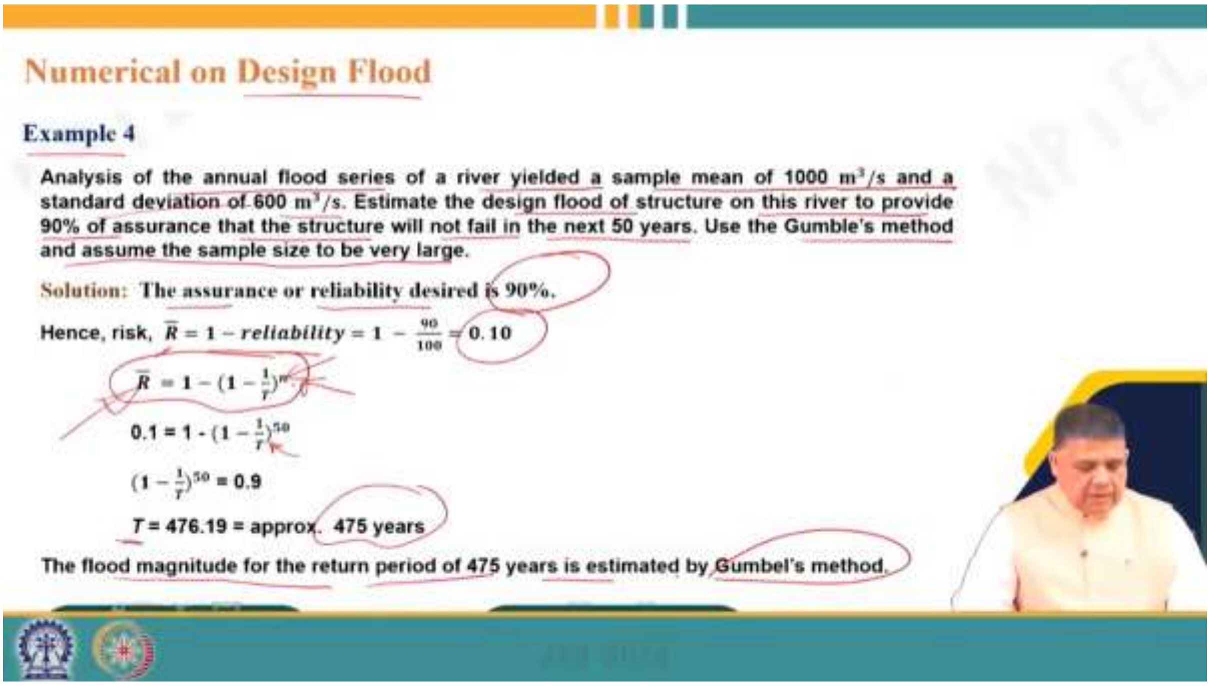
Then we take an example 2 which has been taken from gate 2019 examination. A soil conservation structure has an expected life of 10 years and is designed for a flood magnitude of 50 years return period. The risk of this hydrological design percentage is------(a)18, (b)18.29, (c)18.50, (d)18.40 again, it is a multiple-choice question. We have been given 4 answers and as we know already from the previous problem also, we have to calculate risk and the desired unknowns that are return period and the expected life of the structure is already mentioned. So, here T is given as 50 years, n is given as 10 years and we know the formula R = 1-$(1 - \frac{1}{T})^n$. So, putting T equals to 50, n equals to 10, we calculate the value as 0.1829 or 18.29 % and that matches option B here. So, option B is the correct answer for this particular question.



