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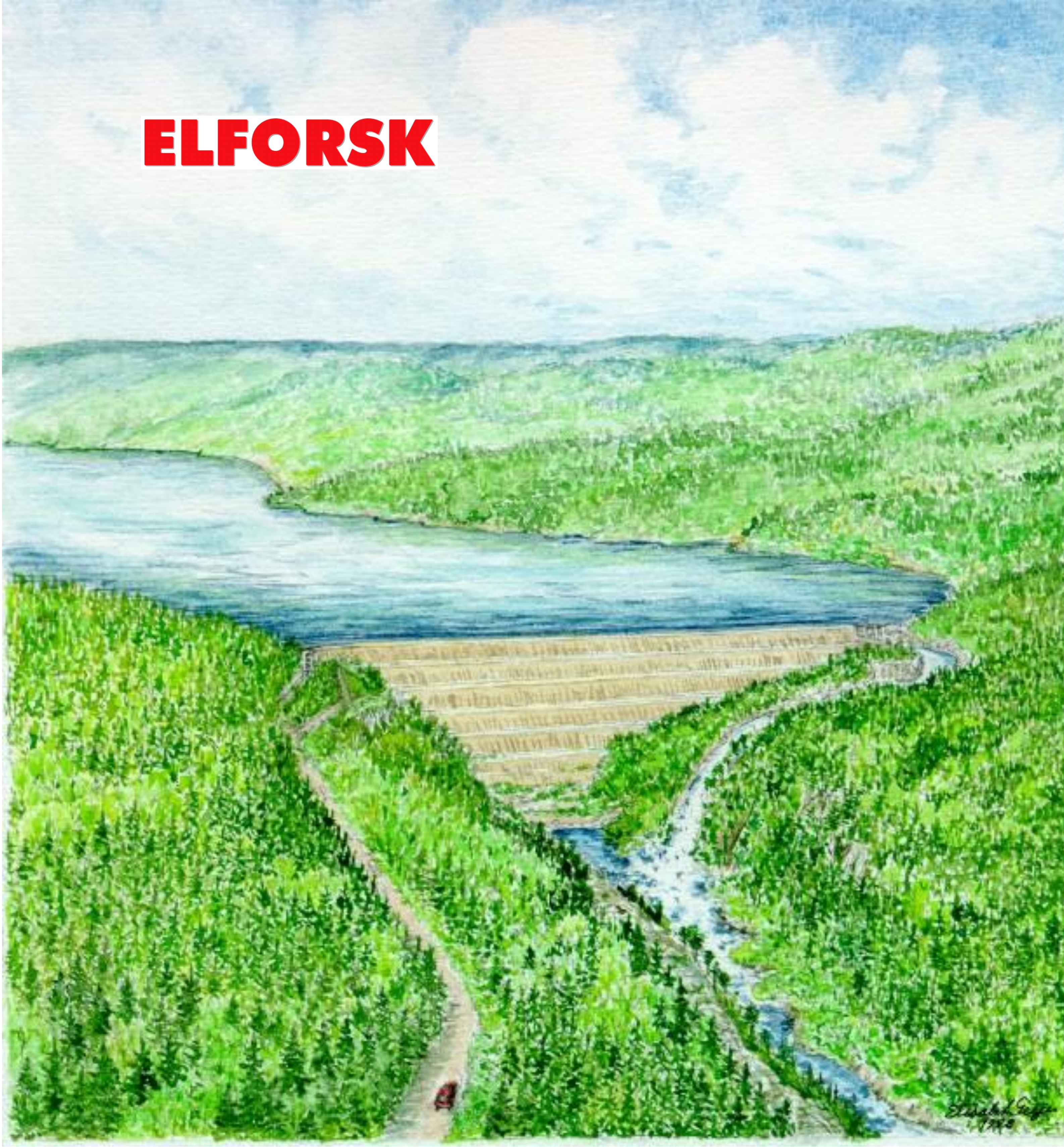

DAMMSÄKERHET

Quantitative risk analysis for dams – a case study in Sweden

Elforsk report 13:07

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Dr. Ignacio Escuder-Bueno, Dr. Luis Altarejos García and Dr. Armando Serrano-Lombillo

March 2013

Preface

According to the Swedish hydropower companies dam safety policy dam safety work should be preventive and meet good international standards. One interpretation of that is that dam safety decisions should be risk informed, which means that decision related to dam safety mitigation measures should be based on information on how the measures affect probability and consequences of dam failures.

With financial support from Elforsk and Svenska Kraftnät through Elforsks R & D program on dam safety and in cooperation with Swedish HydroPower Centre a case study on quantitative risk analysis for dams has been undertaken with Prof. Dr. Ignacio Escuder-Bueno, Universidad Politecnica Valencia as a project manager. The purposes of the project has been to provide common experience of a quantitative method for risk informed dam safety decisions and suggest further initiatives to develop practical applicable risk based methods in dam safety management.

A well defined methodology have been applied and evaluated. The approach has been to use a practical case study as a common fire place where experiences could be exchanged. Involvement of more than 20 experts and researchers in working sessions and steering group meetings has been a way to stimulate knowledge transfer. In the evaluation of the project it was clear that all participants truly have appreciated the benefits from participation. The evaluation also recognized that the project has established a state of the art quantitative risk analysis case that could be a valuable base for future initiatives. Several suggestions on further initiatives to develop practical applicable risk based methods in dam safety management has been presented and discussed. Next steps need some more discussions. However two conclusions are quite clear.

- ***There is a need for better consequence analysis related to dam incidents and failures.*** It is indeed important to notice that this report is a case study. The overall results and quantified risks should be interpreted with regard to uncertainties in estimations of loads, probabilities for failure modes and consequence.
- ***There is also a need for capacity building in "system engineering" related to dams.*** Risk informed decision making related to dam safety urge for knowledge and understanding on how all aspects, from loads to system response and failure modes, mitigation measures and consequences, in a regulated river system relates to dam safety. One way of doing this is to link other ongoing research and development projects (hydrology, debris etc.) with risk modeling to benchmark their results and impact on dam safety.

I would like to express our gratitude to all participants.

Stockholm, March 2013

Cristian Andersson

Summary

The project entitled "Quantitative risk analysis for Hällby – a case study" has been developed in two phases, "Phase I" (or qualitative) undertaken from May to December 2011, and "Phase II" (or quantitative) from January to December 2012. The three main pillars of the project have been: providing robust and defensible practical results for a case study, creating the proper dynamics for knowledge transfer and identifying research needs and opportunities.

With regard to the first pillar, the context and conditions under which risk analysis techniques have been applied by ELFORSK rely in the fact that Hällby Dam, as a practical case study, has been the driving force for knowledge transfer and a common fireplace where experiences have been exchanged.

More in detail, the practical results of the Project have comprised:

- Review of all existing dam safety information on the Dam and downstream area.
- Failure mode identification and analysis.
- Complete risk model.
- Quantitative inputs for the risk model.
- Calculation and evaluation of current risk.
- Risk management principles, indicators and alternatives.
- Evaluation of risk management alternatives.
- Identification of optimum sequences of alternatives implementation.
- Impact of uncertainty in informing decision making

As a second pillar, it was also acknowledged that the processes involved in building dam safety risk models had to be based on sound engineering activities such as failure mode identification, which required the proper consistency and diversity of expertise within the working team. To cope with such requirements, the management team has developed the works together with the "working group" and "invited expertise from consultancies and universities", and has periodically reported to ELFORSK's steering committee.

The working sessions dynamics and the step by step process followed, have made it possible to generate all the information in a transparent way, sharing the documentation with all the participants, who have had the opportunity to upload and discuss their contributions within the group. By these means, this methodology has helped to achieve a real knowledge transfer dynamic among participants.

As a third main pillar of the project, a wide field for research and development has been identified.

Research needs include the analysis of existing interdependencies within the risk model of a single dam, the risk analysis of several dams connected along a river reach or a system, and to move ahead in the analysis of the consequences of failure. Identified opportunities come from the fact that the risk model can be connected with other lines of research at ELFORSK and can be used to integrate them in a common framework.

In summary, it can be concluded that the challenge of building capacities and knowledge transferring has been very satisfactorily achieved through a quite positive group dynamic, which allowed integrating the expertise of all participants in the project results.

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MEMORY

1 Introduction to Phase II

The Project ”Quantitative risk analysis for Hällby – a case study”, on the initiative of Elforsks R&D program on dam safety in cooperation with Swedish HydroPower Centre, has pursued the following main purposes:

- Provide common experience of a quantitative method for risk informed dam safety decisions.
- Suggest further initiatives to develop practical applicable risk based methods in dam safety management.
- Identify needs and initiate research and development concerning risk analysis, uncertainties, failure modes and probabilities of failure of relevance for dams and dam safety.

Dr. Ignacio Escuder-Bueno (serving as a project manager), Dr. Luis Altarejos García and Dr. Armando Serrano-Lombillo (serving the last two as members of the management team) are the authors of this document, which aims to summarize the overall efforts developed during the project, which has been divided in two phases.

Phase I (from May to December 2011) comprised an elaboration of the scope of work, presentation and analysis of the information and current dam situation, identification of load scenarios, failure modes and consequences and building the architecture of the risk model for Hällby dam. The overall report on Phase I is fully included in this report as **ANNEX 7**, providing detailed information on **DELIVERABLES 1, 2 and 3** of the overall project, with a total of 6 deliverables.

Phase II (undertaken from January to December 2012), presented in this **MEMORY**, has comprised risk calculations, risk evaluation and studies of risk mitigation measures in Hällby dam (in order to clarify all the terminology used, **ANNEX 1** provides a **GLOSSARY** of terms used within the MEMORY). Phase II has required the elaboration of input data that results later in risk calculation and evaluation, as well as studying the impact on risk reduction of different risk mitigation measures (alternatives). More in detail, the tasks undertaken under Phase II have included:

- Assessment of subjective probability estimates for Hällby (**DELIVERABLE 4** of the overall project, included as **ANNEX 2** in this report)
- Performance of “current” risk calculation and definition of structural and non structural risk mitigation measures to be evaluated (**DELIVERABLE 5** of the overall project, included as **ANNEX 3** in this report)
- Evaluation of different risk mitigation measures and management options (**DELIVERABLE 6** of the overall project, included as **ANNEX 4** in this report)

ANNEX 5 summarizes all hypothesis and assumptions for lives and economic consequences, **ANNEX 6** has been incorporated to the present report to provide all **QUANTITATIVE INPUTS** that would allow replication of the results, herein calculated by means of the software iPresas (www.ipresas.com). A license of such software has been issued to ELFORSK as part of the technology transfer side of the project.

Table 1 shows the sequence and content of the working sessions for Phase II, consistently with the process described in Figure 1.

Table 1 Sequence of working sessions

DATE	ACCOMPLISHED TASKS
2/04/2012 3/04/2012 4/04/2012 (***DELIVERABLE 4***)	Training on different type of probability estimates and techniques. Assessment of subjective probability estimates for Hällby. Assigning tasks/commitments for the next working session.
26/06/2012 27/06/2012 28/06/2012 (***DELIVERABLE 5)***	Training on risk computation. Performance of "current" risk calculation. Definition of structural and non structural measures. Assigning tasks/commitments for the next working session.
14/11/2012 15/11/2012 16/12/2012 (***DELIVERABLE 6)***	Training on management options (sequence of corrective measures, efficiency, equity, etc.). Discussion on results with regard to the impact of different alternatives.
10/01/2013 (***PHASE II REPORT***)	Presentation and discussion on the overall results with focus on how to address further research and practical application.

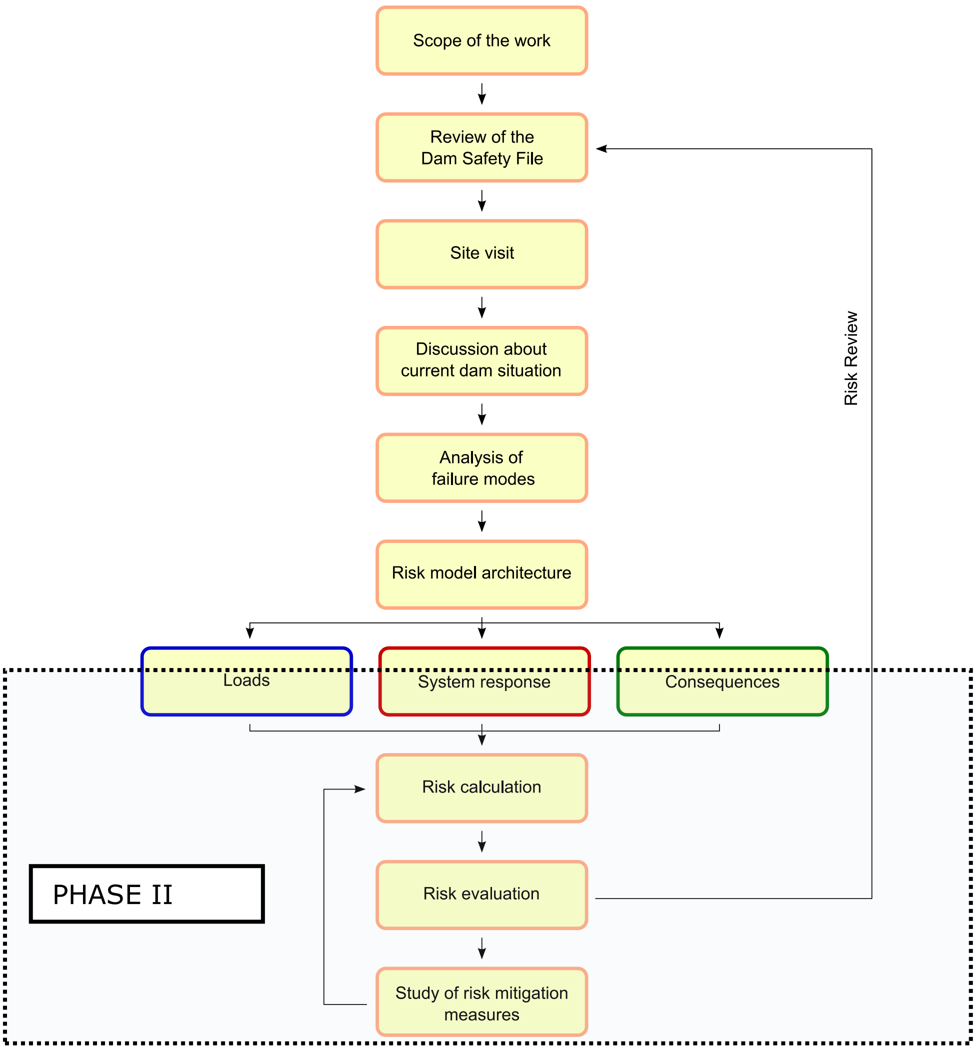


Figure 1. Phase II within the overall risk analysis processes

Finally, of utmost importance in terms of consistency of the process and quality of the final results, the so called "working group" and "invited expertise from consultancies and universities" has been basically the same as in Phase I as well as the "management team" and the steering committee" (see the list of participants in Table 2)

Table 2. Participants on "working group" and "invited expertise from consultancies and universities"

Working group		
Jeanette Stenman	E.ON Vattenkraft Sverige AB	Sundsvall
Assar Svensson	E.ON Vattenkraft Sverige AB	Sundsvall
Carl-Oscar Nilsson	E.ON Vattenkraft Sverige AB	Östersund
Stefan Berntsson/Anders Marklund	Vattenfall Vattenkraft AB	Stockholm
Ylva Helmfrid Schwartz	Tekniska Verken i Linköping	Linköping
Sezar Moustafa	Fortum Generation AB	Stockholm
Ann-Marie Darj	Fortum Generation AB	Stockholm
Victor Carlsson	Skellefteå Kraft AB	Skellefteå
Martin Hansson	Statkraft Sverige AB	Laholm
Gjermund Molle	Statkraft Energi AS	Oslo
Markus Hautakoski	Vattenregleringsföretagen	Östersund
Birgitta Rådman	Vattenregleringsföretagen	Östersund
Magnus Holmgren	Vattenregleringsföretagen	Östersund
Ragnar Asklund	Jämtkraft AB	Östersund
Mats Eriksson	Fortum Generation AB	Stockholm
Invited expertise from consultancies and universities		
Tommy Edeskär	Luleå tekniska universitet	Luleå
Anders Wörman	Kungliga Tekniska högskolan	Stockholm
Farzad Ferdos	Kungliga Tekniska högskolan	Stockholm
Fredrik Johansson	Kungliga Tekniska högskolan	Stockholm
Michaela Dan	Pöyry SwedPower AB	Stockholm
Petter Stenström	Sweco Infrastructure AB	Stockholm
Åke Nilsson	WSP Samhällsbyggnad	Stockholm
Hans Rönnqvist	WSP Samhällsbyggnad	Stockholm
Marie Westberg	ÅF Industry	Stockholm
Stefan Lagerholm	ÅF Industry	Malmö
Project Management		
Prof. Ignacio Escuder-Bueno	Universidad Politecnica de Valencia-iPresas	Valencia
Dr. Armando Serrano-Lombillo	iPresas	Valencia
Prof. Luis Altarejos	iPresas-Universidad Politecnica de Valencia	Valencia
Project Steering Group		
Anders Isander	E.ON Vattenkraft Sverige AB	Göteborg
Jeanette Stenman	E.ON Vattenkraft Sverige AB	Sundsvall
Maria Bartsch	Svenska Kraftnät	Sundbyberg
Jonas Birkedahl	Fortum Generation AB	Örebro
Martin Hansson	Statkraft Sverige AB	Laholm
Lars Hammar / Stefan Berntsson	Vattenfall Vattenkraft AB	Stockholm

2 Quantitative risk model architecture and input data

The risk model architecture was developed on Phase I (see **ANNEX 7)** for a full justification) and has been kept for Phase II computations with some minor changes: removal of failure mode number 5, which was considered extremely unlikely to happen in the working sesion of April 2012 and the subdivision of warning time in five different components.

Figure 2 (overview of the complete model, see also **ANNEX 7**), Figure 3 (load components), Figure 4 (system response components) and Figure 5 (consequence components) show the structure and components of the risk model as built into iPresas software. Figure 6 shows a squeme and conceptual explanation of the components in which warning time has been splitted (T1, T2, T3, T4 and T5 in Figure 5).

