

Clara Spoorenberg: Thank you. Good afternoon. I am going to tell you about vegetation on Dutch levees and practices. As has been made clear several times this morning in the US, a levee is not just a soil structure providing strength to withstand high water stress and a tree is not just a foreign element within a levee. Both levee and tree are considered to be part of a larger system in directing elements on various scales that provide safety against flooding as a whole. Change one thing and you risk complete system changing in order to adapt to the new situation. In the Netherlands, this approach is similar. Trees can be considered as part of the system and I'd like to tell you about vegetation on Dutch levees in this respect. After a small introduction on the location of the Netherlands on this planet and the size of our country and the amount of levees we maintain, I will tell you that according to Dutch national legislation, no trees on levees are permitted. However, trees are not an unusual sight on Dutch levees.

Nevertheless, we claim to meet our required safety levels regardless of the presence of these levee trees. By means of a couple of practical examples, I will explain how we manage this by using either a levee, a tree or a combined approach. Furthermore, I will shortly mention some complimentary properties of trees near or on levees including some Dutch [unintelligible]. For those who are not familiar with [unintelligible] so you will know what we are dealing with. The Netherlands is situated in Western Europe and measures roughly 120,350 kilometers. Two-thirds of the service is up to 7 meters below mean sea level. Our country is threatened by high water level from the North Sea, from large rivers from Germany and Belgium and a couple of big lakes. It is secured against flooding by more than three and a half thousand kilometers of levees, dikes, dams. Some of them are over 1,000 years old. In addition to these primary levees, we maintain 14,000 kilometers of secondary levees along canals, small streams, brooks, creeks and smaller lakes. Only the primary levees are shown on this map. 24 water boards are responsible for the quality and performance of all our water retaining structures.

By law, they are obliged to perform a safety review on the primary levees every five years. The results are reported to our government. Safety reviews contain all but retaining aspects of our levees, including foreign objects [unintelligible]. In the near future, the same review frequency will be compulsory for secondary levees as well. In practice, most water boards have consultants such as myself to perform the review for them. Consequently, as a consultant, you have the benefit of seeing, understanding, reviewing and designing a lot of different systems for a lot of different water boards. Firstly, I'll go into different policies. From a [unintelligible] point of view, Dutch water boards have a various approach regarding their policy toward trees on levees. In practice, we can distinguish between a toleration policy with or without licensing, extinction policy to remove and replant outside the water retaining closed structure and construction measures. Most water boards allowing trees on their levees pay extra attention to their trees during high water.

I'll demonstrate two different policies based on practical examples. Secondly, I'll mention some events resulting in national legislation. In the past, a couple of events have been [unintelligible] related to trees on levees. These events include uprooted trees during their 1995 storm, and stability problems which may be related to the presence of trees. From these events, the Dutch Levee Advisory Board published new national legislation regarding our trees on levees in 2000 and 2001. By brief consideration, I will point out our Dutch policy based on these reports. Finally, I'll include public opinion in the tree discussion. A lot of trees have been removed from levees in the name of safety. Only recently, public opinion has turned against this policy. The Dutch are attached to our trees. They value their natural beauty and I think Americans do not differ from the Dutch in this respect. The water board I live in is called [unintelligible]. This water board looks after 200 kilometers of primary levees. In the last five years safety review, no less than 21,000 trees were assessed only within the influence of these levees. But the removal of 179 trees that did not meet the minimum required vitality, the safety level of

the [unintelligible] levees is guaranteed. Later on in my presentation, I'll come back on the applied tree assessment technique.

One water board down on the other hand, there's hardly a tree to be seen from on any levee. This water board has never tolerated any tree on or near their levee. Maintenance of the strict policy is the keyword to levees free of trees. Such big differences, although we do only have one national legislation regarding our levees. But who is right and in which one would you live? Or are these levees equally safe? As this slide demonstrates, trees may be a burden during a storm, causing damage to the water retaining source that they are part of. But also because of blown branches and damage due to dynamical tree motions during storm conditions, I use this argument for the tree removal policy. Obviously, this is not the first storm that has caused trees to be tipped over on levees. The ability of levees is affected by several aspects such as soil strength properties [unintelligible]. Trees might influence their stability in either a positive or a negative manner. Dependent on the location within the levee profile, the [unintelligible] weight of trees might increase or decrease total stability. If [unintelligible] occurs due to tree motion, this is considered a negative influence. Lowering of the [unintelligible] level on the inland side of the levee might influence stability in a positive way, by the drainage effect or negatively, by the supplement [unintelligible] induced.