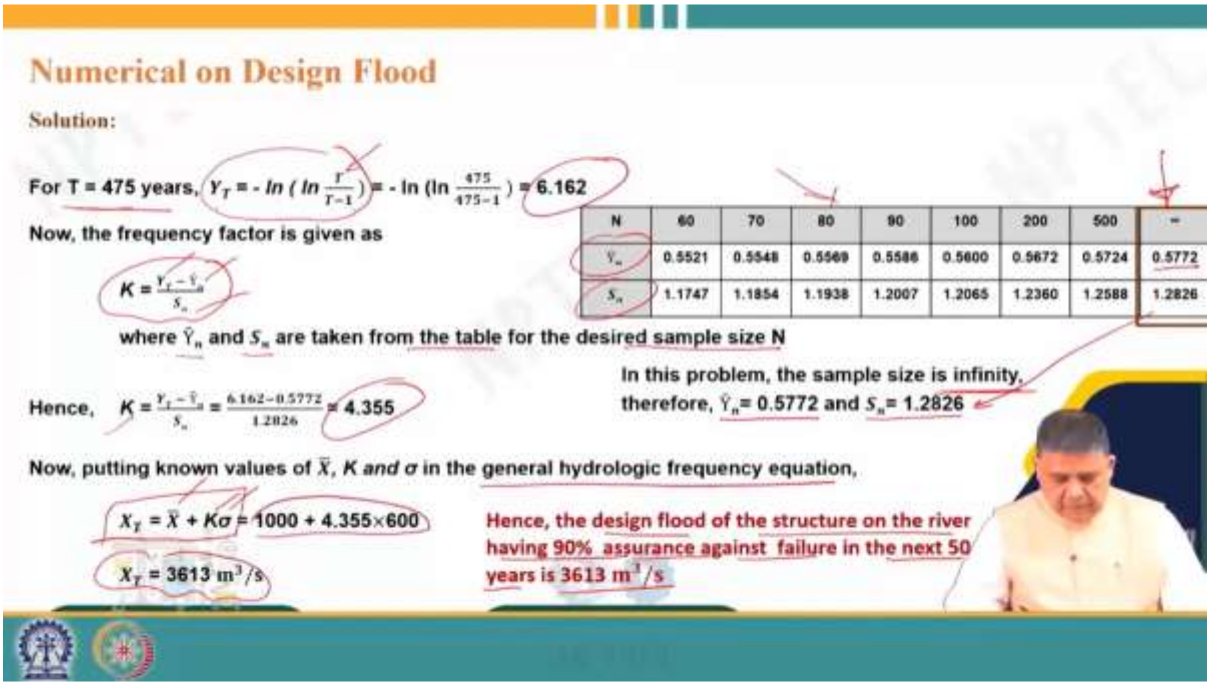
So, we move to the next one, that is a flood control structure having an expected life of n years is designed by considering a flood return period of T years. When T = n where n →∝, the structure's hydrological risk of failure in percentage is ------(a)25.2, (b)68.4, (c)78.2, (d)63.2 a multiple-choice question where four options are given and this question has been taken from gate 2022 examination. So, of course, the formulation remains the same, but here the only issue is that we are talking in terms of T and n and T is where we have to use n in infinity. So, in this formulation, T equals to n is given and n infinity is given. So, when n→ ∞, 1 by this part that is 1-$(1-\frac{1}{T})^n$ or it converts to 1-$(1-\frac{1}{n})^n$ that becomes 1/e and that is the formulation here limit n→ ∞, 1-$(1-\frac{1}{n})^n$is 1/e where e is the Euler's number, a numerical constant used in mathematical calculations and the value of E is 2.71828. I am having this long value, but 2.718 let us say e is equal to 2.718. So, that means, we have to use that value in this case. So, R =1-$\frac{1}{e}$ or 1-$\frac{1}{2.71828}$or it comes out to be 0.632 or 63.2 % and that matches option D here. So, option D is the correct answer to this particular question. So, this is a trick where T equals to n and n→ ∞. So, we have to remember that we have to use the Euler's number in this case, which value is 2.7182.



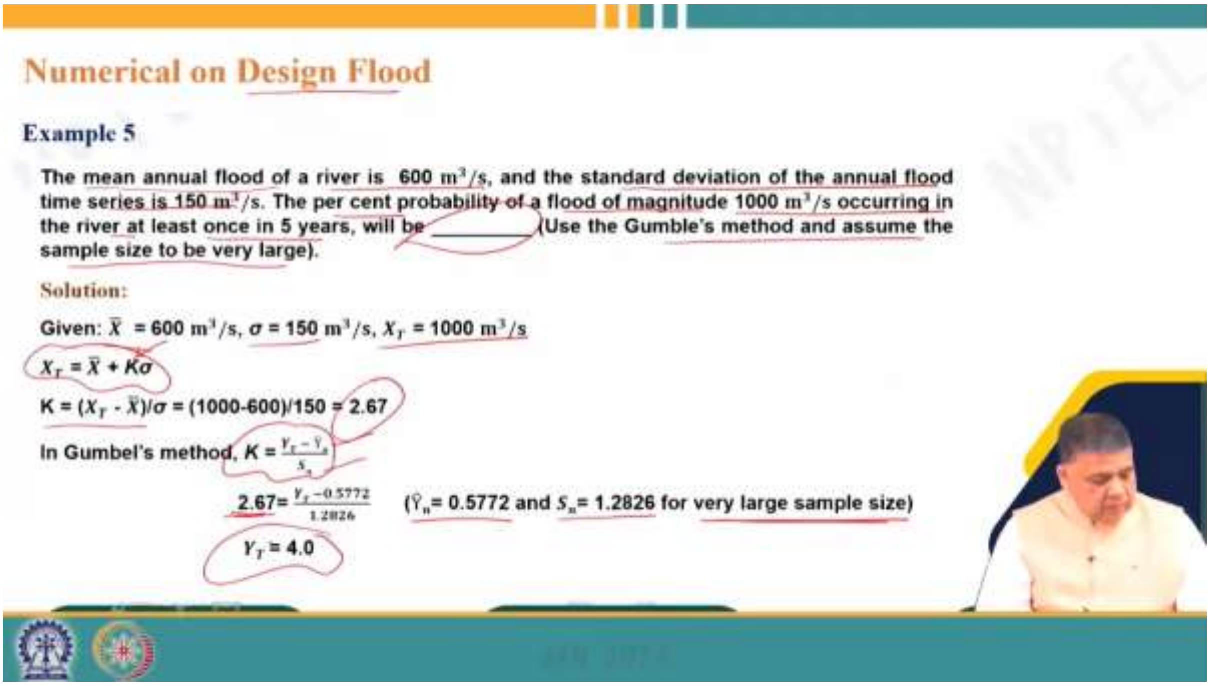
Then we go to example 4, which is a numerical on design flood. Analysis of the annual flood series of a river yielded a sample mean of 1000 cubic meters per second and a standard deviation of 600 cubic meters per second. We made the design flood of a structure on this river to provide 90 % assurance that the structure will not fail in the next 50 years. Use Gumbel's method and assume the sample size to be very large. So, assurance or reliability desired is 90 percent, and we know that the risk is 1 minus reliability. So, 1-$\frac{90}{100}$, that is 10 % risk or 0.1 is the risk, and just now we saw the formula I said that R or $\bar{R}$ that is a risk is 1-$(1-\frac{1}{T})^n$. So, obviously, here we have been given the value of R, and we have to calculate n is also known that is 50 years life is given. So, what is unknown is T. So, by putting these values, we can calculate the value of T, which comes out to be 476.19 or let us say for simplicity 475 years. So, that simply means that we have to get the flood magnitude of the return period of 475 years through using Gumbel's method, and Gumbel's method already we have solved a few examples earlier while discussing the topic.