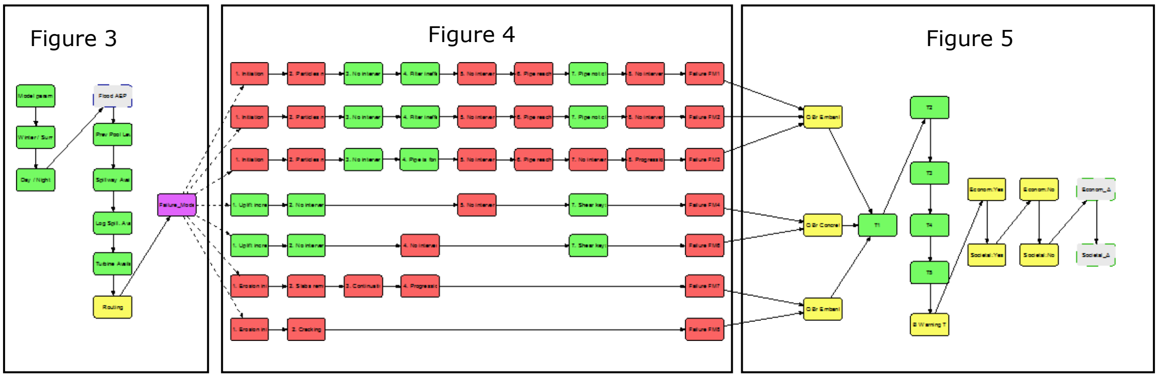


Figure 2. Overview of the risk model

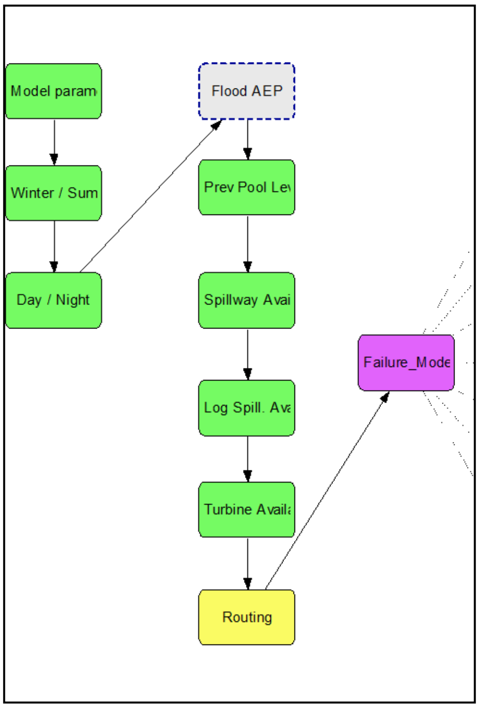


Figure 3. View of the risk model load components

Figure 4. View of the risk model system response components

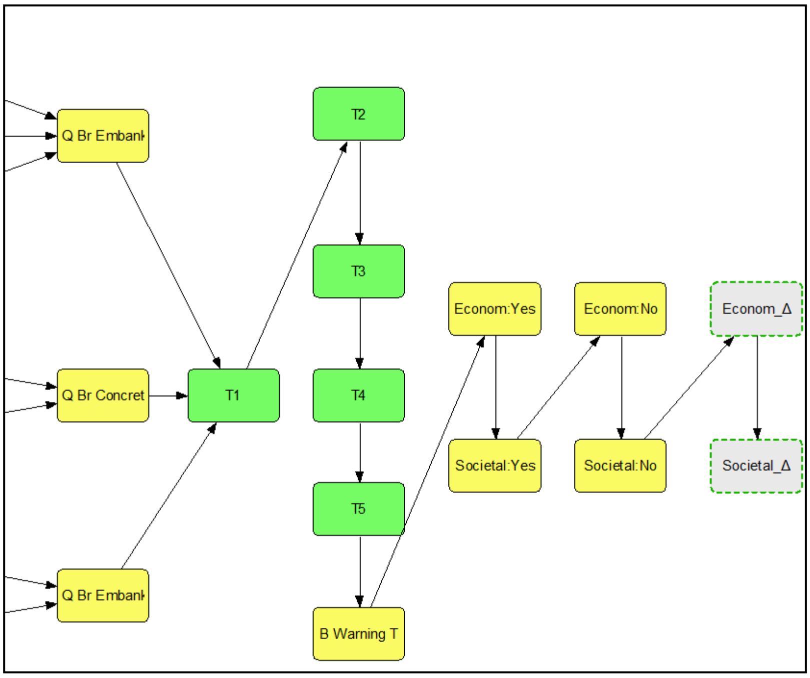
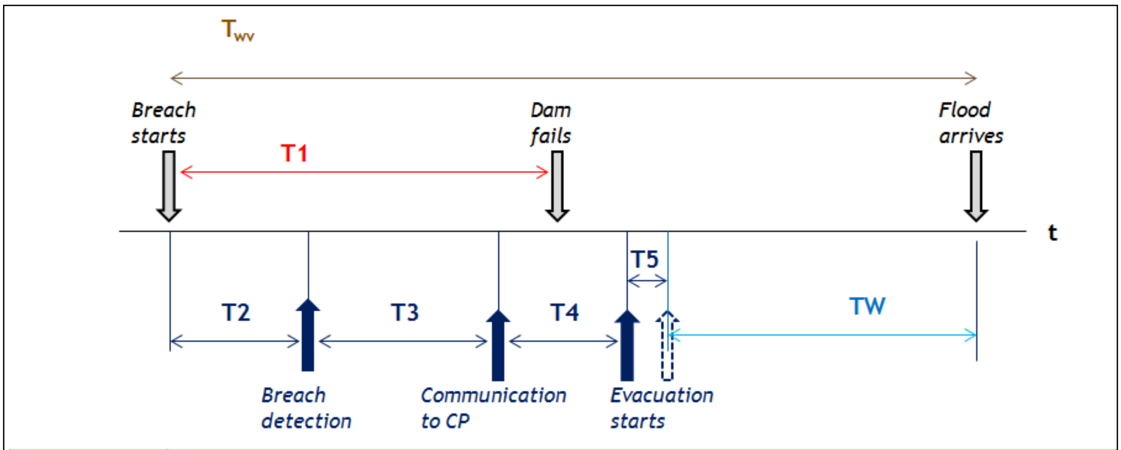


Figure 5. View of the risk model consequence components



Factor	Definition
T1	Breach initiation - Dam failure
T2+T3+T4+T5	Breach initiation - Evacuation (starting time)
T2	Breach initiation - Dam failure detection (T2 might be <0)
T3	Dam failure detection - Communication to Civil Protection
T4	Communication to Civil Protection - Evacuation (starting time)
T5	Day/night factor (T5=0 min during the day; T5=15 min at night)
T_{wv}	Arrival wave time From breach start to affected element (Report 2007)
TW	Warning time TW = Twv - (T2+T3+T4+T5)

Figure 6. Warning time components

Input data are included as **ANNEX 6** to the present report, and have been elaborated by the Management Team, the Working Group and the Invited expertise from consultancies and universities following some of the best international practices, as those referenced at the "Spancold Technical Guide on Risk Analysis Applied to Dam safety Management" (Spanish National Committee on Large Dams, 2012).

More in detail, main techniques and procedures used elaborating Hällby risk model input data are briefly described below:

- Floods have been statistically characterized thus associated with a certain probability of occurrence, explicitly expressed by its annual exceedance probability AEP (probability that the peak discharge of the largest flood in a year whatever is larger than a given discharge Q) or its return period T (the inverse of AEP).
- The study of previous pool levels, aimed at analyzing the probability of finding a certain pool level in the reservoir at the moment of arrival of a flood, has been obtained by using the register of historic pool levels.
- Outlet works and spillways reliability, which can be defined as the probability that every outlet works and spillway behaves properly when needed, has been characterized by estimating the probability of each of the initiating events as defined in the fault tree developed under Phase I (see **ANNEX 7**).
- The data required to carry out each of the flood routing calculation are hydrographs entering the reservoir (inflow hydrograph), previous pool level, characteristic curve of the reservoir, discharge curves of the outlet works and spillways and operating rules. From such set of data, flood routing has been parameterized in terms of each of the three previously mentioned variables and every possible combination (entering flood, previous pool level and availability of the gates, outlets and turbines). Figure 7 shows the set of

considered hydrographs and Figure 8 provides a calculation example for a given hydrograph, previous pool level and gates availability.

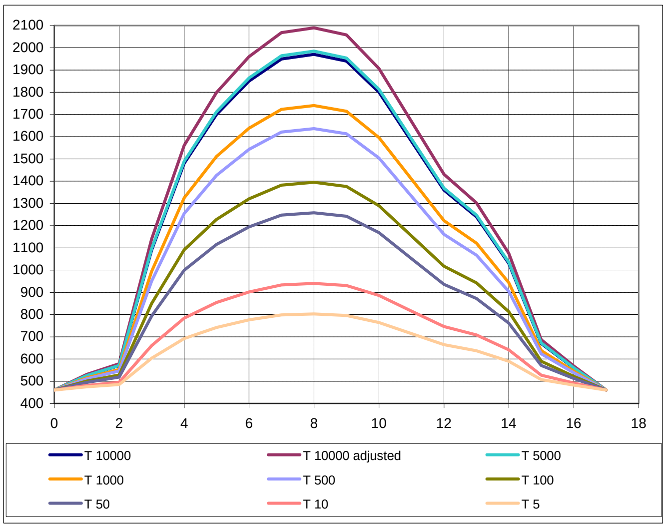


Figure 7. Set of considered hydrographs

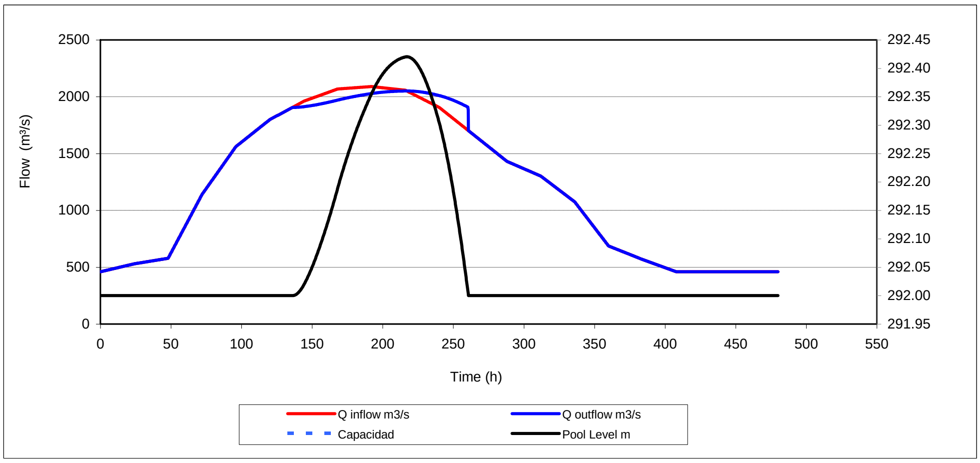


Figure 8. Calculation example for a given hydrograph, previous pool level and gates availability

- The study of failure probabilities is an integrating piece of the risk model necessary to feed it once its architecture has been defined. Once the failure modes have been split in well-defined steps, the probability of each of them has been estimated by means of several tools, such as expert judgment (majority of the nodes), reliability tools (for the failure last nodes of Failure Mode 4 and 6) and some other specific methodologies like simplified fragility curves (for the failure last nodes of Failure Mode 8). Figure 9 shows one of the working sessions devoted to probability elicitation and Figure 10 shows the relative weights, in terms of best estimated failure probability, of each of the analyzed failure modes.

Figure 9. View of a working session devoted to probability elicitation

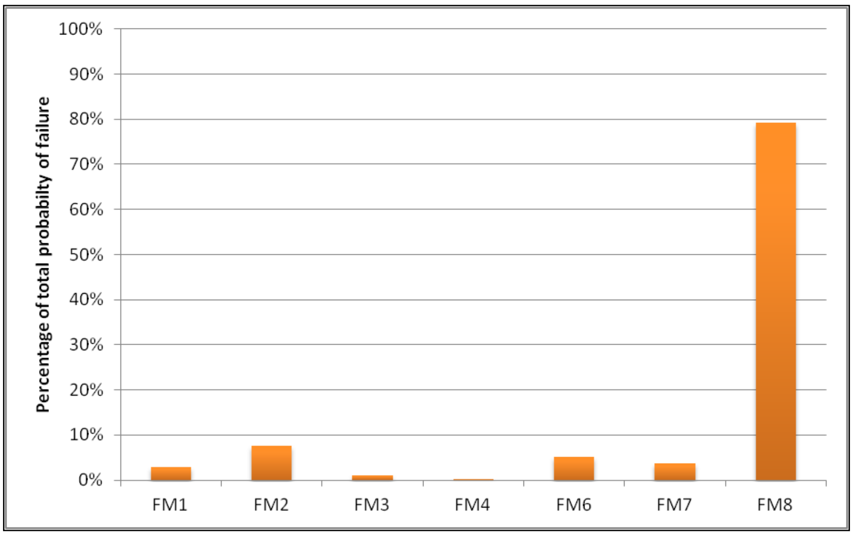


Figure 10. Relative weights, in terms of best estimated failure probability, of each of the analyzed failure modes

- The analysis of consequences consisted of three parts, namely the estimation of the failure discharge, study of the flooding and estimation of its consequences in terms of life and economic losses. First and second were inferred from the Inundation Maps of the Hällby Emergency Action Plan and the third one has been accomplished following the SUFRI methodology (SUFRI project, 2n ERA-Net Funding Initiative, 2009-2011, SUFRI methodology for flood risk assessment in urban areas) completed with some Swedish published data and statistics (*Modern Cost-Benefit Analysis, by Johansson/Kristrom, 2011*; Population and housing, census 1960-1990 (TPR); and http://enipedia.tudelft.nl/wiki/Gulsele_Powerplant). Figure 11 shows the downstream reach considered (from Hällby Emergency Action Plan inundation mapping) and Figure 12 shows an example of the set of obtained estimates.

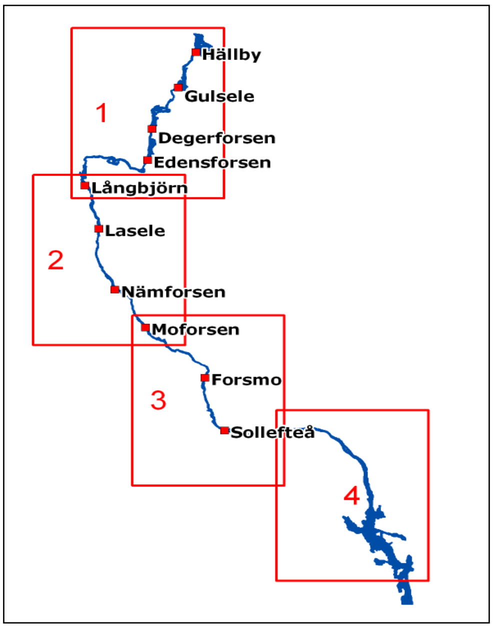


Figure 11. Downstream reach considered (from Hällby Emergency Action Plan inundation mapping)

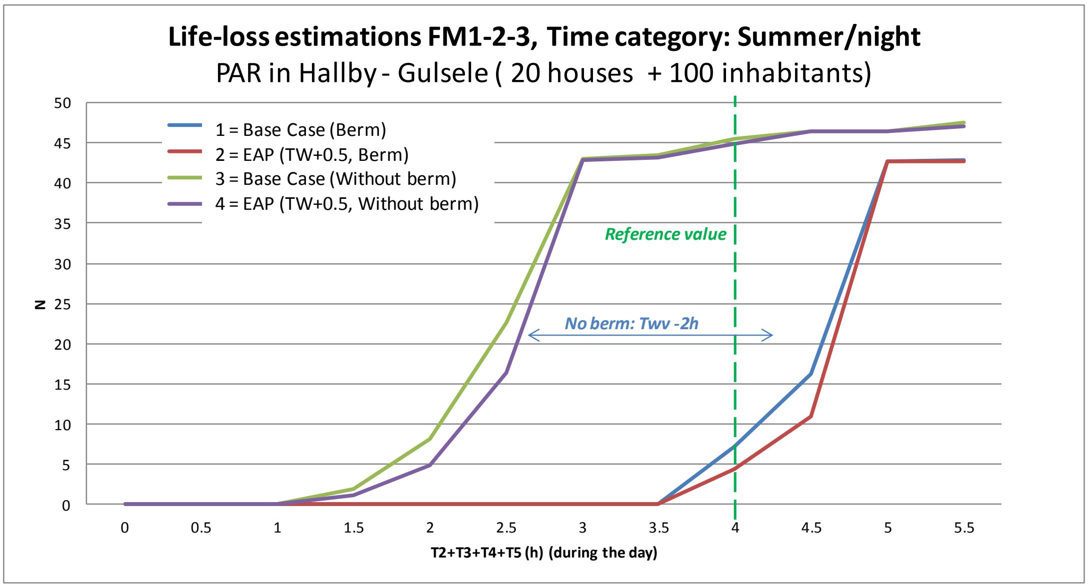


Figure 12. Example of the set of obtained estimates

It is worth to mention some of the issues that have conditioned the consequence estimation work and some of the hypothesis that had to be done in order to obtain the results. In particular:

- Reports on “Emergency preparedness plan Hällby Power Plant” and ”Dam-break Flood Simulation and Consequences Analysis for Hällby Dam Facilities” provided the information on inundation maps and affected areas. However, the hydraulic MIKE 11 model could not be recovered and a more detailed parametric study of how different discharges would affect the downstream area could not me performed (a rough interpolation was used instead).
- According to the existing data, main community downstream Hällby is Junsele, with 1349 inhabitants, though the village of Gulsele is the most exposed in case of dam break, with approximately 100 people.

- Density of population has been adopted as 2.1 inhabitants per household, according to the Swedish national rate.
- Two types of response were considered, one for those failure modes that do not necessarily happen under a flood event (failure modes 1 to 3), and a second one for the others, that basically showed no impact on human fatalities due to the warning time given by the flooding process itself. Four exposure categories have been considered (summer/day, summer/night, winter/day, winter/night).
- Economic consequences of dam failure estimation have included direct impact on residential properties, industrial buildings, traffic routes, community utilities (electricity, water, sewage and communication), indirect impact in terms of loss of energy production and an estimate of the cost of re-building Hällby Power Plant (although this last one has not been included as a cost in the model, as it remains an open question if the owner would have the capability and possiblility to rebuild a dam like Hällby).

With the above mentioned limitations and hypothesis, consequences have been analyzed on the scenario of failure of the dam and on the scenario of non-failure, thus the incremental consequences required in the risk model are later obtained throughout a simple subtraction.

Acknowledging that uncertainties may still be of great impact on the consequence estimation for this case, a sensitivity analysis (see Chapter 7 of the present **MEMORY**) has been performed in terms of warning time and other key parameters, and an improvement on the accuracy of the estimation of economical consequences is highlighted as one of the suggested further steps on Chapter 8.

3 Current risk calculation and evaluation

With all the input variables of the risk model in place, the calculation of the risk was first performed for the current situation, which is typically called Base Case. With regard to the calculation itself, the procedure is conceptually simple. The probability of each branch of the event tree is obtained as the multiplication of all the conditional probabilities of the sub-branches that compose it. Failure probability and total risk can be determined by adding up the results of all the branches. Besides that, there are some considerations specific to the calculation of risk in dam safety that have been also considered when performing the calculations. Namely:

- *Discretization of continuous variables*. Some of the variables appearing in the risk model, such as the water level in the reservoir or the return period of floods, are continuous. When they are to be modelled through event trees these variables must be discretized in several branches. Each of these branches will represent a range of values this variable can adopt. For ulterior calculations, a representative value of this branch will have to be taken, usually the average value of the interval.

- *Common Cause Adjustment and Freezing*. When studying dams like Hällby, with different failure modes, it is needed to consider some specific adjustments such as the common cause adjustment and the freezing of variables. A brief exposition of these concepts and the way they affect the calculations is provided ahead:

  ✓ *Common cause adjustment*. When there are k non-mutually exclusive failure modes within a same scenario (each one with an individual probability p_k), the total probability of failure of the scenario is found within the range fixed by the Theorem of the Unimodal Limits, which is therefore one way of delimiting the magnitude of the total failure probability in scenarios resulting from a common cause. Both upper and lower limit adjustments have been calculated and the average between them has been taken.

  ✓ *Freezing.* In a hydrologic scenario the action imposed by a flood is a process that develops in time. For example, for a certain pool level, it is possible to find failure modes with lower or higher probability of occurrence and this distribution might be different for a superior pool level. However, there is the possibility of not reaching the second pool level because the dam may fail before it is attained. Thought this temporal process is intrinsically difficult to model through event trees, the approximation adopted has been admitting that when a total failure probability of 1 is reached for a given pool level, the same distribution of failure probability is maintained, remaining "frozen" for higher pool levels.

With regard to risk evaluation, although more recommendations exist, the most used ones nowadays have been suggested by USBR (United States Bureau of Reclamation), ANCOLD (Australian Committee on Large Dams) and USACE (United States Corp of Engineers), being these two last conceptually very similar. The character of recommendation of the first and third document, adopted for the evaluation of Hällby Dam (Figure 13 and 14), must be in any case stressed.