This slide shows indications of supplements caused by water withdrawal caused by trees during an extreme dry summer. Whether or not this will cause a stability problem will be found on the local situation regarding [unintelligible] properties. In Dutch levee design, the lists of positive properties of trees are not taken into account. We cannot be certain the tree will be present at the place and the time we need it. Weight can no longer be counted in stability calculations after the trees have been uprooted. And, during winter conditions, no tree induced drainage will occur during high weather conditions. Furthermore, the presence of trees might be random and therefore of limited use in levee design. On one

Dutch levee, seepage was discovered during high water conditions. By the looks of it from the outside, deep tree roots were held responsible for the problem. Once the levee was excavated for investigation, [unintelligible] and burrows were exposed and related to the seepage. One Dutch study points out even decaying roots contribute to the total [unintelligible] of strength and should not be taken out after the tree died for safety reasons. Obviously, this slide shows signs of bank erosion caused by the presence of trees.

This is considered a negative influence on levee safety. Later on, I will mention some study results regarding slow reduction properties of different types of vegetation. As opposed to the ocean picture, trees can be valued for their ability to retain sediment. Apparently, whether or not erosion will occur will depend on local conditions. Trees on levees have long been a discussion issue in the Netherlands. In the first place, there is no argument on [unintelligible] involved. What situation is to be considered the worst case? The situation where the tree is uprooted or the situation where the trees are [unintelligible], but also applying an additional dynamic load to the levee. And how will [unintelligible] either of these situations? We do have some ideas for this. I would exceed my time going into these. As for the decaying tree roots issue, specialists wouldn't agree either. Decaying roots tend to create hollow spaces in the levee including the permeability of root soil [unintelligible]. Small burrowing animals like worms work their way through this leveling of the [unintelligible]. Planting of new trees could reduce the problem by new roots replacing the hollow spaces to form new roots.

I think this slide and the next one will speak for themselves. They show inhabitants pointing out additional functions of trees on levees and demonstrating against the removal of the trees. The value of the presence of a tree to the public can actually be calculated. This is showing a 9 million dollar oak tree that was maintained in the middle of a new highway due to the public influence. I've went through the details of two

practical cases, the last one being rather commonly used in the Netherlands, the first one being a suitable solution for a specific situation. This concerns a special case. The levee had to be improved for safety reasons. The responsible water board planned to take all trees out in order to be able to perform the important work. Action groups demonstrated against this and a judge decided another technique was to be used. Only the necessary trees were to be taken down. A few were cut back. A complete [unintelligible] was installed in order to gain sufficient strength to withstand high water levels and of course to spare the trees. All that I mention is based on the assumption that a tree, including its roots, does not take part in the levee strength. Neither the uprooting nor the dynamic loading situation tree fill will influence the calculated safety level.

All that I mention may include special methods such as [unintelligible]. From a tree's point of view, a lot can be done to improve levee safety with trees. I'll mention an assessment technique and some measures to be taken. A special tree assessment contains tree health condition and tree stability properties. The assessment is performed by a specialist and based on biological characteristics such as crown form, number of branches, length of new branches, etc. The stages of fungus may indicate group mortality. [Unintelligible] of my mechanical defects reaction [unintelligible] may indicate an increasing [unintelligible] risk. It would be [unintelligible] to mention all characteristics used in the assessment technique and you can ask me for more detail if you're interested. If a VTA results in uncertainty about the tree vitality, further investigation is possible. Internal tree degradation can be measured using a [unintelligible] or a penetration measurement. The results will show that the tree is in a critical state regarding the acceptable risk. In addition to cutting down of trees, for levee safety purposes, some tree saving techniques might be applied. Measures include limiting crown dimension in order to reduce the sensitivity to wind, improvements of the growing circumstances for better rooting and therefore, anchoring, or replanting on

a less sensitive location. Cutting back of trees will affect their root system and will reduce wind loads.

The previously mentioned negative influence on some trees on levees, a couple of positive properties can be measured. Trees outline the landscape. Moreover, Dutch levees with trees are considered a cultural heritage. Their function may be valued for recreational purposes. The same is applicable to trees and natural resources that may govern levees. In this respect, the complete levee system, vegetation affects water transportation properties. Changes in vegetation from grass to trees or the other way around will result in different resistance to flow and therefore may influence the upstream or downstream flow regime. In a detailed Dutch study, the flow pattern for different kinds of vegetation was calculated in order to model the system's resistance to flow characteristics of the complete system. Despite the contradicting specialists' opinions, based on the study results, we might conclude that trees may contribute to levee stability in both a positive or a negative manner. Counting only the negative aspects that occur and neglect the positive influence might be a too conservative approach for the design of levees, resulting in a legislation stating no trees on levees are allowed.

From the Dutch experience, it is clear that under certain circumstances, trees can be tolerated on or near levees using both methods from the levee, the tree and a combined approach. All mentioned measures have to be designed to take out or compensate a negative effect of trees on levee safety. Coming back to what I said in my introduction and what has been mentioned several times today, in levee design, all aspects, including trees, should be taken into account. So, before removing all trees from the levees, for example, for wooden shoe production purposes, all possible systems, consequently, have to be studied. Thank you for your attention.