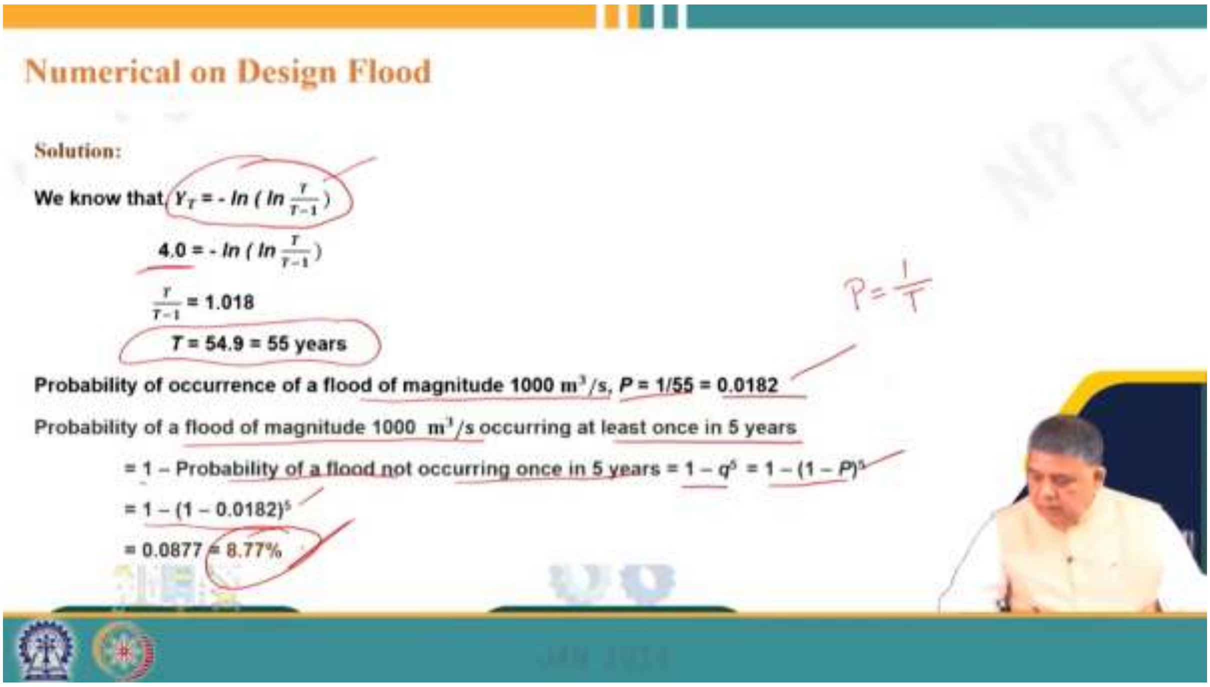
So, for T equals to 475 years, we know that Gumbel's method the variate Y_T=ln(ln$\frac{T}{T-1}$) that it is a function of return period that is which is 470 years 75 years in this case. So, lnY_T comes out to be 6.162, and also, we know that for Gumbel's method frequency factor is given by this relationship K=$\frac{Y_{T-}\widehat{Y_n}}{S_n}$ where Y bar Y Y n bar and S n bar are taken from the table for desired sample size of n and in our problem the sample size infinity. So, obviously, we have to use the table and here in this table we have been given Y n bar and S n for n equals to infinity also. So, that means, our Y n bar becomes 0.5772 and S n becomes 1.2826 that is from here we take the value. So, that means, now we know Y T we knew Y n bar and S n. So, we can calculate the value of K, and the value comes out to be 4.355. Now we can use the general hydrologic frequency equation. So,$X_T = \bar{\bar{X}} + K\sigma$. So, X bar and sigma are already given the problem statement K value we have already estimated. So, putting these values we get X_T = 3613 cubic meters. Hence the design flood of the structure on the river having 90 percent insurance against failure in the next 50 years is 3613 cubic meters per second that is the answer to this particular question.