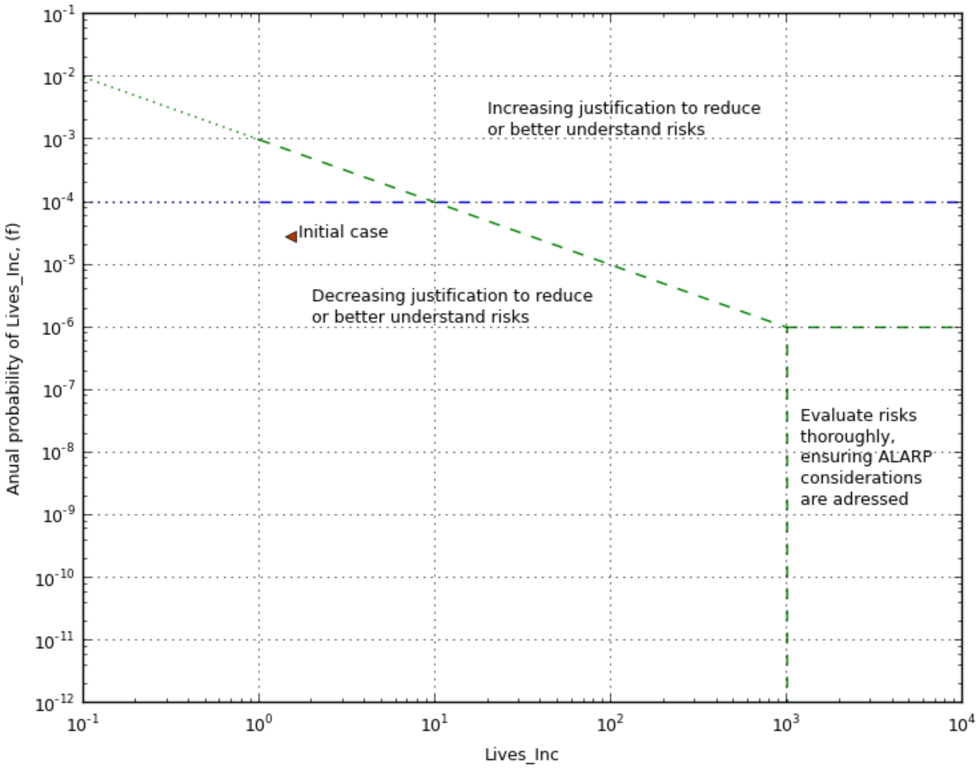


Figure 13. Hällby Dam Risk evaluation against USBR Guidelines

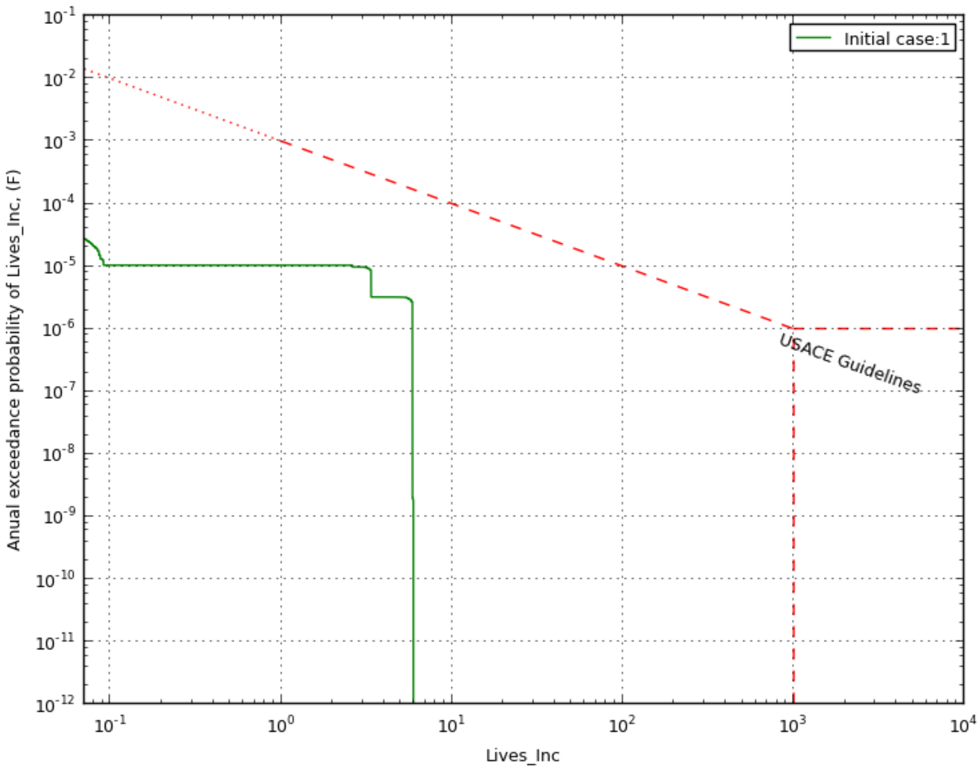


Figure 14. Hällby Dam Risk evaluation against USACE Guidelines

Both graphs show, first in terms of an f-N dot representation and second in terms of an F-N curve, how Hällby would currently fit below the thresholds of strong recommendation for taking actions, which does not mean that some actions (risk management alternatives) may not deserve to be considered (see Chapter 4, 5 and 6 of this Memory).

Finally, if total risk is decomposed to track the impact of each of the considered failure modes for Hällby (Figure 15), it can be concluded that most of the risk is due to the potential for hydrologic failure (FM8), followed by the potential for internal erosion through the clay-concrete contact of the dam. Though the graph of Figure 15 is only based on best estimates, the impact of uncertainty on some of the factors that have more influence on such risk estimates (i.e. gate reliability and the existence of the berm) has been addressed in Chapter 7 of the present **MEMORY** by means of a sensitivity analysis.

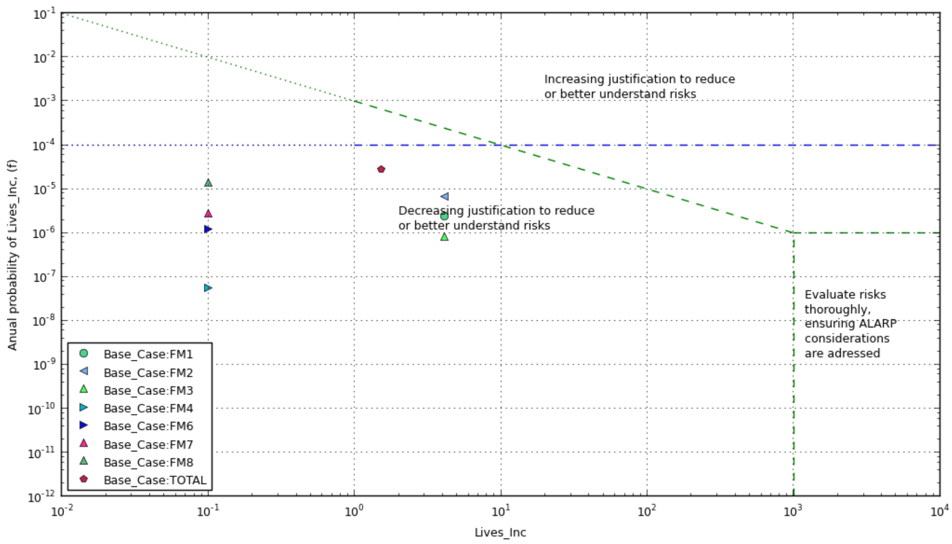


Figure 15. Hällby Dam Risk evaluation against USACE Guidelines

Though all world wide existing evaluation tolerability guidelines are set in terms of expected loss of lives, it is worth to present the following charts in terms of expected economic losses (Figures 16 and 17).

As expected, changes in economic impact by failure mode are almost negligible.

Note: values on expected economic losses do not include reconstruction costs of Hällby or any other of the potentially failed dams downstream. Very approximately, if it had to be accounted, Ekstrand proposes the estimation of the dam reconstruction cost based on reservoir capacity as follows:

$$CR = 17.606 + 0.13965 \cdot KAF$$

where CR denotes reconstruction cost (in dollars) and KAF is the reservoir capacity in acree-feet (x103). For Hällby, with a reservoir capacity of 165 hm3 (292 m.a.s.l.), the reconstruction cost is 36.3 M$ (year 2000). The present value of the estimated reconstruction cost is 65.2 M$ (in 2012, with a discount rate of 5%) equivalent to 417.8 million SEK (1SEK=0.156$).

Ref: E.R. Ekstrand. Estimating economic consequences from dam failure in the safety dams program. U.S. Department of the Interior. Bureau of Reclamation, EC-2000-01, 2000.

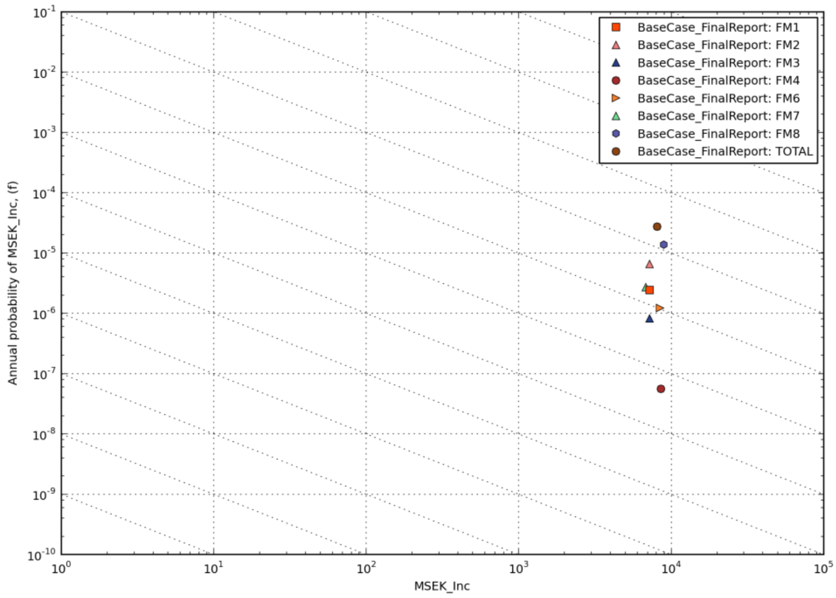


Figure 16. Hällby Dam Risk f-D graph (D in Millions of SEKS)

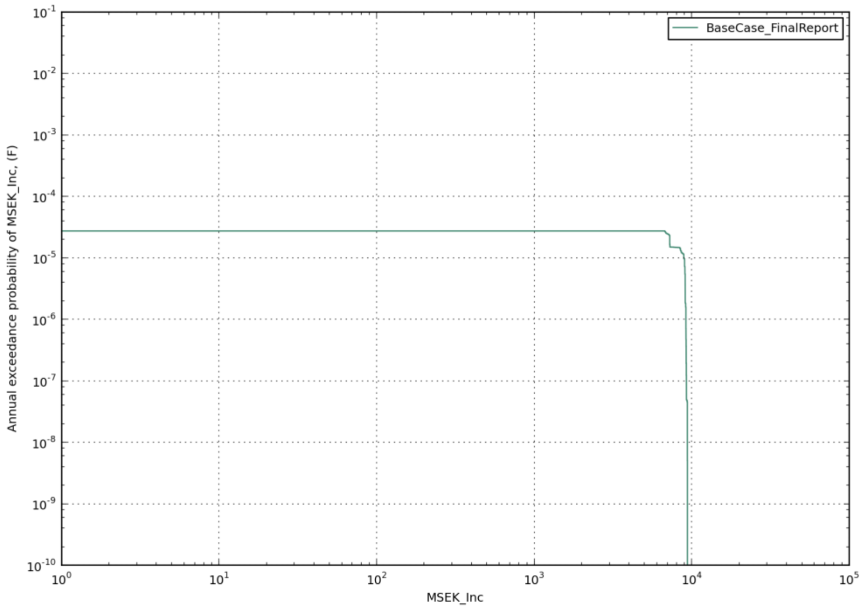


Figure 17. Hällby Dam Risk F-D graph (D in Millions of SEKS)

4 Management principles and indicators

When performing a Risk Analysis, risk reduction decision-making is one of the most important parts of the process. Decisions are made after considering possible alternatives and analyzing their effect on infrastructure risk. Generally, two principles are recommended to guide this decision-making process:

- **Equity:** This principle arises from the right every individual has to a certain level of protection. Its application is done through the concept of individual risk, that is, the probability that at least one person dies as a result of infrastructure failure. Following this definition, individual risk tolerability recommendations that guarantee a certain level of protection for every individual of the population are related to the principle of equity. The application of this principle should prevail when individual risk is above the recommended value of tolerability (i.e., when individual risk is unacceptable, which can be found in the two guidelines adopted for risk evaluation in the present work, by USBR and USACE).

- **Efficiency:** This principle arises from the fact that society possesses limited resources which must be spent in the most efficient way. When considering several risk reduction measures, the one producing a higher risk reduction at a lower cost should be chosen first, that is, the one that optimizes the expenditure. This is usually the prevailing principle when risk is tolerable. A distinction between two types of efficiency, depending on the targeted risk, can be done as follows:

  - ✓ Societal efficiency: When the target risk to be reduced is societal risk (usually expressed in loss of life/year).

  - ✓ Economic efficiency: When what is analyzed is economic risk reduction, that is, the searched strategy is the most advantageous from an economic point of view.

In summary, two different principles are used to guide decision-making: equity and efficiency. This can result in contradictions since what can be an optimal measure from the equity point of view may not be so from the efficiency point of view and vice-versa.

Linked to one or both of such principles, risk indicators allow the quantification of efficiency and equity of any risk reduction measure. These indicators are obtained from the effect the measure has on infrastructure risk and from its implementation and maintenance costs. The main risk indicators found in literature are:

- **CSLS** (Cost per Statistical Life Saved). This indicator shows how much it costs to avoid each potential loss of life as a result of infrastructure failure when applying a measure. CSLS compares costs with societal risk reduction, so when considering several measures, the measure with a minimal value of this indicator will be the one that employs the resources in a most efficient way. Therefore, this indicator represents the principle of societal efficiency. Its value is obtained through the following formula:

$$CSLS = \frac{C_a}{r_s(base) - r_s(mea)}$$

Where r_s*(base)* is the risk expressed in loss of lives for the base case, r_v *(mea)* is the risk in lives after the implementation of the measure and C_a is the annualized cost of the measure that includes its annualized implementation costs, annual maintenance costs and the potential changes in operation costs generated by the adoption of that measure.

- **ACSLS** (Adjusted Cost per Statistical Life Saved): This indicator has the same structure as CSLS but introduces an adjustment of the annualized cost to consider the economic risk reduction generated by the implementation of the measure. As in the previous case, it represents the efficiency principle, though for adjusted costs, so it considers both societal and economic efficiency. ACSLS is also used to apply the ALARP (As Low as Reasonably Practicable) criterion, by indicating that as long as tolerability recommendations are respected, a measure can be rejected if it is not cost-efficient enough. It is obtained with the following equation:

$$ACSLS = \frac{C_a - (r_e(base) - r_e(mea))}{r_s(base) - r_s(mea)}$$

Where r_e *(base)* is the economic risk of the infrastructure for the base case and r_e *(mea)* is the economic risk after the implementation of the measure.

- **CBR** (Cost-Benefit Ratio): This indicator arises from the comparison of the costs of a measure with the benefits on the economic risk reduction resulting from its implementation. Therefore, this ratio shows which measure is the most cost-effective.

$$CBR = \frac{C_a}{r_e(base) - r_e(mea)}$$

Other indicators proposed and used by the risk management team of this project have been:

- **CSFP** (Cost per Statistical Failure Prevented). This indicator expresses how much it costs to avoid infrastructure failure for each measure. It combines costs with failure probability so it takes into account the principles of economic efficiency and equity. It is calculated as follows:

$$CSFP = \frac{C_a}{f_p(base) - f_p(mea)}$$

Where f_p *(base)* is the annual failure probability for the base case and f_p *(mea)* is the failure probability after the measure implementation.

- **ACSFP** (Adjusted Cost per Statistical Failure Prevented). This indicator presents the same form as CSFP but introduces an adjustment on the annualized cost to consider the reduction of economic risk produced by the implementation of the measure. It is calculated with the following formula:

$$ACSFP = \frac{C_a - (r_e(base) - r_e(mea))}{p_f(base) - p_f(mea)}$$

- **EWACSLS** (Equity Weighted Adjusted Cost per Statistical Life Saved)**:** As its name indicates, it is obtained from ACSLS by introducing a correction to consider the equity criterion. This indicator is calculated with the following formula:

$$EWACSLS = \frac{ACSLS}{\left(\frac{\max(r_i(base), IRL)}{\max(r_i(mea), IRL)}\right)^n}$$

  Where *IRL*, stands for Individual Risk Limit and *n* is a parameter that allows giving a higher weight to efficiency or equity in the prioritization process. If the value of *n* is very high, the prevailing prioritization principle is equity whereas if it is very low, efficiency prevails. Moreover, if the infrastructure's failure probability is lower than *IRL*, the only prevailing principle is efficiency (through ACSLS), since the denominator of the formula is then 1. Therefore, the equity principle is only applied in the cases where individual risk in unacceptable (above tolerability thresholds).

In addition to the former risk indicators, it is also possible to directly use the risk reduction in terms of decrease in probability of failure, societal or economic risk (minimize probability of failure, minimize societal risk and minimize economic risk), indicators which have been also been applied to Hällby within this work.

Table 3 and Figure 18 summarize the risk management principles and indicators taking into account for Hällby case study, which have been calculated by means of the software iPresas (www.ipresas.com).

Table 3. Risk management principles and indicators considered for Hällby

Indicator	Principles
CSLS	Societal efficiency
ACSLS	Societal and economic efficiency
CBR	Economic efficiency
CSFP	Equity
ACSFP	Economic efficiency Equity

EWACSLS	Societal and economic efficiency Equity
Minimum Probability of Failure (IRDI in Figure 15)	Equity
Minimum social risk (SRDI in Figure 15)	Societal efficiency
Minimum economic risk (ERDI in Figure 15)	Economic efficiency

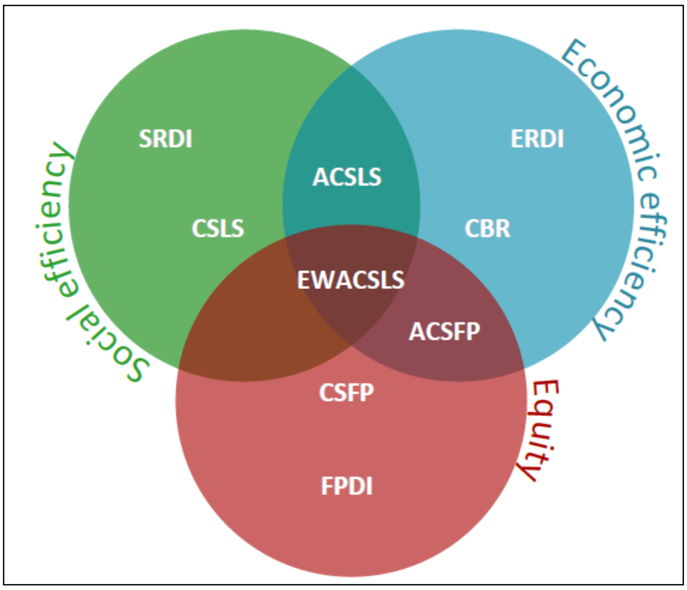


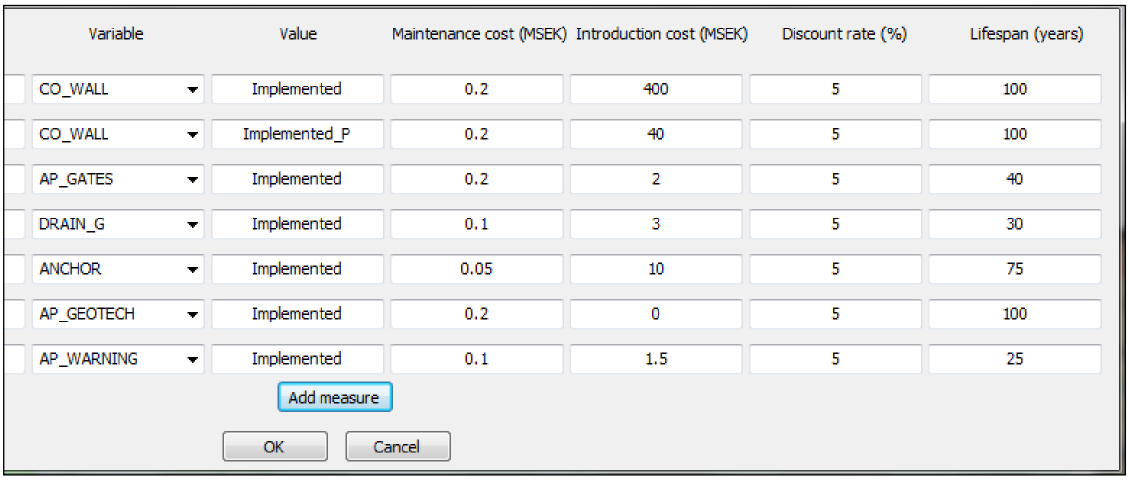
Figure 18. Venn diagram showing the relationship between risk indicators and efficiency and equity principles

5 Evaluation of management alternatives

Management options were worked out by four different teams of participants during working session 6 (November 2012) devoted to different areas: gates, geotechnical issues, structural aspects and organizational factors. As a result, seven different management options have been considered:

- **AP_GATES**: Action Plan related to the gates (includes a series of actions that increase the gate reliability).
- **AP_GEOTECH**: Action Plan related to increase the capacity of detection and reaction under a geotechnical driven failure mode.
- **AP_WARNING**: Action Plan focused on diminishing Warning Time in case of an emergency.
- **CO_WALL_P**: Partial Cut Off wall close by the contact between concrete and rockfill sections.
- **CO_WALL**: Complete Cut Off wall along the axis of the rockfill dam.
- **DRAIN_G**: Improvement of the drainage system under the concrete structures, including grouting and refurbishment of drains.
- **ANCHOR**: Post-tensioned Anchors to increase sliding stability of the concrete structures.