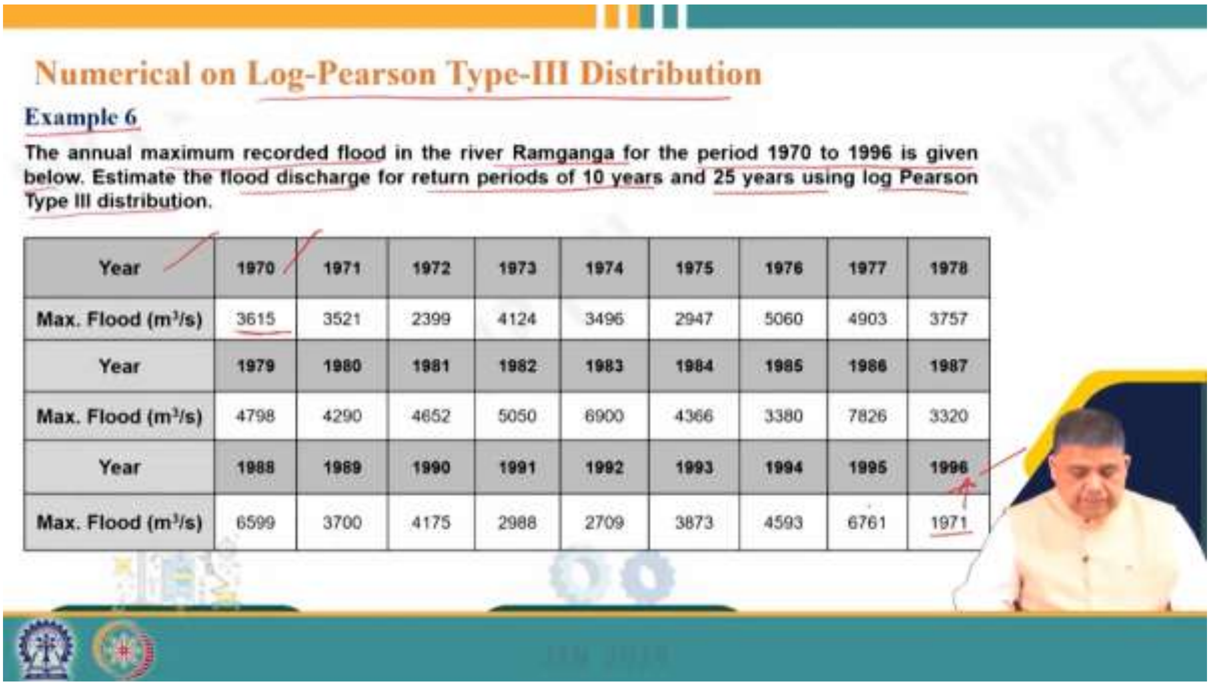
Then we go to example number 5 and this is again a problem on design flood that is the mean annual flood of a river is 600 cubic meters per second and the standard deviation of the annual floods time series is 150 cubic meters per second. The percent probability of flood of magnitude 1000 cubic meters per second occurring in the river at least once in 5 years will be and that is where the fill in the blanks we have to do. So, we use Gumbel's method and assume the sample size to be very large. So, here$\bar{\bar{X}}$ is given σ is givenX_T is given. So, from here from using the general hydrologic frequency equation we can find out the value of K. So, from here we get K equals to 2.67 and we know that K is given by K=$\frac{Y_{T-}\widehat{Y_n}}{S_n}$. So, K value is known and we know that very large sample size in the previous case we saw from for infinity the values of Y N bar is 5 7 7 2 and S N is 1.2826. So, putting the values of K, Y N bar, and S N in this equation which are known, we can calculate Y T which comes out to be 4, and we know that Y T, the variate Y T, is calculated for Gumbel's distribution is calculated by this relationship that is Y T related to T.



So, Y T equals to 4. So, from here we can calculate the return period which comes out to be T equals to 54.9 or 55 years. So, the proper probability of occurrence of a flood of magnitude 1000 cubic meters per second is P equals to 1/ 55 is T P we know that P = 1/T. So, it is 0.0182, and probability of flood of magnitude 1000 cubic meters occurring at least once in 5 years, that is 1 in probability of flood not occurring once in 5 years 1 - Q^9 or 1 –$(1-p)^5$ that is N basically 5 years we are looking at. So, it is 1- (1- 0.18) to 0.182 that is the probability we have calculated to the power 5 and it comes out to be 8.77 percent. So, that means, that is what we have to fill here that is it is 1. 8.77 percent probability.