Each of these management alternatives (named as Variables in Figure 19) have been introduced in the above mentioned software for evaluation, together with their introduction and maintenance cost (in Millions of SEKs), lifespan (in years), and discount rate (in percentage).



Variable	Value	Maintenance cost (MSEK)	Introduction cost (MSEK)	Discount rate (%)	Lifespan (years)
CO_WALL	Implemented	0.2	400	5	100
CO_WALL	Implemented_P	0.2	40	5	100
AP_GATES	Implemented	0.2	2	5	40
DRAIN_G	Implemented	0.1	3	5	30
ANCHOR	Implemented	0.05	10	5	75
AP_GEOTECH	Implemented	0.2	0	5	100
AP_WARNING	Implemented	0.1	1.5	5	25

Figure 19. Alternatives (management options) considered

Data from maintenance cost, introduction cost, discount rate and lifespan are used to calculate both annualized cost (C_a) and cost at present value (PV) by means of the following formulae:

$$C_a = C_{mant} + \frac{C_{\text{int}}}{(1+r)} \cdot \frac{r \cdot (1+r)^n}{(1+r)^n - 1}$$

And,

$$PV = \frac{C_{\text{int}}}{(1+r)} + \sum_{i=1}^{n} \frac{C_{mant}}{(1+r)^{i+1}}$$

Where C_a is the annualized cost (econ. units/year), PV is the present value (econ. unit), C_{mant}: Cost of maintenance (econ. units/year), C_{int}: Measure's introduction cost (econ. units), r: Discount rate (%), n: Measure's life span (years)

The following step consists of modifying the risk model to reflect the effect of the mitigation measures to be evaluated. Then, the calculation is repeated for each of them. Finally, the subtraction of the risk result obtained in the situation with a measure from the Base Case result provides the impact on risk of any particular measure.

In order to track the impact in risk of each of the alternatives, as this impact has to imply a variation of input data from the Base Case, the files given in **ANNEX 6** will include, for such variations, a new set of values. They can be generally found under the label of "Variable Implemented" although, for the case of the cut off wall, "Implemented" will be related to the complete work, while "Implemented_P" will be related to the previously described "partial" cut off wall.

Figure 20 shows the impact in risk (represented against USBR Tolerability Guidelines) of each alternative, one by one, as compared to the Base Case.

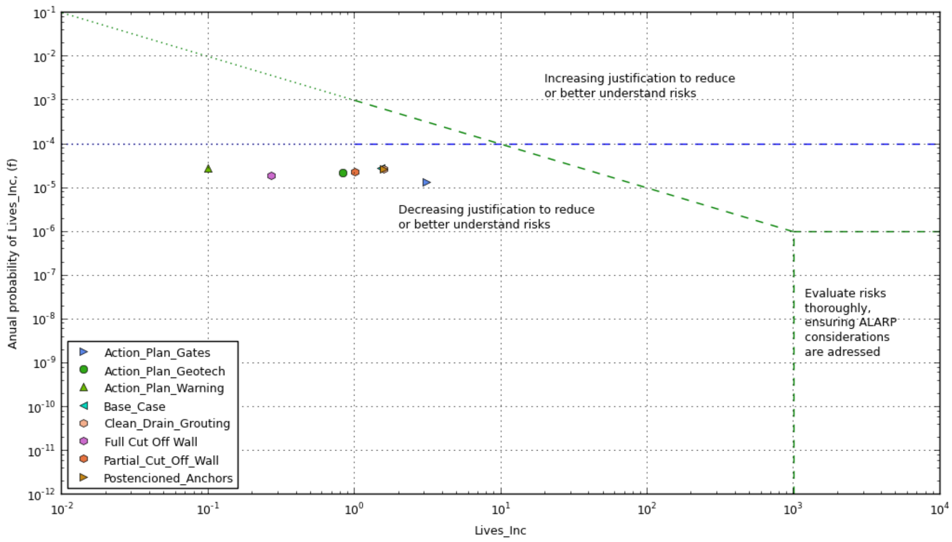


Figure 20. Impact in Risk of each alternative separately (USBR Tolerability Guidelines Graph)

Figure 21 and Figure 22 show the overall reduction of risk that may be achieved by implementing all the considered alternatives plotted against USBR and USACE Tolerability Guidelines graphs respectively.

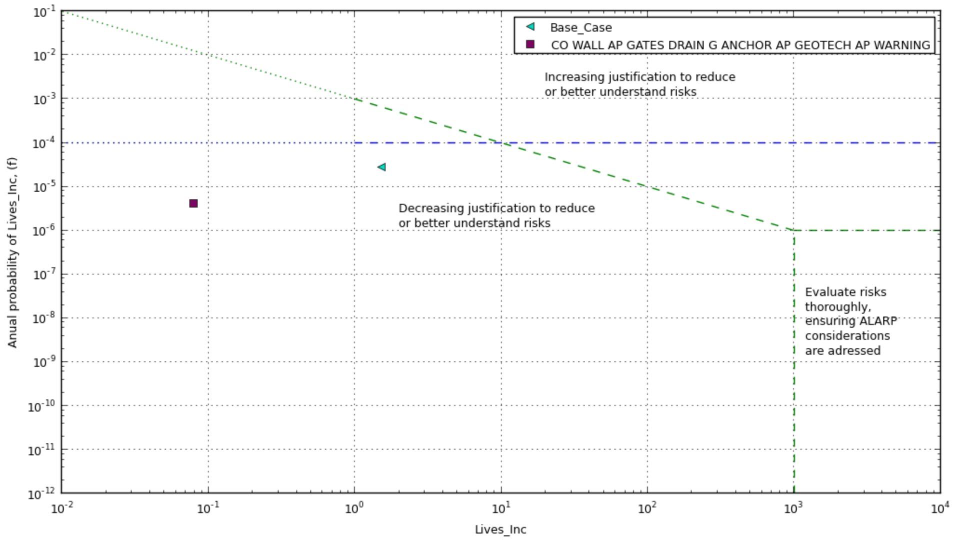


Figure 21. Impact in Risk of all alternatives together (USBR Tolerability Guidelines Graph)

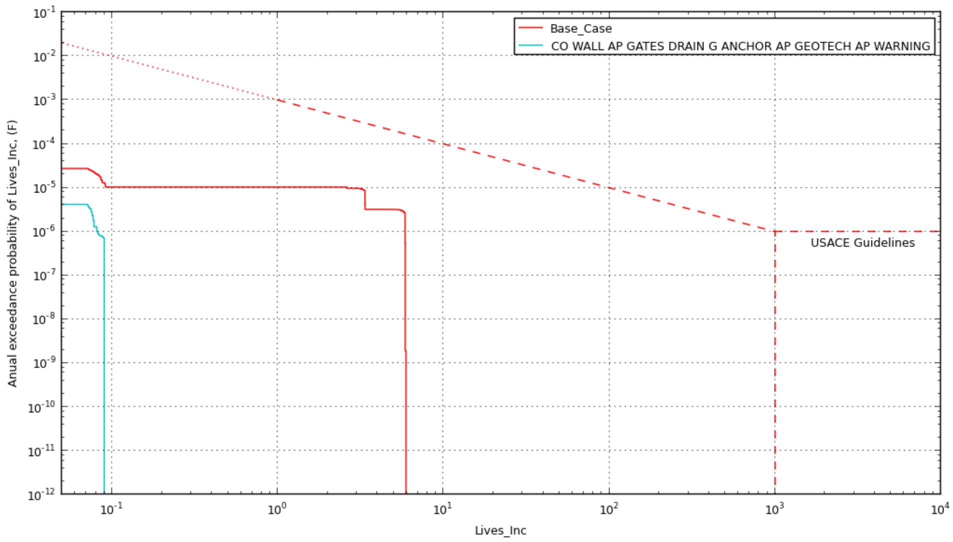


Figure 22. Impact in Risk of all alternatives together (USACE Tolerability Guidelines Graph)

Following the same structure for plotting results as in Chapter 3, charts in terms of expected economic losses (Figures 23, 24 and 25) are also provided (as in Chapter 3, reconstruction costs have not been considered within the risk model).

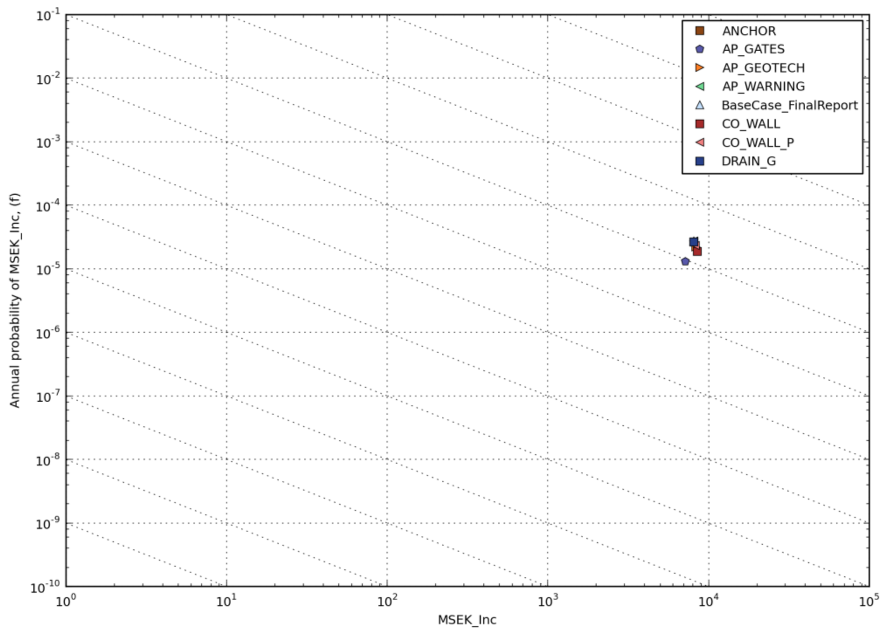


Figure 23. Impact in Risk of each alternative separately (f-D Chart; D in Millions of SEKs)

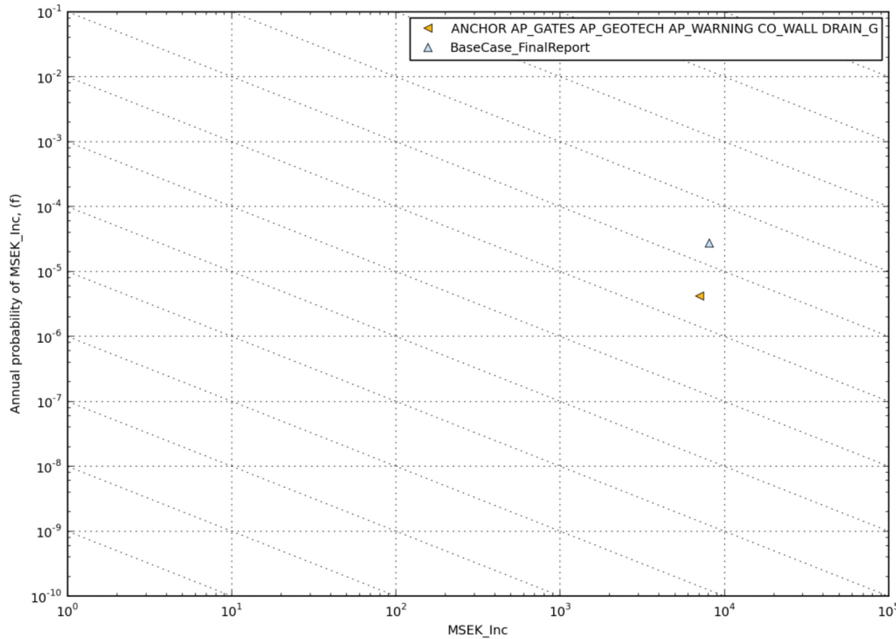


Figure 24. Impact in Risk of all alternatives together (f-D Chart; D in Millions of SEKs)

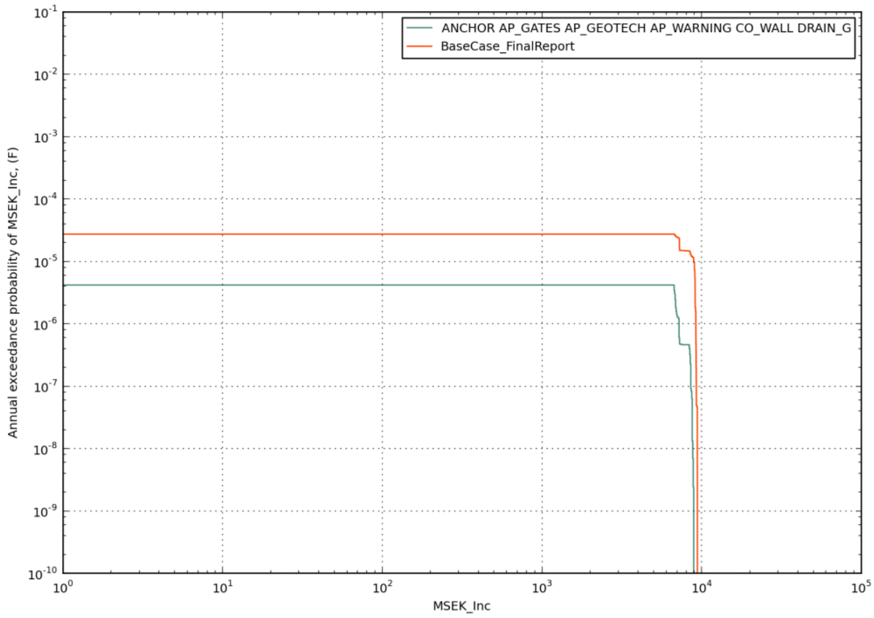


Figure 25. Impact in Risk of all alternatives together (F-D Chart; D in Millions of SEKs)

6 Optimum sequences of risk management alternatives

In the previous chapter, the impact of each alternative under study was evaluated by comparing a base case risk model with a modified risk model that incorporated the effect of each particular alternative.

Moreover, the difference between the results of the original and the modified model, which is the impact on risk, can be measured through different indicators. Once all alternatives have been evaluated separately, it is possible to recommend which one should be implemented first on the basis of the calculated risk indicators. Then, the analysis is repeated assuming the first measure has already been implemented (in order to capture in an adequate way possible nonlinearities in the superposition of measures).

By following this process iteratively a measure implementation sequence emerges, which is optimal with regard to the employed criterion. This type of sequence proves to be a very helpful tool in safety management of critical infrastructure. However, it should be mentioned that risk informed decision-making is very complex, and not only technical aspects are important, but political, psychological and societal considerations may also play a significant role.

Results on different prioritizations according to all different principles, indicators and variables discussed previously in this **MEMORY** have been obtained by means of the software iPresas-manager (www.ipresas.com).

Such results have been grouped when the optimum sequence obtained has been the same. In particular, it has happened for the following sets of indicators:

- Indicators considering loss of life: CSLS, ACSLS and EWACSLS
- Indicators focused on cost per prevented failure and cost benefit ratio: CSFP, ACSFP and CBR
- Minimization of social risk
- Minimization of economic risk and failure probability

It is important to mention than simulations have been run under one particular restraint: when either the complete or the partial cut off wall have been chosen at a particular step, based on the value of any of the indicators, the other possibility cannot be later chosen and it is removed from the options.

Figures 26, 28, 30 and 32 show, for the four different set of results, the “implementation step” as plotted against the most representative variable for each case, which are social risk, economic risk, social risk and probability of failure respectively. Figures 27, 29, 31 and 33 show the risk reduction path plotted against USBR Tolerability Guidelines graph.

Tables 4, 5, 6, 7 show the "implementation cost" at each step together with the reduction achieved in terms of "Failure Probability", "Incremental Economic Risk" and "incremental "Societal Risk", for the same four sets of sequences.