Now, we go to the next problem that is a numerical on log Pearson type 3 distribution and it is example 6. The annual maximum recorded flood in the river Ramganga for a period 1970 to 1996 is given below estimate the flood discharge for return periods of 10 years and 25 years using log Pearson type 3 distribution. So, we have been year 1970 to 1996 we have been given maximum flood value starting from 3615 in 1970 to 1971 in 1996.



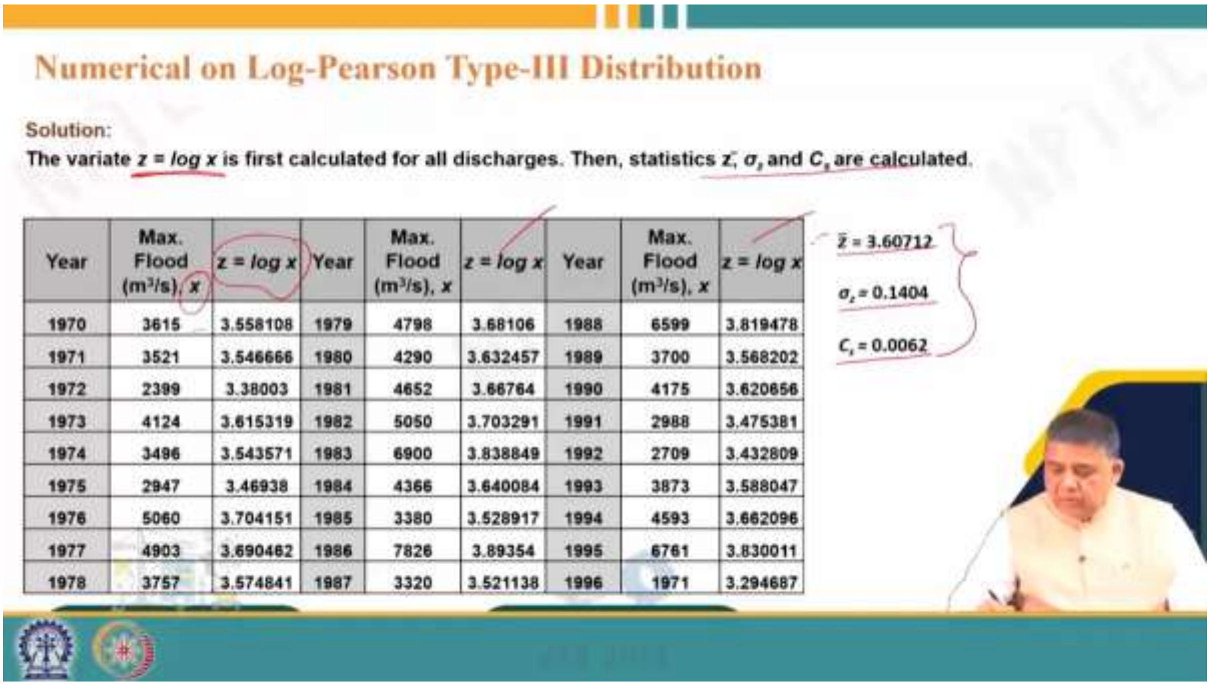
Numerical on Log-Pearson Type-III Distribution

Example 6

The annual maximum recorded flood in the river Ramganga for the period 1970 to 1996 is given below. Estimate the flood discharge for return periods of 10 years and 25 years using log Pearson Type III distribution.

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Max. Flood (m^3/s)	3615	3521	2399	4124	3496	2947	5060	4903	3757
Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
Max. Flood (m^3/s)	4798	4290	4652	5050	6900	4366	3380	7826	3320
Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Max. Flood (m^3/s)	6599	3700	4175	2988	2709	3873	4593	6761	1971

Now, we know that for log Pearson type 3 the variate we use that is we log transform the variate. So, we of course, we have to first log transform all the values and then we have to calculate the statistic Z bar sigma Z N C S. So, of course, first thing we have to do is that this is the x value and Z we have to calculate Z equals to log x. So, corresponding Z values. So, for all x Z values first thing we have to calculate and then once we have the Z series with us then we can calculate Z bar which comes out with 3. 60712 sigma Z is 0.1404 and C S is 0.0062. So, that way once we have the data series, we can calculate all these values the formula we already know or you can if you are using Excel, they can straight away calculate all these values.



Numerical on Log-Pearson Type-III Distribution

Solution:

The variate $z = log\ x$ is first calculated for all discharges. Then, statistics $\bar{z}$, σ_z and C_s are calculated.

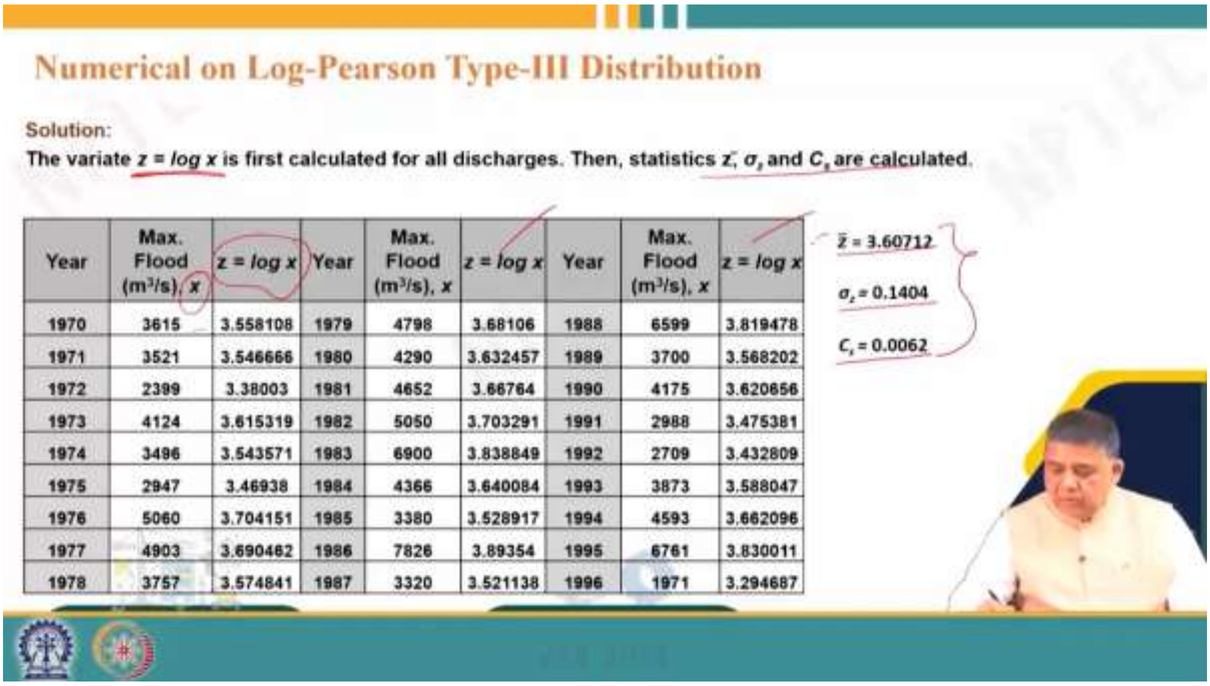
Year	Max. Flood (m^3/s), x	$z = log\ x$	Year	Max. Flood (m^3/s), x	$z = log\ x$	Year	Max. Flood (m^3/s), x	$z = log\ x$
1970	3615	3.558108	1979	4798	3.68106	1988	6599	3.819478
1971	3521	3.546666	1980	4290	3.632457	1989	3700	3.568202
1972	2399	3.38003	1981	4652	3.66764	1990	4175	3.620656
1973	4124	3.615319	1982	5050	3.703291	1991	2988	3.475381
1974	3496	3.543571	1983	6900	3.838849	1992	2709	3.432809
1975	2947	3.46938	1984	4366	3.640084	1993	3873	3.588047
1976	5060	3.704151	1985	3380	3.528917	1994	4593	3.662096
1977	4903	3.690462	1986	7826	3.89354	1995	6761	3.830011
1978	3757	3.574841	1987	3320	3.521138	1996	1971	3.294687