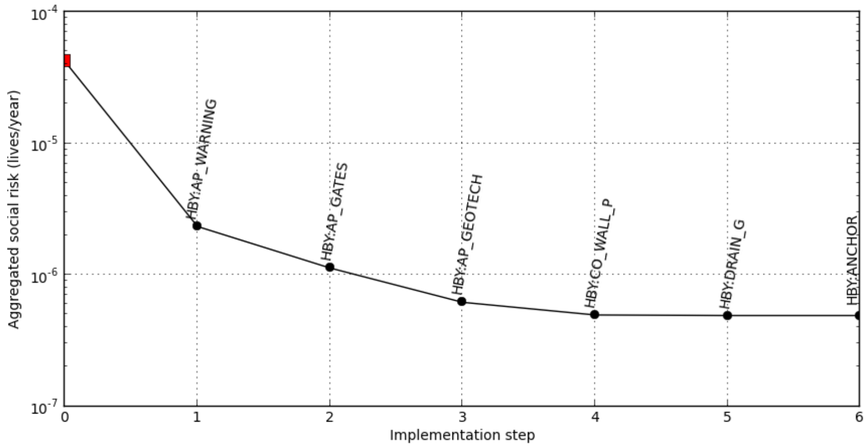


Figure 26. Optimum sequence given by indicators considering loss of life CSLS, ACSLS and EWACSLS

Table 4. Cost versus risk reduction for the optimum sequence given by indicators considering loss of life CSLS, ACSLS and EWACSLS

Step		Costs Present Value	Failure Probability	Incr. Eco. Risk	Incr. Social Risk
		(MSEK)	(1/Year)	MSEK/Year	Lives/Year
0	BASE CASE		2.75E-05	2.22E-01	3.39E-05
1	AP_WARNING	2.77	2.75E-05	2.22E-01	2.33E-06
2	AP_GATES	7.94	1.31E-05	9.39E-02	1.13E-06
3	AP_GEOTECH	11.72	7.41E-06	5.30E-02	6.18E-07
4	CO_WALL_P	53.60	6.04E-06	4.31E-02	4.95E-07
5	DRAIN_G	57.92	5.98E-06	4.26E-02	4.90E-07
6	ANCHOR	68.37	5.98E-06	4.26E-02	4.90E-07

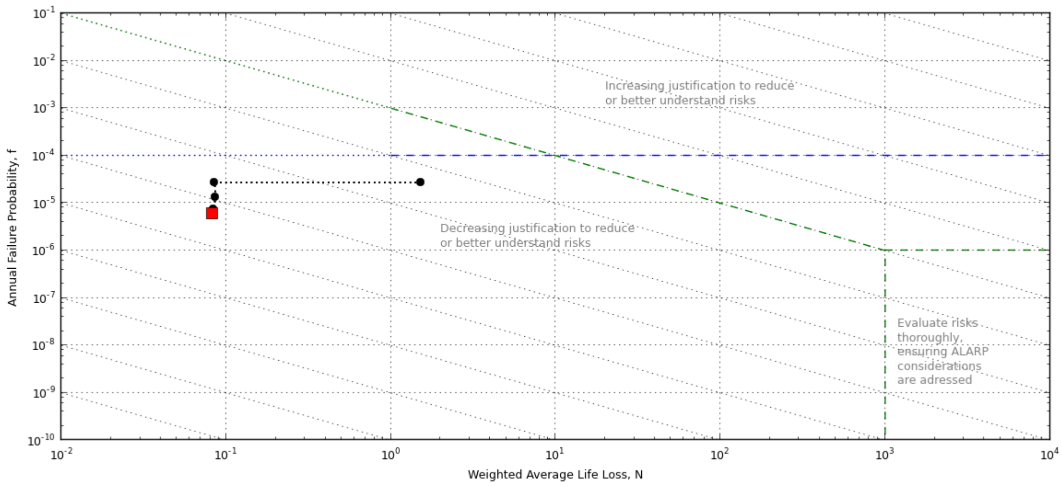


Figure 27. Risk reduction path for the optimum sequence given by indicators considering loss of life CSLS, ACSLS and EWACSLS

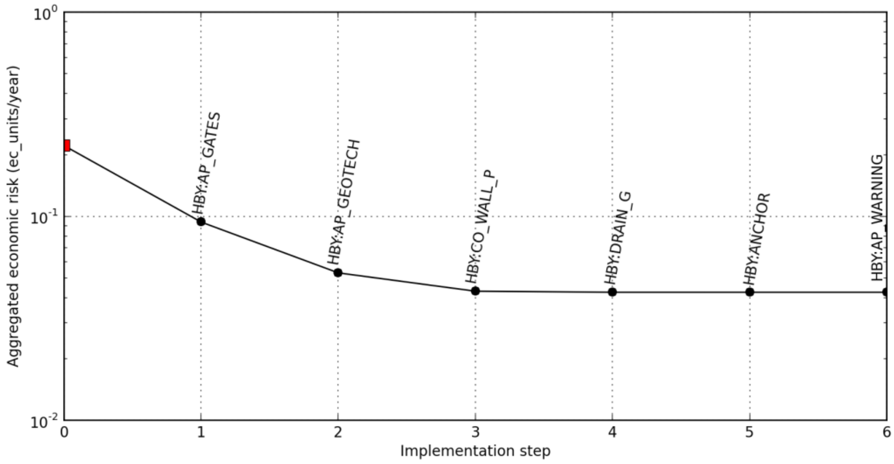


Figure 28. Optimum sequence given by indicators focused on cost per prevented failure and cost benefit ratio: CSFP, ACSFP and CBR

Table 5. Cost versus risk reduction for the optimum sequence given by indicators focused on cost per prevented failure and cost benefit ratio: CSFP, ACSFP and CBR

Step		Costs Present Value	Failure Probability	Incr. Eco. Risk	Incr. Social Risk
		(MSEK)	(1/Year)	MSEK/Year	Lives/Year
0	BASE_CASE	0.00	2.75E-05	2.22E-01	3.39E-05
1	AP_GATES	5.17	1.31E-05	9.39E-02	3.27E-05
2	AP_GEOTECH	8.95	7.41E-06	5.30E-02	1.36E-05
3	CO_WALL_P	50.83	6.04E-06	4.31E-02	9.06E-06
4	DRAIN_G	55.15	5.98E-06	4.26E-02	9.06E-06
5	ANCHOR	65.60	5.98E-06	4.26E-02	9.06E-06
6	AP_WARNING	68.37	5.98E-06	4.26E-02	4.90E-07

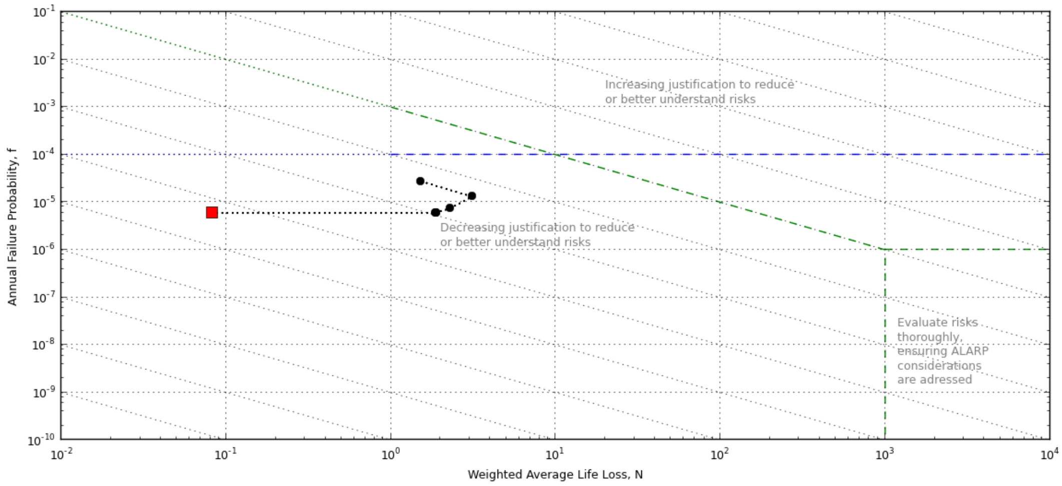


Figure 29. Risk reduction path for the optimum sequence given by indicators focused on cost per prevented failure and cost benefit ratio: CSFP, ACSFP and CBR

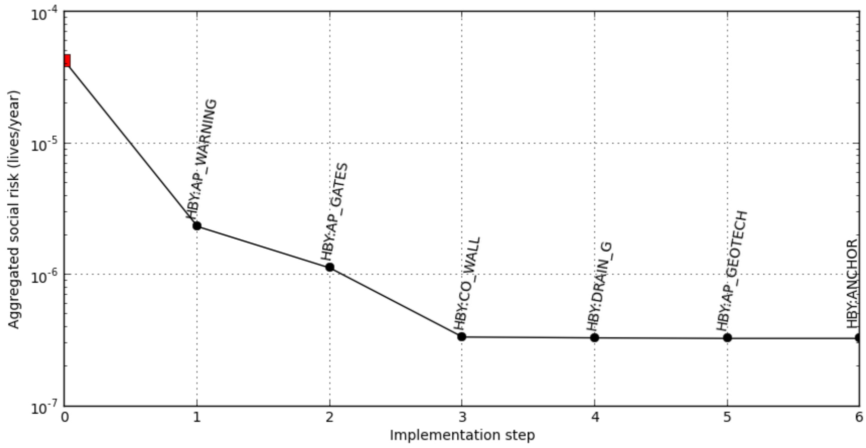


Figure 30. Optimum sequence given by minimization of social risk

Table 6. Cost versus risk reduction for the optimum sequence given by minimization of social risk

Step		Costs Present Value	Failure Probability	Incr. Eco. Risk	Incr. Social Risk
		(MSEK)	(1/Year)	MSEK/Year	Lives/Year
0	BASE_CASE	0.00	2.75E-05	2.22E-01	3.39E-05
1	AP_WARNING	2.77	2.75E-05	2.22E-01	2.33E-06
2	AP_GATES	7.94	1.31E-05	9.39E-02	1.13E-06
3	CO_WALL	392.68	4.27E-06	3.03E-02	3.37E-07
4	DRAIN_G	397.00	4.21E-06	2.98E-02	3.32E-07
5	AP_GEOTECH	400.78	4.17E-06	2.96E-02	3.29E-07
6	ANCHOR	411.23	4.17E-06	2.95E-02	3.29E-07

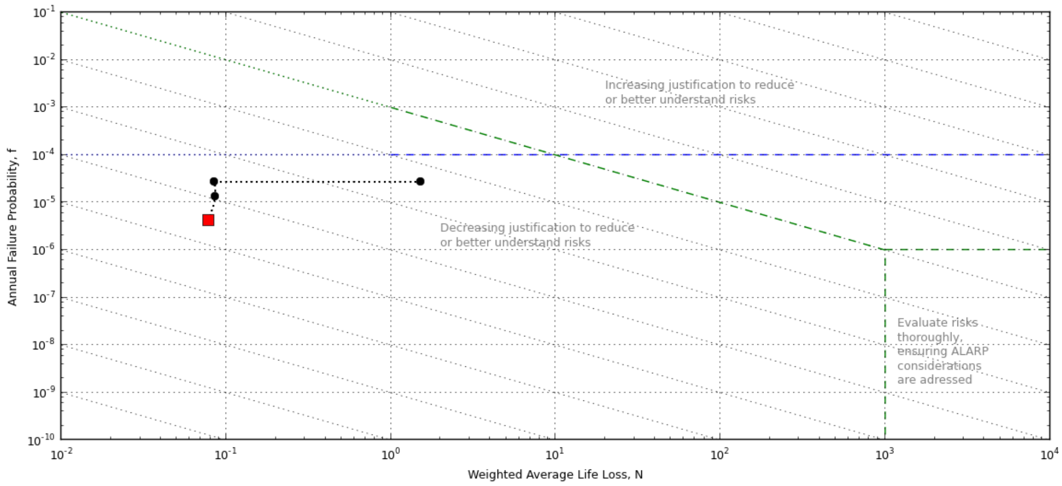


Figure 31. Risk reduction path for the optimum sequence given by minimization of social risk

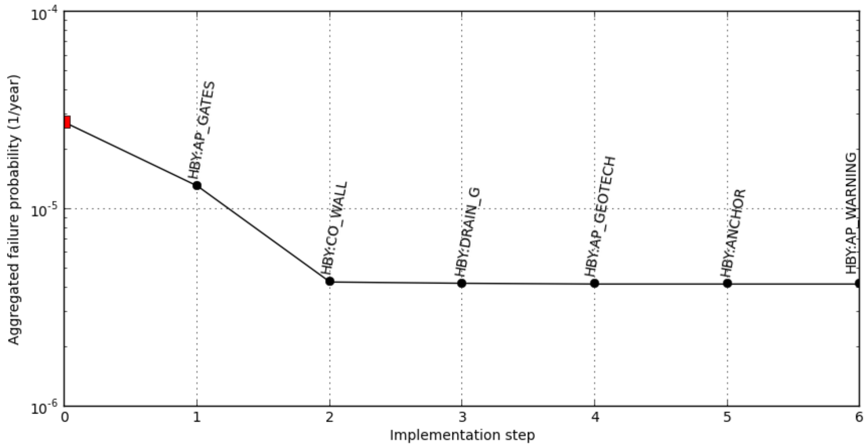


Figure 32. Optimum sequence given by minimization of failure probability and economic risk

Table 7. Cost versus risk reduction for the optimum sequence given by minimization of failure probability economic risk

Step		Costs Present Value (MSEK)	Failure Probability (1/Year)	Incr. Eco. Risk MSEK/Year	Incr. Social Risk Lives/Year
0	BASE_CASE	0.00	2.75E-05	2.22E-01	3.39E-05
1	AP_GATES	5.17	1.31E-05	9.39E-02	3.27E-05
2	CO_WALL	389.91	4.27E-06	3.03E-02	3.12E-06
3	DRAIN_G	394.23	4.21E-06	2.98E-02	3.12E-06
4	AP_GEOTECH	398.01	4.17E-06	2.96E-02	2.99E-06
5	ANCHOR	408.46	4.17E-06	2.95E-02	2.99E-06
6	AP_WARNING	411.23	4.17E-06	2.95E-02	3.29E-07

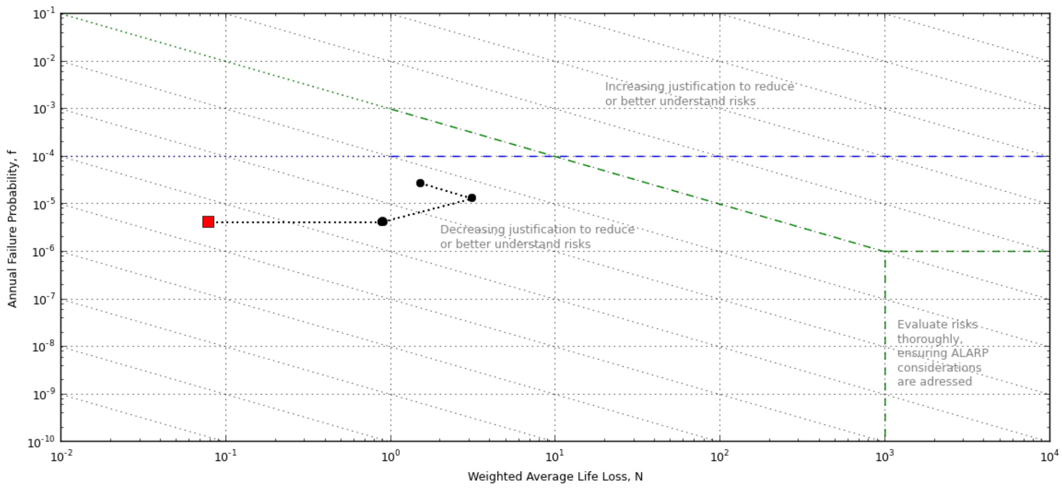


Figure 33. Risk reduction path for the optimum sequence given by minimization of failure probability and economic risk

7 Taxonomy and impact of uncertainties

The process of Risk Analysis incorporates a series of uncertainties that have a relevant impact in the understanding and interpretation of the probability results of the model. The term uncertainty encompasses mainly two concepts of different essence: natural variability and epistemological uncertainty.

It is understood by natural variability the random character inherent to natural processes. It can manifest as the variability along time of phenomena that take place in a precise point of the space (temporal variability) or the variability across the space of phenomena that take place in different points but simultaneously (spatial variability). Classic examples of temporal variability are the magnitude of a flood in a certain section of a river or the intensity of a seismic event in a certain location. Natural variability can be quantified through mathematical models adjusted to reproduce the analyzed phenomenon in a more or less approximate way. The larger the amount of available data, the better the adjustment will be. However, the variability inherent to the natural phenomenon cannot be reduced.

Epistemological uncertainty is related to the lack of knowledge resulting from either insufficient data, or from the incapacity to understand the operating mechanisms of a given phenomenon. This uncertainty can be reduced through the collection of additional information, the gathering of more data and an increase of knowledge. On the contrary, this uncertainty is very difficult to quantify.

Epistemological uncertainty can be divided in two categories: uncertainty of the model and uncertainty of the parameters. The uncertainty of the model refers to the ignorance of the extent to which a model reproduces reality faithfully. It reflects the incapacity of representing reality or of identifying the best model to do it. The uncertainty in the parameters arises from the restricted capacity to estimate them in an adequate manner from a limited number of data from tests or calibration, and also from the inherent limitations of the statistical techniques used in their estimation.

Figure 34 provides an scheme of the taxonomy of common uncertainties in dam safety risk analysis.

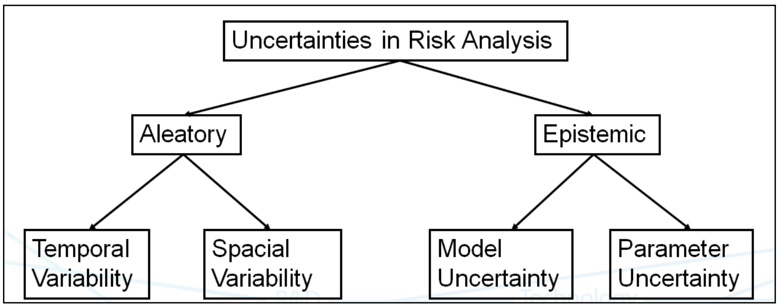


Figure 34. Taxonomy of common uncertainties in dam safety risk analysis (from SPANCOLD Technical Guide on Risk Analysis Applied to Management of dam safety, SPANCOLD 2012)

For the case of Hällby, although a detailed and systematic study on the uncertainty and its sources has not been performed within the scope of the present project, a sensitivity analysis has been performed to illustrate the potential of the issue in terms of informing decision making.

First sensitivity analysis has been run to account for the uncertainty when assessing the gate availability values, whose probabilities were elicitated by the participants on working session 5 (June 2012).

Figure 35 shows the estimation of the uncertainty in assessing the reliability of a single gate after computing the developed fault tree with the individual probability estimations of each participant. Figure 36 shows the impact of assuming either the highest or the lowest estimates within the risk model in terms of informing decision making.

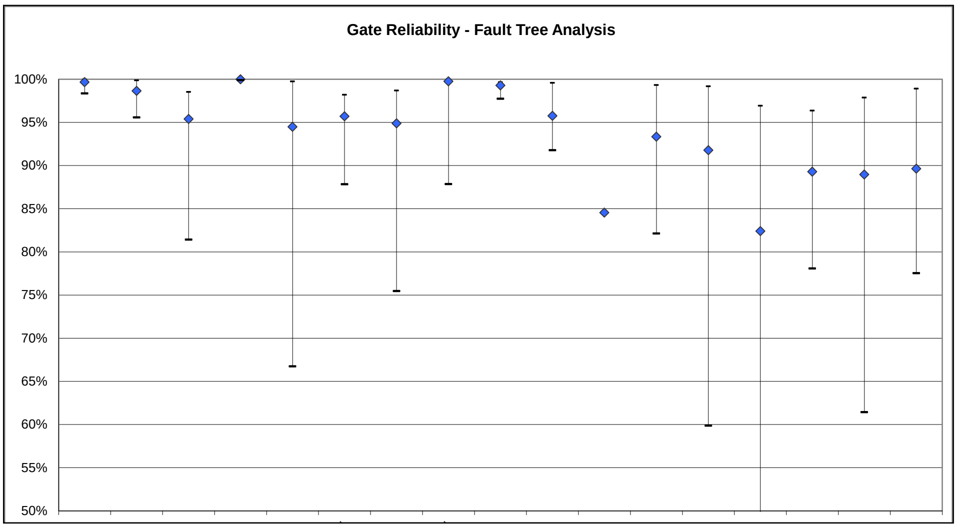


Figure 35. Estimation of the overall spillway gate reliability by running the fault tree with the individual probability estimations of each participant in working session 5 (17 participants)

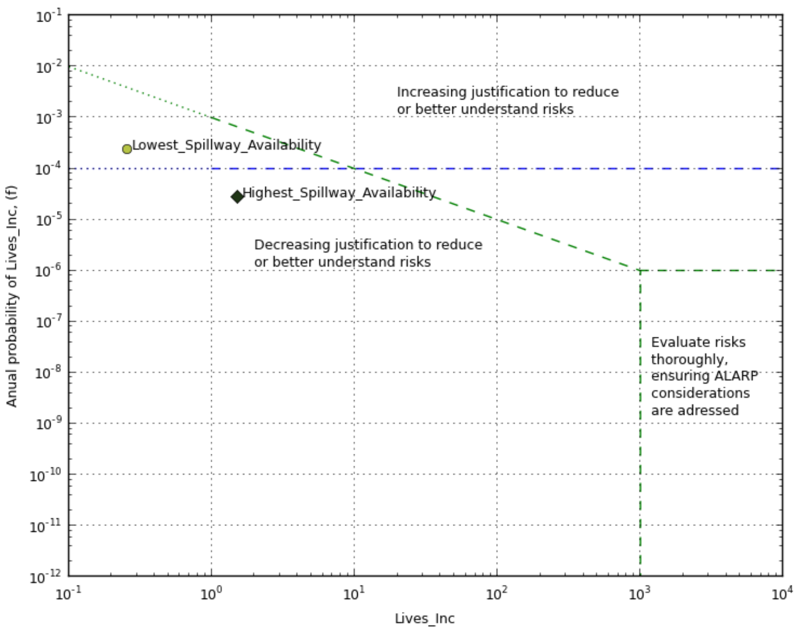


Figure 36. Estimation of the impact o impact of assuming either the highest or the lowest estimates for individual gate reliability within the risk model in terms of informing decision making (USBR Guidelines)

Second sensitivity analysis has been run to account for the uncertainty when assessing all factors that influence the life loss estimates, being the most important the warning times whose values were also elicitated by the participants on working session 5 (June 2012).