$\bar{z} = 3.60712$

$\sigma_z = 0.1404$

$C_s = 0.0062$

And then once the value of k z for given t and c z are calculated using the log Pearson type distribution table that is what we need basically. And we discussed earlier that we have a standard table the kt value for positive skew and for negative skew both and for us C S is given as 0.0062. So, this is the Cs column and t of course, we have to calculate t to t in 25. So, these are the k values for different return periods and so obviously, we have to look for 10 years and our value 0.0062 so that means, we are here and our focus is somewhere here. So, these are the two. So, for 10 years we have to of course, interpolate our value has to be between 1.282 to 1.292. So, from here we get K equals to 2.67 and we know that K is given by Y T minus Y N by S N. So, K value is known and we know that very large sample size in the previous case we saw from for infinity the values of Y N bar is 5 7 7 2 and S N is 1.2826. So, putting the values of K, Y N bar, and S N in this equation which are known, we can calculate Y T which comes out to be 4, and we know that Y T, the variate Y T, is calculated for Gumbel's distribution is calculated by this relationship that is Y T related to T. So, Y T equals to 4. So, from here we can calculate the return period which comes out to be T equals to 54.9 or 55 years. So, the proper probability of occurrence of a flood of magnitude 1000 cubic meters per second is P equals to 1 by 55 is T P we know that P equals to 1 by T. So, it is 0.0182, and probability of flood of magnitude 1000 cubic meters occurring at least once in 5 years, that is 1 in probability of flood not occurring once in 5 years 1 minus Q to the power 9 or 1 minus 1 minus P to the power 5 that is N basically 5 years we are looking at. So, it is 1 minus 0.18 to 0.182 that is the probability we have calculated to the power 5 and it comes out to be 8.77 percent. So, that means, that is what we have to fill here that is it is 1. 8.77 percent probability. Now, we go to the next problem that is a numerical on log Pearson type 3 distribution and it is example 6. The annual maximum recorded flood in the river Ramganga for a period 1970 to 1996 is given below estimate the flood discharge for return periods of 10 years and 25 years using log Pearson type 3 distribution. So, we have been year 1970 to 1996 we have been given maximum flood value starting from 3615 in 1970 to 1971 in 1996. Now, we know that for log Pearson type 3 the variate we use that is we log transform the variate. So, we of course, we have to first log transform all the values and then we have to calculate the statistic Z bar sigma Z N C S. So, of course, first thing we have to do is that this is the x value and Z we have to calculate Z equals to log x. So, corresponding Z values. So, for all x Z values first thing we have to calculate and then once we have the Z series with us then we can calculate Z bar which comes out with 3. 60712 sigma Z is 0.1404 and C S is 0.0062. So, that way once we have the data series, we can calculate all these values the formula we already know or you can if you are using Excel, they can straight away calculate all these values. And then once the value of k z for given t and c z are calculated using the log Pearson type distribution table that is what we need basically. And we discussed earlier that we have a standard table the k t value for positive skew and for negative skew both and for us C S is given as 0.0062. So, this is the C S column and t of course, we have to calculate t to t in 25.



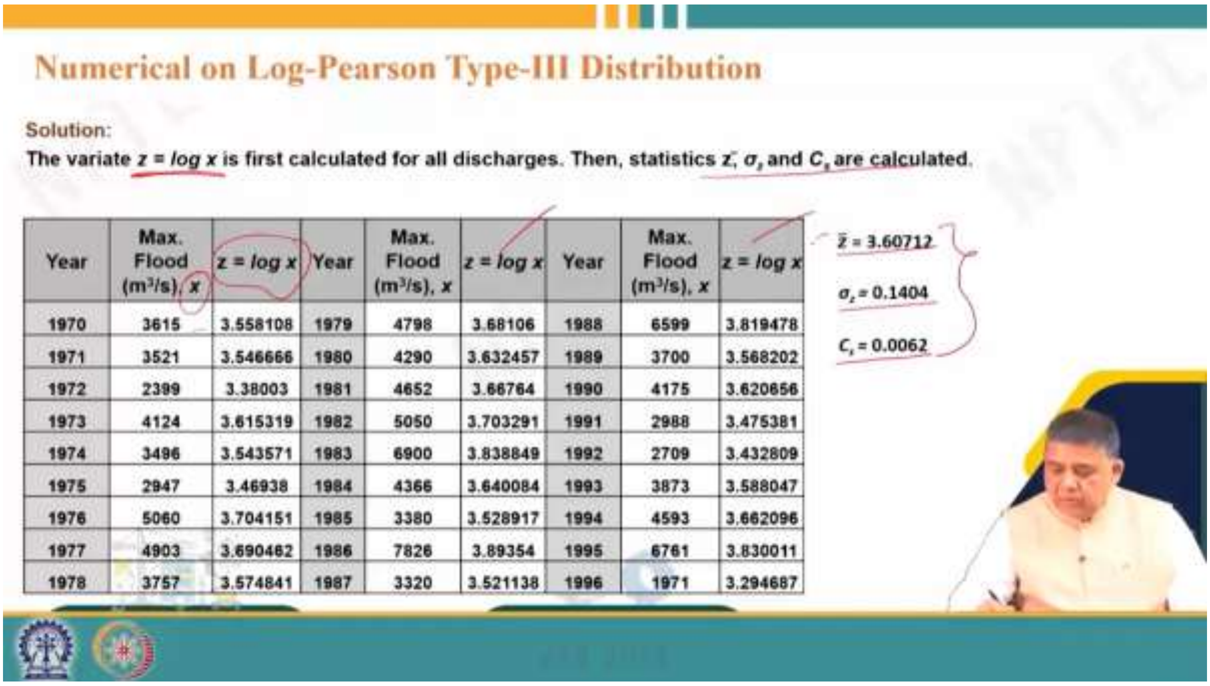
Year	Max. Flood (m³/s), x	z = log x	Year	Max. Flood (m³/s), x	z = log x	Year	Max. Flood (m³/s), x	z = log x
1970	3615	3.558108	1979	4798	3.68106	1988	6599	3.819478
1971	3521	3.546666	1980	4290	3.632457	1989	3700	3.568202
1972	2399	3.38003	1981	4652	3.66764	1990	4175	3.620656
1973	4124	3.615319	1982	5050	3.703291	1991	2988	3.475381
1974	3496	3.543571	1983	6900	3.838849	1992	2709	3.432809
1975	2947	3.46938	1984	4366	3.640084	1993	3873	3.588047
1976	5060	3.704151	1985	3380	3.528917	1994	4593	3.662096
1977	4903	3.690462	1986	7826	3.89354	1995	6761	3.830011
1978	3757	3.574841	1987	3320	3.521138	1996	1971	3.294687