As already described in chapter 2 of the present **MEMORY**, the order of magnitude of the impact of warning time as compared to the wave arrival time in the expected life losses was considered an important value due to the number of simplifications and assumptions performed when consequences had to be estimated.

Table 8 shows the difference of the estimated wave arrival time with and without the existing berm, which has led to different fatality estimates as those already shown in Figure 12. Figure 37 shows the impact in risk due to the change of that variable.

Table 8. Difference of the estimated wave arrival time with and without the existing berm (taken from Dam-Break flood simulation and consequence analysis for Hällby Dam facilities, 2007). In parenthesis, times without the berm.

Dam	Actual time in hours after dam breach at Hällby
Hällby	N/A
Gulsele	**5,25 (3,12)**
Degerforsen	**7,15 (4,45)**
Edensforsen	**11,10 (5,45)**
Långbjörn	**12,78 (6,85)**
Lasele	**16,45 (7,85)**
Nämforsen	**17,12 (8,18)**
Moforsen	**No breach**
Forsmo	**No breach**
Sollefteå	**No breach**

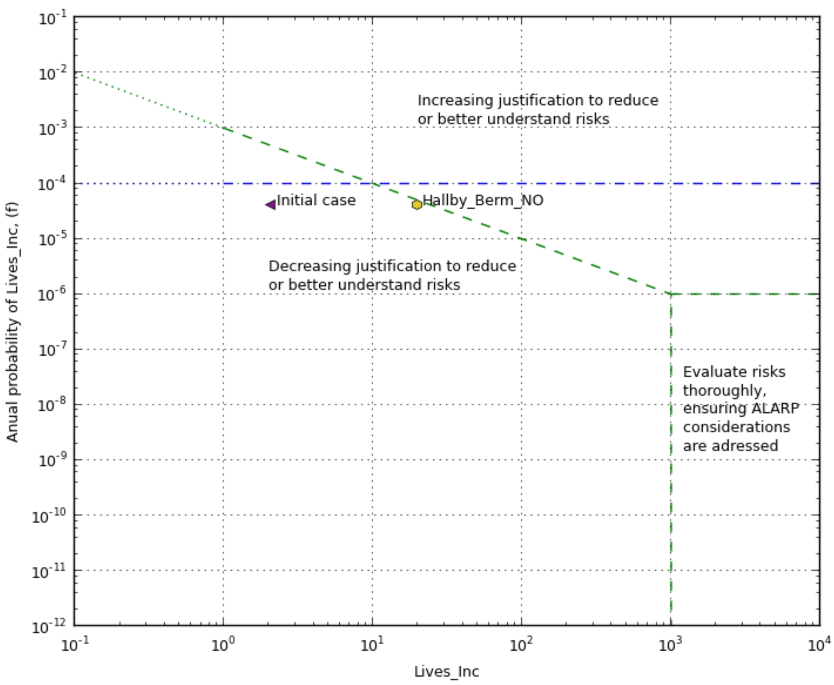


Figure 37. Sensitivity analysis on the relation between Wave Arrival Time and Warning Time for the case with and without the existing berm.

8 Overall achievements, research needs and opportunities

After all the work presented in the previous chapters, it can be affirmed that the essential conditions required for any type of risk management approach to be effective have been achieved within the scope of this project.

In particular, as stated by ISO 31000:2009, such essential conditions are that the approach creates and protects value, can be an integral part of organizational processes and part of decision making, explicitly addresses uncertainty, is systematic, structured and timely, is based on the best available information, is tailored, takes human and cultural factors into account, is transparent and inclusive, is dynamic, iterative and responsive to change, and facilitates continual improvement and enhancement of the organization.

In order to illustrate both the achievements and the potential for research through the components of the developed quantitative risk model for Hällby, Tables 9, 10 and 11 have been built to reflect the different degree of complexity achieved when elaborating the inputs required for the risk model, as well as some issues linked to evaluation and management of Hällby risk, as informed within this project.

In principle, all complexity levels that have not been covered (i.e. going beyond empirical approximate methods in estimating failure consequences) will need an improvement in data availability and may open important windows for research and new developments. In any case, this fact is not only restricted to the not covered complexity issues (as there is always room for improvement) and it does not mean that it has to be completed before moving further (in fact, it is suggested to keep the focus on improvement of current data and applicable techniques while using current best achieved practices to inform today´s decision making issues)

Taken the above mentioned statements into a consideration, some of the main research needs detected are listed below:

- The extension of the applied methodology to a portfolio of dams located along a river reach or a river system. In the Swedish case this would mean analysis of rivers with series of several dams and in some cases with different owners.

- Systematic approach to address the existing interdependencies inside the dam risk model. For instance, a flood event cause by a storm affects the inputs in several parts of the risk model: nodes of gate reliability, nodes of detection and intervention, nodes of consequences, etc. These interdependencies are important because some failures do not come from extreme events with very low probabilities but from unusual events which trigger cascading effects throughout the model, impairing the safety levels.

- The consideration of ice loads within the risk models and its improvement for the Swedish case.

- The estimation of both societal and economic consequences has a lot room to be improved, considering economic models to measure the real impact of a failure for the dam owner.

Table 9. Inputs and degree of complexity achieved for "load" components of the risk model

MODEL COMPONENT	**COMPLEXITY LEVEL 1**	**COMPLEXITY LEVEL 2**	**COMPLEXITY LEVEL 3**
FLOODS	Existing anual hydrographs and interpolation/extrapo lation if needed	Uncertainty analisys over existing hydrology	Seasonal hydrology incorporating uncertainty analysis
PREVIOUS POOL LEVEL	Maximum Operating Pool Level	Historical records adjustment	Inflows and water demands simulation
GATED SPILLWAYS AND OUTLET WORKS RELIABILITY	Standard recommended values	Simplified fault trees plus probability estimates	Complete fault trees plus probability estimates
FLOOD ROUTING	Inflow equals Outflow untill maximum discharge capacity	Operating Rules procedures or clear existing rules for flood routing	Consideration of a full and potentially complex system of water resources

Table 10. Inputs and degree of complexity for "system response" components of the risk model

MODEL COMPONENT	**COMPLEXITY LEVEL 1**	**COMPLEXITY LEVEL 2**	**COMPLEXITY LEVEL 3**
FAILURE MODES	Overtopping	Overtopping Internal Erosion (Emb. D.) Sliding (Concr. D)	All failure modes from expert judgement working sessions
CONDITIONAL FAILURE PROBAILITY	Published general curves	Expert judgment	Numerical modelling and Montecarlo simulations
DAM BREACH AND HYDROGRAPHS	Those included in Emergency Action Plan	Expert judment and distinguishing for each failure mode	Numerical modeling and Montecarlo simulations

Table 11. Inputs and degree of complexity achieved for "consequence" components of the risk model, impact of corrective measures and uncertainty

MODEL COMPONENT	*SIMPLIFIED LEVEL*	*INTERMEDIATE LEVEL*	*ADVANCE LEVEL*
CONSEQUENCES	Empirical methods for damage plus interpolation from Emergency Action Plans	Empirical methods for damage plus hydraulic simulation of downstream response	Simulation methods for damage plus hydraulic simulation of downstream response
CORRECTIVE MEASURES	Standard actions (many published in scientific literature)	Detailed particular solutions plus approximate budget	Detailed to construction project level
OVERALL UNCERTAINTY	Only sensitivity analysis	Uncertinty over most relevant variables	Complete uncertainty analysis over natural and epistemic components

Moreover, the work herein presented can be considered a first piece of a bigger puzzle: the integrated safety management of infrastructures which are relevant for the society.

Among the identified opportunities that this project opens, it is worth to mention the following examples on how risk models can be connected with ongoing research within ELFORSK or research environments where ELFORSK participates, such as the Dam Safety Interest Group of CEATI:

- The improvement in hydrology and hydrological forecasts under the HUVA project, as well as projects related to dam safety as the "Spillway system reliability project" and the "Debris-pilot project" can be linked with risk models to benchmark their results and their relative impact on dam safety, thus helping to get an added value from them.

- Quantitative risk models as the one developed for Hällby can also be used to extend the applicability of results obtained in projects as the so called "Maintenance and Reinvestment project".

Also in terms of opportunities, the existence of overarching legislative pieces in Europe (Directives) and in other parts of the world, which go beyond specific codes and standards on dam safety is an important support to implement integrated safety management schemes of many different types of risk and a wide spectrum of infrastructures.

Particularly in Europe, the following Directives acknowledge and explicitly require that risk analysis be utilized as the primary tool for critical infrastructure management:

- European Directive 2007/60/EC on the assessment and management of flood risks (so-called EU Flood Directive) considers that floods can be caused by the interaction of a range of sources such as rainfall, river flood, maritime flood or structural collapse (including effects of climate change) in addition to other important hazards such as terrorism, sabotage and vandalism, aimed at destroying flood defence infrastructures.

- European Directive 2008/114/EC on the identification and designation of European critical infrastructures and assessment of the need to improve their safety levels defines “critical infrastructure” as an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions.

Finally, once identified the achievements, research needs and opportunities, it is worth to mention that with today´s state of development on quantitative risk analysis, any dam owner adopting this approach will:

- Reinforce decision making processes so that they are better justified, defensible and transparent (good governance).

- Make sure investments are effective and efficient in risk reduction (cost savings).

- Characterize business risks and ensure they are compatible with mid and long term sustainability of the operator (business sustainability).

9 References

All references needed to either contextualize or fully understand all techniques and procedures employed under this project can be found at the "SPANCOLD Guide on risk analysis applied to dam safety management" (SPANCOLD, 2012).

Among more than 140 different references included at the above mentioned document, some especially important references for expert elicitation have been provided to the participants in the working sessions as pre-readings. Namely:

L. Altarejos-García, I. Escuder-Bueno, A. Serrano-Lombillo & A. Morales-Torres. Factor of safety and probability of failure in concrete dams. Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management – Escuder-Bueno et al. (eds) © 2012 Taylor & Francis Group, London, ISBN 978-0-415-62078-9 251

A. Krounis & F. Johansson The influence of correlation between cohesion and friction angle on the probability of failure for sliding of concrete dams. Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management – Escuder-Bueno et al. (eds) © 2012 Taylor & Francis Group, London, ISBN 978-0-415-62078-9 251

M. Westberg & F. Johansson. System for concrete dam reliability with respect to foundation
Stability. Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management – Escuder-Bueno et al. (eds) © 2012 Taylor & Francis Group, London, ISBN 978-0-415-62078-9 251

Bureau of Reclamation in cooperation with U.S. Army Corps of Engineers: Dam Safety Risk Analysis Best Practices Training Manual. Denver, Colorado, version 2.2 edition, April 2011. Chapters reviewed were:

- Erosion of rock and soil
- Flood overtopping
- Concrete gravity dams
- Concrete buttress dams
- Spillway overtopping
- Internal erosion

Finally, the ELFORSK-iPRESAS shared presentation, on October 2012 CEATI Workshop –Planning for Extreme Events-, entitled "An application of a risk-informed approach to dam safety and dam management in Sweden: Hällby Dam case study", has also been provided as pre-reading.

ANNEXES

ANNEX 1: GLOSSARY

Risk. Risk is the combination of three concepts: what can happen, how likely it is to happen and which are its consequences. In Risk Analysis applied to dam safety, what can happen refers to dam failure (see definition of failure mode), the how likely it is to happen is the combination of the probability of occurrence of certain loads and the conditional failure probability of the dam given those loads (see definition of failure). Finally, the consequences are the facts resulting from the failure of the dam, including economic consequences and loss of life among others (see definition of consequences).

Incremental risk. It is the part of risk exclusively due to the dam failure. It is obtained by subtracting from the consequences of the dam failure the ones that would have happen anyway, that is, even if the dam had not failed.

Failure probability. Within the scope of Risk Analysis applied to dam safety, the concept failure is not limited exclusively to the catastrophic breakage of the dam but includes any event that might produce adverse consequences. In this sense, the terms failure and breakage are interchangeable in this document, which gives them a broader sense.

Consequences. Several adverse effects or consequences can ensure a dam failure:

Damage to people. In principle, apart from loss of life, damage to people could also consider other aspects such as people injured with different degrees of gravity. However, due to the difficulty of quantification of wounded numbers, quantitative analysis usually focuses only on the first aspect.

Direct economic damage caused directly by the impact of the flood and the most visible type. It includes the cost associated with the damage suffered by the dam itself.

Indirect economic damage happening after the event as a result of the interruption of the economy and other activities in the area.

Other damages. Related to environmental damage, social disturbing, loss of reputation, attachment to historical or cultural heritage, etc. All of these aspects are difficult to quantify thereby they are usually treated in a qualitative way.

In Risk Analysis it is common practice to deal with incremental consequences. This means that in case of a flood arriving and the dam failing, only the additional consequences due to the dam failure are considered and not those that would have also taken place if the dam had not failed (in other words, only the consequences of the flood itself are considered). For the purposes of calculation, this means that it is necessary to perform the calculation of consequences for both cases of failure and no failure, then obtaining the incremental consequences through the subtraction of both results.

Loading scenario. To obtain the risk associated with a dam, the calculation is usually disaggregated into various scenarios, depending on the event that originates failure. For instance, a dam can fail when subjected to a flooding or to an earthquake, and it is convenient to do those calculations in a separate way, each situation being called loading scenario.

Failure mode. A failure mode is the particular sequence of events that can cause failure or disrupt function of the dam-reservoir system or part of it. This series of events is associated with a determined loading scenario and has a logical sequence, which starts with a main initial triggering event, is followed by a chain of development or propagation events and culminates in dam failure.

fN graph. An fN graph is a way of representing risk. In this graph, the probability of failure is represented in the vertical axis (f) and its consequences are represented in the horizontal one (N). Thus, risk will be the dimension that combines both axes. In this way risk would be smaller in the lower left corner (orthogonal sense) and would grow towards the upper right corner. The diagonal lines in an orthogonal sense to the one depicted would be the iso-risk lines (lines made of combinations of equal risk value). Logarithmic scales are usually used in this kind of graphs. Note: when the consequences are in economic terms, these graphs are usually referred as **fD**.

FN graph. One of the most extended representations of risk is the FN graph, which is simply the cumulated form of fN graphs. In this way a curve is obtained instead of discreet points. In this curve, the horizontal axis represents the consequences (N) and the vertical axis the probability that these consequences (F) are exceeded. Note: when the consequences are in economic terms, these graphs are usually referred as **FD**.

Event tree. An event tree is a representation of a logical model that includes all the possible chains of events resulting from an initiating event. As its name indicates it is based on the mathematical structure known as tree that is widely used in many other contexts.

Fault tree. A fault tree is a top-down, deductive logical tool in which a major undesired event (failure) is postulated then analyzed systematically. The goal of Fault Tree Analysis (FTA) is to develop all events or combination of events that might cause failure. These events can be of any nature: mechanical faults, human faults, external conditions, etc. The failure or undesirable event analyzed in the tree is called top event and it is drawn in the top part of the diagram. Under it, all the events that might induce the top event to happen are drawn. This is done successively until reaching the lowest level where the basic events (i.e., the ones that do not require further development) are found.

Influence diagram. The influence diagrams are compact conceptual representations of the logic of a system. On its most generic form, an influence diagram is any representation including the relations between possible events, states of the environment, states of the system or subsystems, and consequences. An influence diagram offers a visual representation of a risk model. Each variable of the system is represented as a node and each relation as a connector or arc. It is possible to build an event tree from an influence diagram in order to perform a calculation at a later stage.

Risk Evaluation. Risk evaluation is the process of evaluating the importance of the risk associated with the failure of a dam. The phase of risk evaluation is the point where judgments and values are (implicitly or explicitly) introduced in decision-making by including the notion of risk importance.

ALARP. The criterion ALARP (As low as reasonably practicable) is a concept related to tolerable risks. It means that in order to accept a risk as tolerable, all mitigation measures must be applied as long as their cost is not disproportionably high with regard to the risks they reduce.

Note: this **GLOSSARY** has been extracted from the SPANCOLD Guide on Risk Analysis Applied to management of Dam Safety (SPANCOLD, 2012)

ANNEX 2: DELIVERABLE 4

Sweden, 2012/04/02 to 2012/04/03

This document is accompanied by a zip file with all the presentations and documents which were used during the sessions plus the pictures that were taken. People are referred to in this document and in the accompanying files by their initials. The initials used are:

- MWW: Marie Westberg Wilde (ELFORSK)
- ASL: Armando Serrano Lombillo (CTO R+D, iPresas)
- LAG: Luis Altarejos García (CTO Projects, iPresas)

Day 1 (Stockholm, 2012/04/02)

Day 1 was devoted to the presentation of Phase II "Quantitative risk analysis for Hällby – a case study" followed by the first work session on elicitation of probabilities for the different failure modes.

The morning session started with a short presentation from Marie Westberg Wilde, where project status was reviewed and the main objectives of Phase II were showed to the assistants. It continued with two presentations from iPresas-UPV team.

The first one was made by Luis Altarejos García. It was an introduction to probabilities in the context of risk analysis, why are they needed, what role they play in risk models and how they can be evaluated using different approaches depending upon the available information. The two techniques selected for Hällby dam were briefly introduced: expert judgment and reliability models.

The second presentation was made by Armando Serrano Lombillo. This presentation included an introduction to concepts of probability, stressing the distinction between objective probability and subjective probability and how these two can be mixed in the context of risk analysis. The process of assigning probabilities was presented for the Hällby case, including the use of helpful tools such as verbal mappings of probability. A warm-up training exercise on assigning probabilities and recognizing biases was done by the group before starting with the elicitation of probabilities for the different failure modes of Hällby dam.

Morning session continued with elicitation of probabilities, starting with Failure Mode 1: Internal erosion of the core in the transition zone. The objective was to show the methodology on a step-by-step basis, assuring that everybody got actively involved in the session. The tools used to go through the process were the PDF documents prepared by iPresas engineers for each failure mode, which were available to participants through Project place some days before the session. Luis Altarejos García acted as Facilitator of the session with the help of Armando Serrano Lombillo.

The first step was to review and refresh the Failure Mode 1 description, so all participants were able to understand the chain of events that lead to failure. The proposed failure mode structure was reviewed and the links with the monitoring system of Hällby dam were highlighted. It was reminded that conditional probabilities were to be obtained, so at each step of the failure mode it had to be taken into account that previous steps had already happened.

Then probability elicitation started with node 1 of the failure mode. Care was taken that the whole group had a good understanding of what was being evaluated at every step, trying to bridge the differences derived from each participant’s background, expertise and knowledge on the topic. Analysis of the less likely and more likely factors for the failure mode to progress to node 2 was done. The USBR verbal descriptors of probability used for this node were explained. The purpose was to obtain fragility curves, describing the relationships between the conditional probability of failure and values of one or more loading variables. According to this, the loading variables that were already proposed in previous sessions were discussed by the group. Also the selection of the values of the loading variables where the probability had to be evaluated were discussed. After this, all participants were asked to give their estimations of probabilities for node 1. Water level was adopted as the loading variable in this case. Three water levels were selected: dam crest, top of the core and the normal operating level. Three values of probabilities were needed for each single value of water level: a lower bound, an upper bound and a best estimate. The best estimate could be placed anywhere between the bounding values, not necessarily in the middle.

The same process was repeated for node 2 to end with the morning session.
Afternoon session was devoted to go through nodes 3 to 9 of Failure Mode 1. The process followed for node 1 in the morning session was repeated systematically for the rest of the nodes of this Failure Mode. Discussions were promoted, so all participants had the opportunity to express their opinions and reasoning. Queries and clarifications were made on any relevant aspect of the analyzed failure mode. This rather slow but systematic, step by step process, allowed all participants to be familiar with the dynamics of probability elicitation sessions in the context of risk analysis.

The results of probabilities estimated by each participant were processed during the session by Armando Serrano Lombillo using an ”ad hoc” excel file prepared by iPresas. This made it possible to show the group the results of probabilities estimated for each node by all participants. Using graphics that helped to visualize the ranges of upper and lower bounds and also the best estimate values proposed, everyone could compare his/her estimations with those of the rest of the group. This enhanced the discussions and hard thinking of the participants. Debates took place and finally participants were asked to either maintain their estimations, or to modify them according to the results of the discussion.

Morning session (9:00 – 11:30)

- [MWW] Introduction to Phase II
- [LAG] Introduction to different probability estimation techniques
    - file `01 [LAG] LAG - Methods_probability_assignment.pdf`
- [ASL] Introduction to probability elicitation
    - file `02 [ASL] ASL - Probability elicitation trainning.pdf`

Afternoon session (12:30 – 16:00)

- [Group] Probability elicitation for Failure Mode 1
    - file `03 [iPresas] Probabilities for Failure Mode 1.pdf`

Pictures of Day 1

Day 2 (Stockholm, 2011/09/14)

Day 2 was devoted to the rest of the failure modes of the Hällby dam Risk Model. It was divided into a morning session and an afternoon session.
Morning session started with the elicitation of probabilities for Failure Mode 2: Internal erosion of the core into the foundation, and Failure Mode 3: Internal erosion of the soil foundation. As these two failure modes are linked to internal erosion processes and so they share some features with Failure Mode 1, the process was quite fluent, following the same step by step methodology as for Failure Mode 1.

To allow going through all the relevant failure modes within the day schedule, it was decided that results of comparisons of probabilities from participants would be processed by iPresas team after the session, and then published in the Project place. A period of time of three weeks is going to be given to participants to have the opportunity to review carefully the estimations and to allow changes where considered appropriate.

Morning session continued with the first structural failure mode, which was Failure Mode 4, following the same methodology. In this case, it was proposed by iPresas team to build a mathematical model that will comprise some of the nodes of this failure mode. Doing so, probability elicitation is needed only for some of the nodes. The probability of the rest of the nodes will be obtained using reliability techniques together with a deterministic model of the dam. The main features of the models to be used and the main parameters involved, with their representative ranges of values were discussed by the group. Probability elicitation was done using Reagan's verbal descriptors.

Failure Mode 5: Structural failure of the buttress dam section, was considered to be much less likely than the other failure modes. It was suggested to skip this model in the session. The iPresas engineers will discuss this failure mode in an internal workshop probability elicitation session, to check its relative likelihood in comparison to others. Description of the process followed and the results will be communicated and a decision will be taken regarding the role of this failure mode within the model.

Afternoon session continued with Failure Mode 6: Sliding of concrete dam along a discontinuity in the foundation. As for Failure Mode 4, a combination of a mathematical model together with reliability techniques will be used to estimate the probabilities of some of the nodes. Accordingly, probability elicitation was needed only for the rest of nodes that will not be included in the model. The process followed was the same pattern already described.
The last part of the afternoon session was devoted to Failure Mode 7: Toe erosion at the spillway section, and Failure Mode 8: Overtopping in the embankment session. All the nodes of these failure modes were estimated using probability elicitation.

To end up with the session, participants were asked to evaluate their estimations according to their field of expertise and experience.

Morning session (8:30 – 11:30)

- [Group] Probability elicitation for failure modes 2, 3 and 4
    - file `04 [iPresas] Probabilities for Failure Mode 2.pdf`
    - file `05 [iPresas] Probabilities for Failure Mode 3.pdf`
    - file `06 [iPresas] Probabilities for Failure Mode 4.pdf`

Afternoon session (12:30 – 16:00)

- [Group] Probability elicitation for failure modes 6, 7 and 8
    - file 07 [iPresas] Probabilities for Failure Mode 6.pdf
    - file 08 [iPresas] Probabilities for Failure Mode 7.pdf
    - file 09 [iPresas] Probabilities for Failure Mode 8.pdf

Pictures of Day 2

NEXT STEPS FOR THE WORKING GROUP

Work to be performed before next working session (June 26-29)

- Review, update and/or validation of the probabilities assigned by participants.

ANNEX 3: DELIVERABLE 5

Sweden, 2012/06/26 to 2012/06/27

This document is accompanied by all the presentations and documents which are mentioned below. People are sometimes referred to in this document by their initials. The initials used are:

- MWW: Marie Westberg Wilde (ELFORSK)
- IEB: Ignacio Escuder Bueno (iPresas)
- ASL: Armando Serrano Lombillo (iPresas)
- LAG: Luis Altarejos García (iPresas)

Day 1 (Stockholm, 26/06/2012)

Day 1 was devoted to training and understanding the logic of Hällby's risk model and all the inputs that have gone into it. Also, preliminary risk results were presented and their meaning and implications for the next steps were discussed. The day was divided in the following sessions.

- [MWW, IEB] Project schedule. Where are we in the risk analysis process?
- [ASL] Hällby risk model. Framework and logical structure
    - file `01 Framework and logical structure.pdf`
- [LAG] Hällby risk model. Loading sub-model
- [LAG] Hällby risk model. Response sub-model
- [LAG] Hällby risk model. Consequences sub-model
- [LAG] Hällby risk model. Preliminary results

Figure 1 shows the preliminary results for individual risk. As can be seen, Hällby is just below the USACE (U.S. Army Corps of Engineers) tolerability guidelines (Base Case). Evacuation procedures (EP_Yes) have no impact on individual risk, as individual risk is being assumed equal to failure probability. The impact of the spillway reliability (Gates xx%), which had not been estimated at this point, can be seen, as well as a sensitivity analysis on the uncertainty of the expert elicitation probabilities (Prob Max – Prob Min).

Figure 2 shows how much each FM is contributing to the total probability of failure. As can be seen, FM8 (Overtopping) is the predominant failure mode. Figure 3 shows the impact of the uncertainty in the expert elicitation process and how it can make FM3 (Internal erosion) the top contributing failure mode. Figure 4 shows the impact of spillway availability, and how a high reliability would lower the probability of the Overtopping failure mode to the point where it ceases to be the top contributing failure mode.

This last result in particular prompted the group to spend enough efforts on Day 2 estimating the spillway reliability.

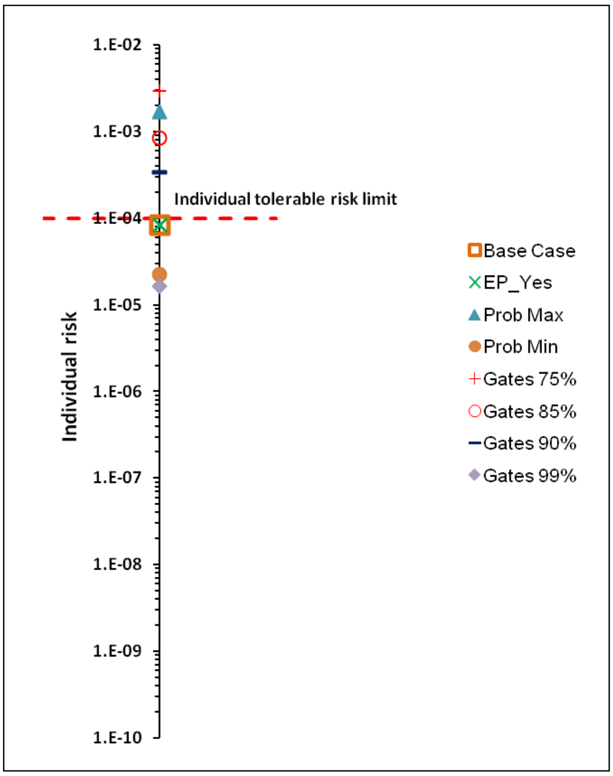


Figure 1. Preliminary results of individual risk for Hällby dam under several hypothesis plotted against USACE tolerability guidelines.

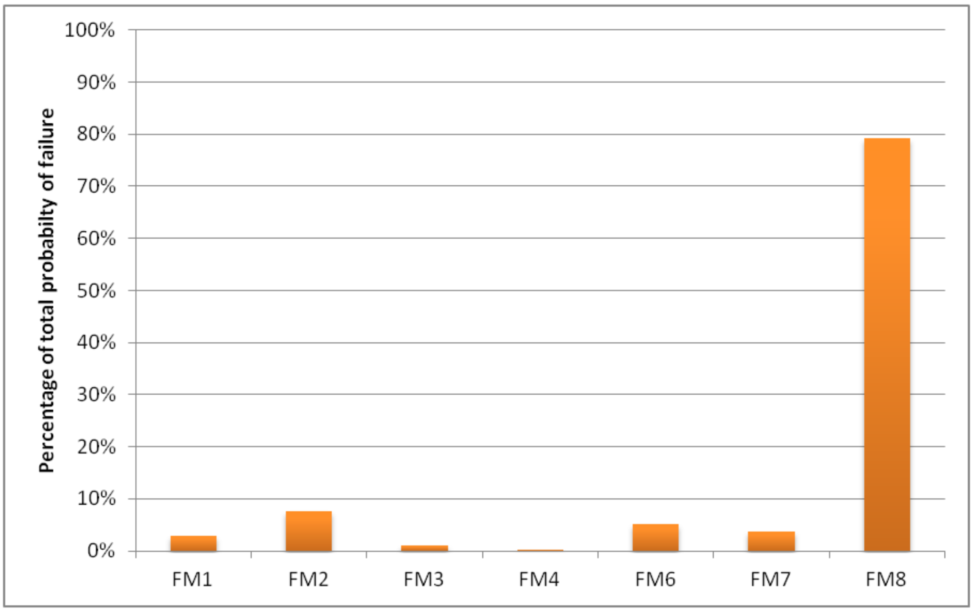


Figure 2. Percentage of total probability of failure for each failure mode (Base case).

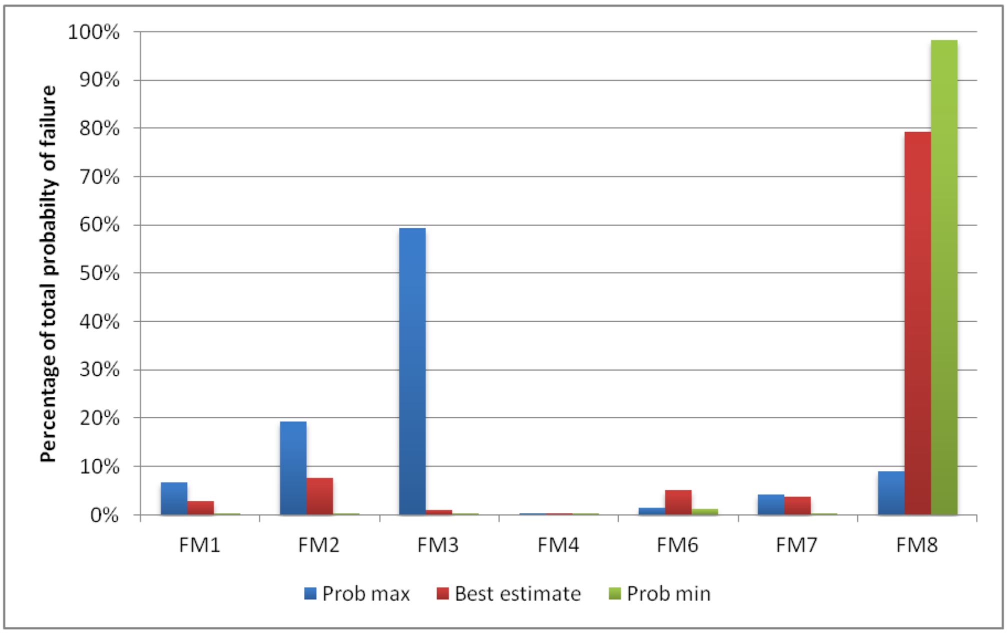


Figure 3. Percentage of total probability of failure for each failure mode (effect of expert elicitation uncertainty).

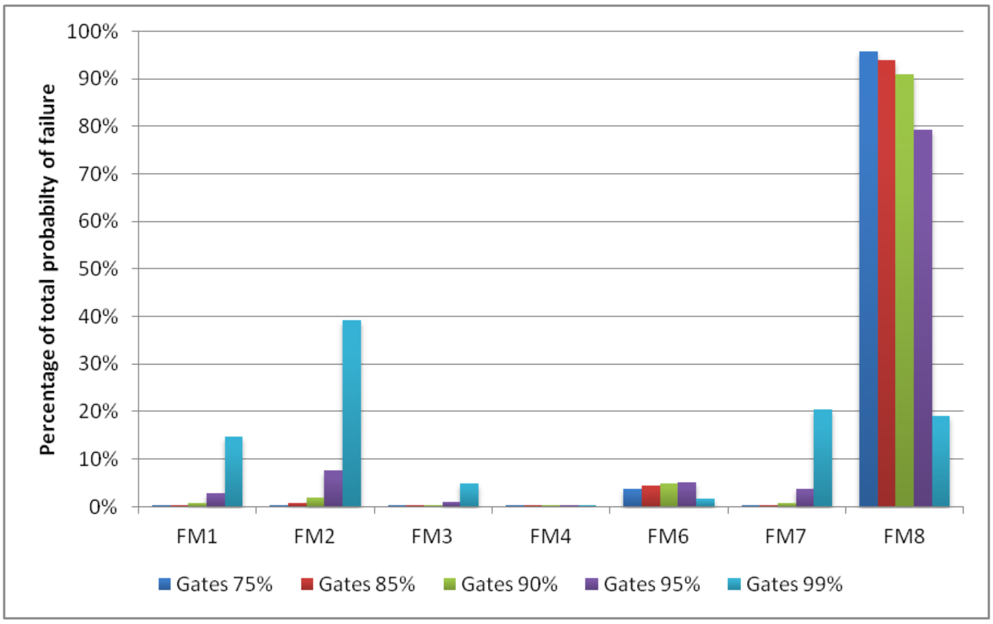


Figure 4. Percentage of total probability of failure for each failure mode (effect of spillway reliability).

Day 2 (Stockholm, 27/06/2012)

Day 2 was mainly devoted to collecting more input from the working group in order to better estimate two aspects of the risk model: spillway reliability and warning time. Some time was also used to collect proposals for risk reduction measures.

For the first issue (spillway reliability), the fault tree developed in previous work sessions was reviewed and discussed, and then a probability elicitation session was carried out. Figure 5 shows the form used to collect the estimates and Figure 6 shows the overall estimates. **Figure 7** shows the impact of these estimates in individual risk.

Probability of gate not opening when needed (24 h) in flood scenario due to:

	Worst case	Best estimate	Best case
MACHINERY BREAKDOWN			
1 Lift machinery failure			
2 Gate structure failure			
POWER FAILURE			
3 Power system failure			
4 Portable 'on site' power system failure			
5 'Off site' diesel system failure			
CONTROL SYSTEM FAILURE			
6 All control systems fail			
HUMAN FACTOR			
7 Accidental			
8 On purpose			
ENVIROMENTAL ISSUES			
9 Debris (not open)			
10 Large amount of debris (blockage)			
11 Lightning			
Overall estimation			

Name:

Figure 5. Form used to collect the estimates regarding gate reliability

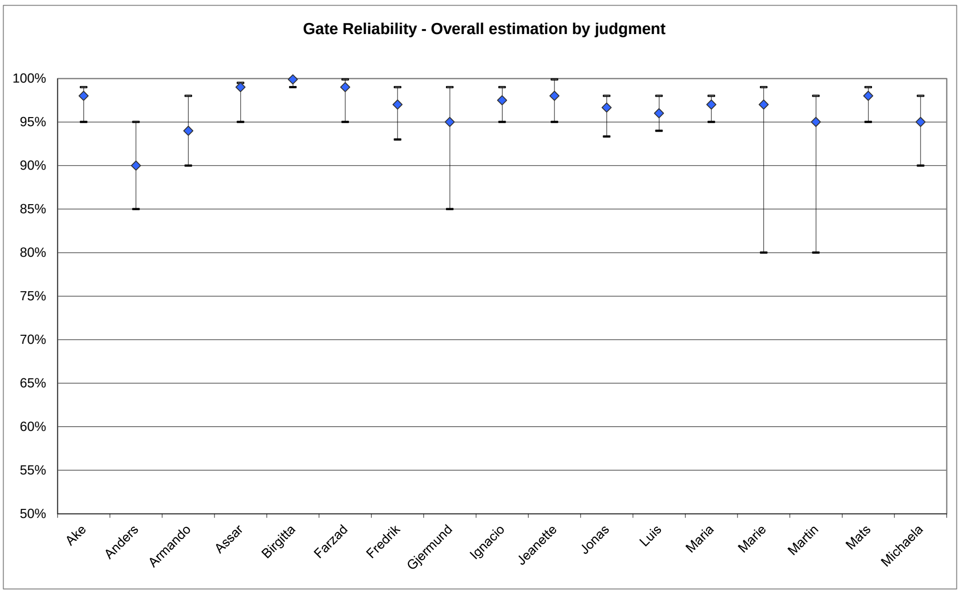


Figure 6. Estimation of the overall spillway gate reliability by each of the working group members.

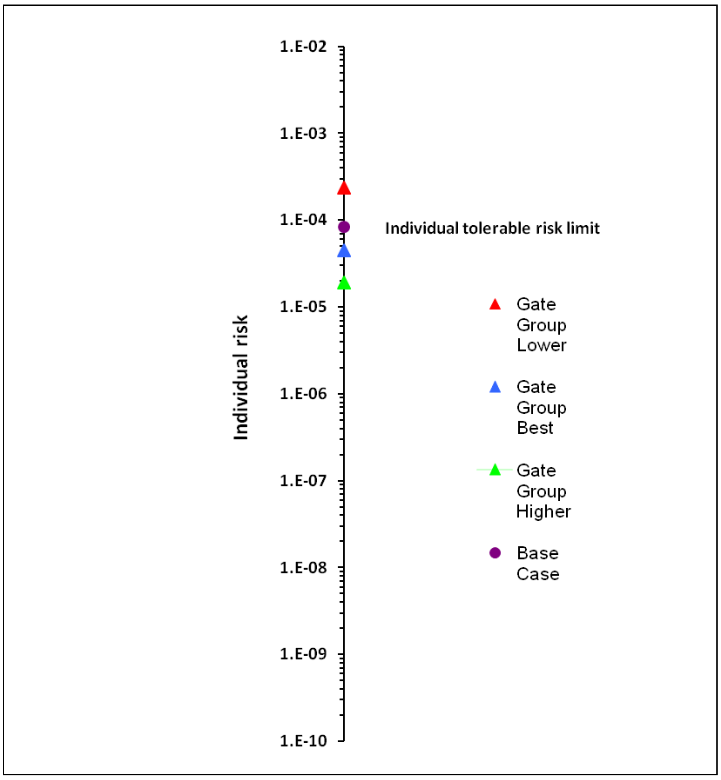


Figure 7. Preliminary results of individual risk for Hällby dam with the overall reliability estimates made during the working session.

All the probability estimations have been post processed. The Fault Tree has been run with the individual probability estimations of each participant and Figure 8 shows the results obtained.