So, these are the k values for different return periods and so obviously, we have to look for 10 years and our value 0.0062 so that means, we are here and our focus is somewhere here. So, these are the two. So, for 10 years we have to of course, interpolate our value has to be between 1.282 and 1.292 and we get to 1.30138 ah I think there is something wrong in this interpolation. So, we need to correct that. So, it has to be between 1.282 and 292. So, this value is not correct, but you can always interpret the value and for 25 years here 25 year this value has to be 1 point it has there is some error in both these interpolation values, but I think you know how to interpolate the values between these two.

So, our interpolation values have to be there. So, k z has to come from this table basically. So, now ah for calculating ah t for the different recurrent periods we know that we have to use the hydrological ah general hydrological equation z t z bar k z sigma z and we know z bar we know sigma z where you have obtained the values of k z. So, obviously, z t value ah we can ah find out. So, g t is here and of course, we are interested in the x value the x t value. So, obviously, we have to take the antilog of ah g t and ah our values come out to be 6163.11 for 10 years return period and 7281.15 for 25 years. So, flood discharge for a given return period of 10 years and 25 years is 6163 and 7281 cubic meter per second. Of course, these values will change when you correct ah correct k and recalculate. So, that that is you have to do on your own ah you will get a different number, but procedure remains the same. Now we take ah the last problem that is analysis of a 100-year annual flood series and this problem is on confidence interval. Analysis of 100-year annual flood series ah a of a river yielded a sample size mean of 1500 cubic meter per second and standard deviation of 900 cubic meter per second.

Estimate the 200-year flood of a river using Gumbel's method, estimate the 90 percent confidence interval of the value. So, obviously, ah it is a ah it is a basically 200 year flood ah, but formula remains same that x t equals to x bar k sigma ah that is standard deviation and ah we are using Gumbel's method. So, that means, the k is given by this relationship y t minus y n bar by S n and y t we know that is related to t that is the variety related to t that has to be calculated using this relationship. So, return period t is 200 years. So, y 200 is l n l n ah we have to put 200 points minus 1 that is t t minus 1 and we have to calculate the value of y 200 which comes out to be 5.32. Now our sample size is 100. So, this is the table we have to use for getting the y n bar and S n. So, if our value is 100 so, obviously, we can straight away read from here. So, y n ah bar comes out to be 0.56 and S n comes out to be 1.2065. So, that means, k 200 we can calculate because we know y_{200} we know y n bar we know S n. So, putting the values we get k 200 is 3.945 and putting all these values in this equation x 200 is x bar plus k 100 k ah sigma ah we know x bar and ah sigma are already given and k we have calculated.

So, x_{200} comes out to be 4645 cubic meter per second. So, that is the magnitude of flood ah using ah the Gumbel distribution. Now we have to calculate ah the 94 90 percent confidence interval and for that we know that for ah for given ah probability x 12 is given by x t plus ah plus minus f c S_c where f_c has to be taken from the ah table here which is the probability table. So, we have 90 percent. So, the value of f c can be read from here which comes out to be 1.645. So, from here we read this value and also, we know S c ah S c we need where S c is given by B n. So, sigma and n we already know and we know that B is a function of k. So, k value already we have calculated. So, putting the values of k here we can calculate the value of B which comes out to be 4.82. So, now ah we know B we know sigma we know n.



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So, we can calculate the value of S c. So, S c comes out to be 434 433.8 or 434. So, putting the known values in this equation. So, we know x t we know f c we know S c now. So, x 1 and x 2 2 limits ah the upper limit comes out to be 5359 cubic meter per second, the lower limit comes out to be 3931 cubic meter per second. So, these are the two confidence limits. So, the 200-year flood in the river using Gumbel's method comes out to be 4645 and the 90 percent confidence interval for the predicted value is 3931 and 5359.

So, that is the answer. So, this is our magnitude and these are our lower and upper limits confidence limits that is what we discussed that our value could lie in between anywhere between these two values though we have estimated this is exact number. So, with this we come to the end of this lecture. So, we have we have tackled two different issues in the first part we talked about flood plain zoning different concepts and how to do it and second part we took ah problems numerical on various aspects of flood. So, thank you very much please give your feedback and also ah ask questions if you have any doubts, we shall be happy to answer on the forum.

Thank you very much.