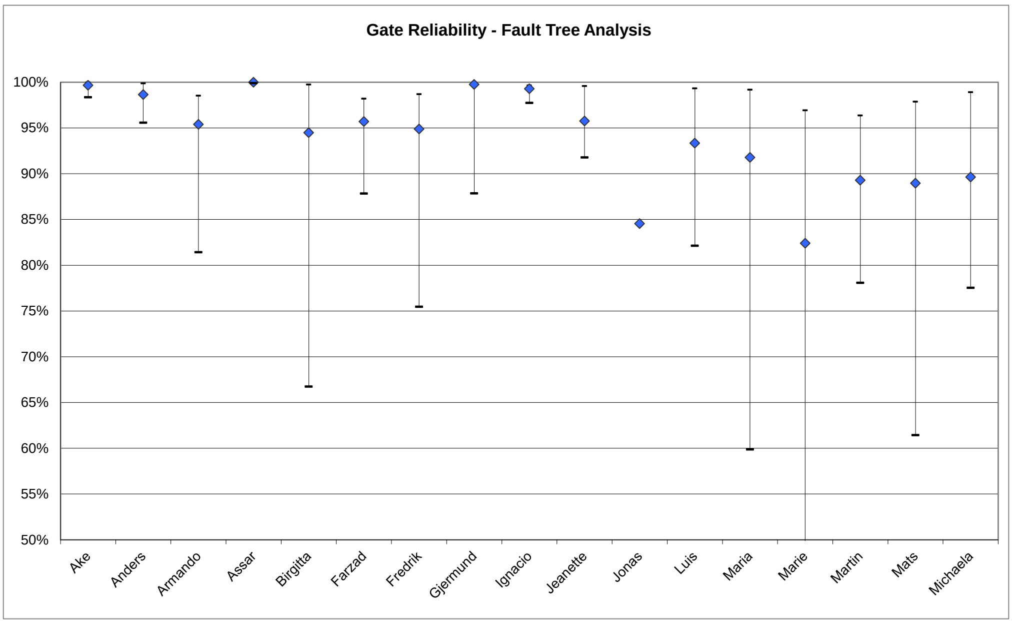


Figure 8. Estimation of the overall spillway gate reliability by running the Fault Tree with the individual probability estimations of each of the working group members.

With all this data, three estimations have been made for the gate reliability (Figure 9):

- The average of the overall estimations.
- The average of the reliabilities obtained by running the Fault Tree with each participant's individual estimations.
- The results obtained by running the Fault Tree with the average of the individual estimations.

As can be seen, the results are similar for the three procedures, which is a positive sign. Note: all the averages have been calculated as geometric averages.

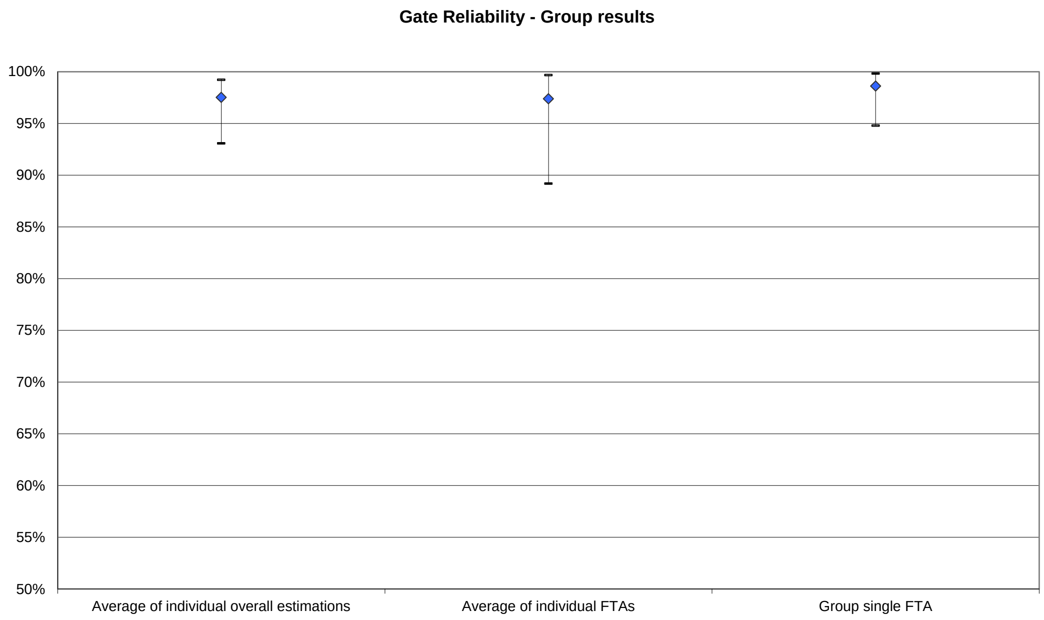


Figure 9. Comparison of the gate reliabilities obtained through different methods.

Regarding the topic of warning time, the process by which the failure of the dam and the evacuation of people downstream of the dam would take place was discussed in detail and estimates for the time each sub process would take were obtained for different failure modes. These estimates will be used for the final version of the risk model.

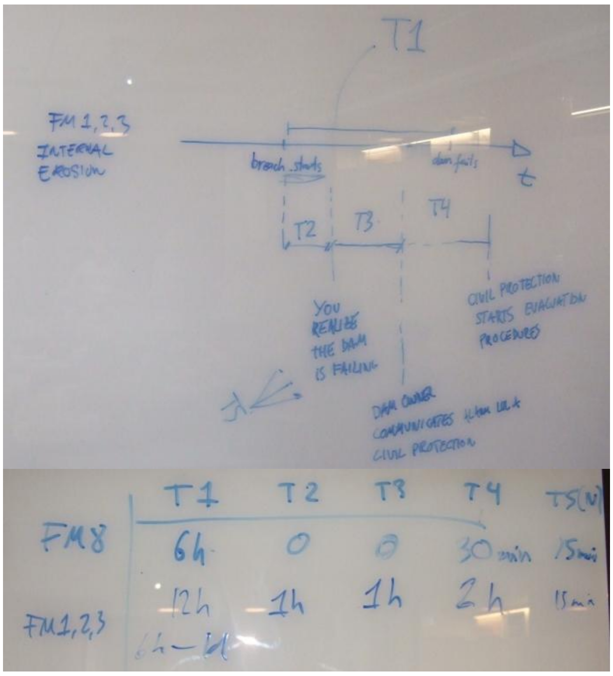


Figure 10. Discussion on components of warning time

Finally, the next table shows the risk reduction measures proposed by the working group members.

Participant	Comment
Åke Nilsson	Increase the spillway capacity since the case 'n-1' cannot discharge a 100-year flood in a safe way. This can be done by operating the bottom outlet. This discharge possibility was used during construction. The bottom outlet needs a new machinery and fairly large new construction downstream to get the gate in operation condition again. The operation can after upgrading and reconstruction be possible to operate if everything else has proved be ineffective. If the bottom outlet can be operated in addition to the spillway this will also be effective to a large blocking of debris. The opening of the bottom outlet should thus be done only in a very late stage and at very high water levels (to avoid overtopping) if everything else has proven to be ineffective.
Anders Marklund	Testing program for emergency diesel Verify that preventive maintenance plans regarding gate machinery is complete Routine for alarm chain, phone numbers, etc. Feasible study regarding long term degradation of sodium chloride
Assar Svensson	Redundant control circuits automation for normal operation and KAS Install camera for viewing dam construction / storage Receive more detailed information to clarify, troubleshooting on gates when problem occurs (renew automation system)
Farzad Ferdos	Electrical resistivity analysis of the embankment dams to see the current situation for the internal erosion to start Some sort of emergency plan for people living exact/at immediate downstream of the dam. Immediate danger zone needs to be addressed more exactly. Some sort of alarm Systems at their houses combined with some educational/informative meetings Increase at least to investigate/built lab/numerical models of the spillway and the effect of the by-passing of huge amount of flood water through (more than 1500 m3/s which bring up the overtopping, toe erosion and stability problems
Fredrik Johansson	Rebuild/model trials for high flows for energy dissipaters
Gjermund Molle	Instrumentation including camera monitoring The dam shall be monitored so that conditions that can be lead to reduction of the plants security may be closed as early as possible
Michaela Dan	Information to population (inundation maps) Emergency discharge capacity, including ensuring reliability of blasting of existing gates Independent assessment of what it is an initiation of sunny day break (hidden): stats the emergency actions Independent assessment of reliability of the whole surveying system (not only instrumentation) Independent assessment of failure modes: internal erosion, overtopping, slope sliding, etc.
Maria Bartsch	From a modeling point of view, get proper input for the consequence sub-model, including the right people in the workshop discussing response plans, successful evacuation, etc. From a safety improvement point of view, finalize the emergency blasting plan to enable "opening" of gates and thus reduce probability of Failure Mode 8 (Overtopping due to gate problem + flood).
Martin Hanson	Calculate the hydraulic and consequences. How many houses are affected? Is it 11 hour to impact or not? Practice alarm plan together with the authorities Make sure the maintenance people are well known with the conclusions of the "best knowledge" of the dam weaknesses. For example: the main issue is the discharge safety. Gate must open. Network connected camera of downstream slope of the dam
Jonas Birkedahl	Management options (what should be considered) • Which FM's are so serious so we need to take care of • Needs of investigation to reduce uncertainties in our judgments • What FM should we work with protection methods • What can we do with emergency plannings • Education of own personal and others • Can we get very early information of these FM if they are in starting position – a lot of time for actions • Activities to reduce the risk if they are started, so it will be in principle not

	¿bigger? risks (both structural and non-structural) • What kind of impact will this give to the organization In the end: you have an organization that is fully aware of the risks and know what to do if indications appear that you might have a problem. Do the same procedures in 5-10 years from now continuously

Next steps for the working group

- Review the risk reduction measures for any errors or omissions.
- Review the gate reliability estimations. For this second task, some material has been prepared. File `02 Fault tree.pdf` contains the fault tree that has been used to make the gate reliability estimations. Please remember that the estimations were made for the second level of nesting. Also, file `03 Gate reliability estimations.pdf` contains the estimations made by each participant as well as the result of running their estimations through the Fault Tree.

ANNEX 4: DELIVERABLE 6

Sweden, 2012/11/14 to 2012/11/16

This document is accompanied by all the presentations and documents which are mentioned below. People are sometimes referred to in this document by their initials. The initials used are:

- IEB: Ignacio Escuder Bueno (iPresas)
- ASL: Armando Serrano Lombillo (iPresas)

Day 1 (Stockholm, 14/11/2012)

Day 1 was devoted to fully explore the results of Hällby's risk model for the current situation or BASE CASE, as well as to define the managing options and their impact on current inputs.
The day was divided in the following sessions.

- [IEB] Project schedule. Where are we in the risk analysis process?
- [IEB and ASL] Hällby risk model. Current risk estimates (BASE CASE)
- [IEB] Sensitivity analysis to gate reliability and warning time

Both current risk estimates and sensibility and uncertainty related to gate reliability and warning time results were given to all participants to support the discussion.

  - file `01 Hällby risk model handbook WS 6.zip`

- [IEB and ASL] Discussion by the group on the risk reduction measures to consider and the implications on the risk model
- [IEB] Expert judgment and new quantitative estimates by the group

Management options were worked out by four different teams devoted to different areas: gates, geotechnical issues, structural aspects and organizational factors. By the end of the day, a representative of each group presented different management options, as well as their impact on the risk model and estimated budget.
As a result, seven different management options have been considered:

1. **AP_GATES**: Action Plan related to the gates (includes a series of actions that increase the gate reliability)
2. **AP_GEOTECH**: Action Plan related to increase the capacity of detection and reaction under a geotechnical driven failure mode.
3. **AP_WARNING**: Action Plan focused on diminishing Warning Time in case of an emergency
4. **CO_WALL_P**: Partial Cut Off wall close by the contact between concrete and rockfill sections
5. **CO_WALL**: Complete Cut Off wall along the axis of the rockfill dam
6. **DRAIN_G**: Improvement of the drainage system under the concrete structures, including grouting and refurbishment of drains
7. **ANCHOR**: Post-tensioned Anchors to increase sliding stability of the concrete structures

Figure 1 illustrates the way data was collected and discussed.

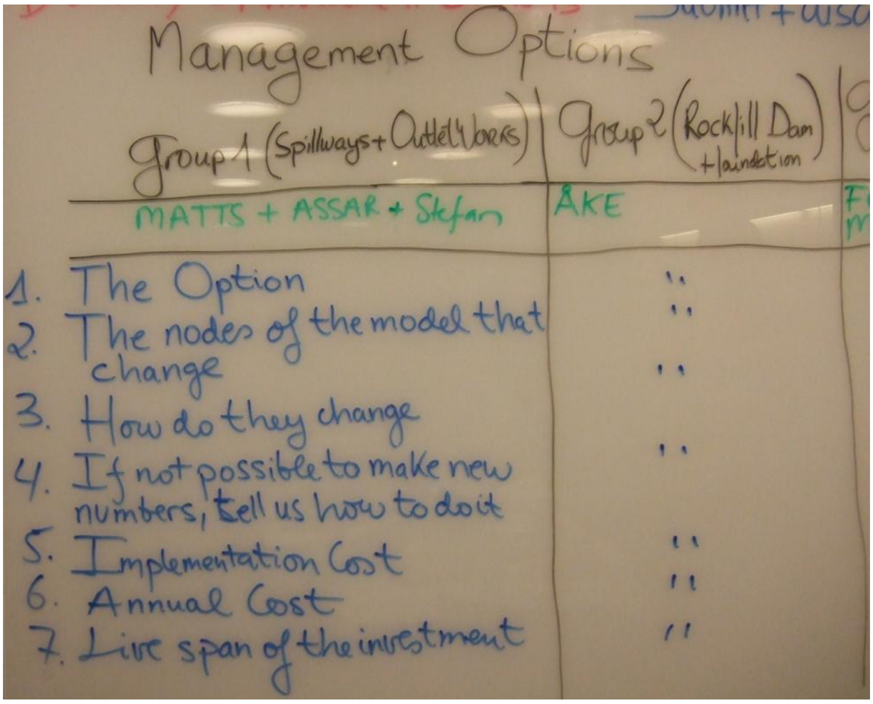


Figure 11. Collection of data from the workshop on management option

Table 1 summarized the input data that have been considered for each management option within the risk model

Variable	Value	Maintenance cost (MSEK)	Introduction cost (MSEK)	Discount rate (%)	Lifespan (years)
CO_WALL	Implemented	0.2	400	5	100
CO_WALL	Implemented_P	0.2	40	5	100
AP_GATES	Implemented	0.2	2	5	40
DRAIN_G	Implemented	0.1	3	5	30
ANCHOR	Implemented	0.05	10	5	75
AP_GEOTECH	Implemented	0.2	0	5	100
AP_WARNING	Implemented	0.1	1.5	5	25

Add measure

OK Cancel

Table 12. Overall characteristics of considered management options

A Zip File, containing the 25 files which are included in the risk model are given (all the in editable format), being all sensitivity inputs and management options included and easy to track (Table 2)

- file `02 Input files to the overall risk model.zip`

0_D6_Sensitivity.txt
1_D6_Expousure_WinterSummer.txt
2_D6_Expousure_DayNight.txt
4_D6_Previous_Pool_Level.txt
5_D6_Spillway_Availability.xls
6_D6_Log_Spillway_Availability.xls
7_D6_Turbine_Availability.xls
8_D6_Routing.xls
9_D6_Conditional_Probabilities_FM1.xls
10_D6_Conditional_Probabilities_FM2.xls
11_D6_Conditional_Probabilities_FM3.xls
12_D6_Conditional_Probabilities_FM4.xls
13_D6_Conditional_probabilities_FM6.xls
14_D6Conditional_Probabilities_FM7.xls
15_D6_Conditional_Probabilities_FM8.xls
16_D6_Consequences_QBreach_Embankment.xls
17_D6_Consequences_QBreach_Concrete.xls
18_D6_T1_BreachStarts_DamFails.xls
19_D6_T2_BreachStarts_BreachDetected.xls
20_T3_BreachDetected_CommunicationCP.xls
21_D6_T4_CommunicationCP_EvacuationStarts.xls
22_D6_T5_DayNight_ExtraTime.xls
23_D6_Basic_Warning_Time.txt
24_D6_Consequences_Economical.xls
25_D6_Consequences_Societal.xls

Table 2. List of files with all inputs to the overall risk model

Al
l management options have been calculated by the software iPresas-Calc (www.ipresas.com) first separately, to obtain the individual impact on current risk, and then sequentially, with all possible combinations.
A Zip File, containing the 7 files of individual results is given:

- file `03 Results one by one.zip`

Another Zip File, containing the 126 different combinations is also given:

- file `04 Results all combinations.zip`

Day 2 (Stockholm, 27/06/2012)

Day 2 was mainly devoted to discuss on different principles (basically equity and efficiency) and indicators to inform decision making for managers, once all risk calculations have been performed.
The day was divided in the following sessions.

- [IEB] Efficiency and Equity indicators to prioritize investments
- [IEB] Results of impact in risk of considered measures, by using and updating the existing Hällby risk model. How to use the updated risk model with investment alternatives to prioritize investments and support dam safety governance.
- [ASL] Summary of computational tools, techniques and capabilities needed to perform a quantitative risk analysis
- [IEB] Conclusions of the session and catalogue of research needs and potential

Presentations used can be found in the following pdf files:

- file `05 Principles and indicators for management options.pdf`
- file `06 Computational tools techniques and capabilities.pdf`
- file `07 Portfolio management example.pdf`
- file `08 Prioritizating investments in dams.pdf`

Results on different prioritizations according to all different principles, indicators and variables discussed on Day 2 have been obtained by means of the software ipresas-manager (www.ipresas.com) and are given grouped when the optimum sequence remains constant:

- Indicators considering loss of life CSLS, ACSLS and EWACSLS
    - file `09 Outcomes of management type 1.zip`
- Indicators focused on cost per prevented failure and cost benefit ratio: CSFP, ACSFP and CBR
    - file `10 Outcomes of management type 2.zip`
- Minimization of social risk
    - file `11 Outcomes of management type 3.zip`
- Minimization of economic risk and failure probability
    - file `12 Outcomes of management type 4.zip`

For such 4 different set of results (Figure 2, 3, 4 and 5), the "Implementation Step" has been plotted against the most representative variable (i.e. social risk for ACSLS), and "Implementation Cost" has been plotted against "Social Risk", "Economic Risk" and "Probability of Failure" in all cases (files 09, 10, 11 and 12).

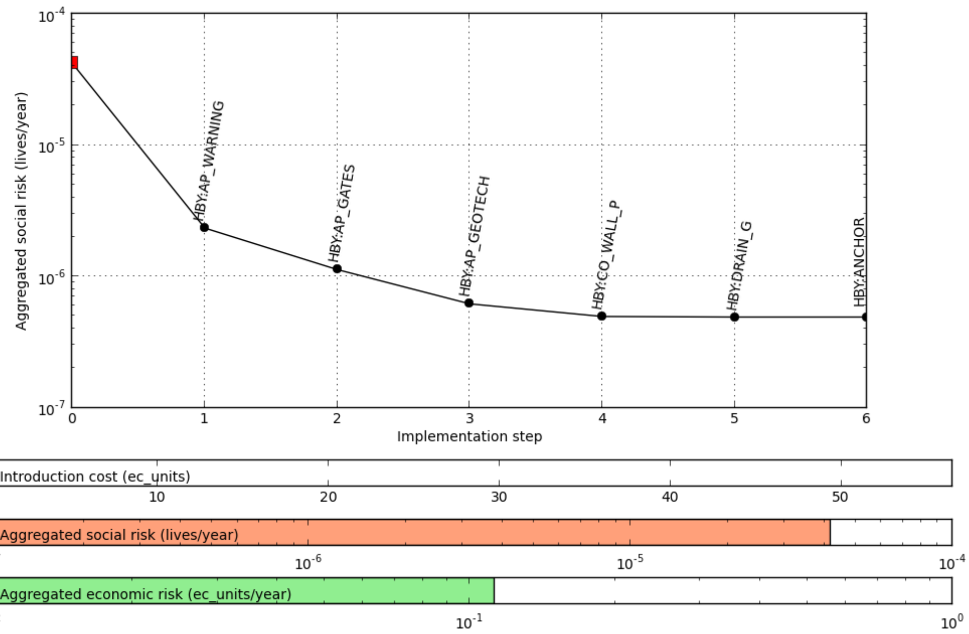


Figure 2. Optimum sequence given by Indicators considering loss of life CSLS, ACSLS and EWACSLS

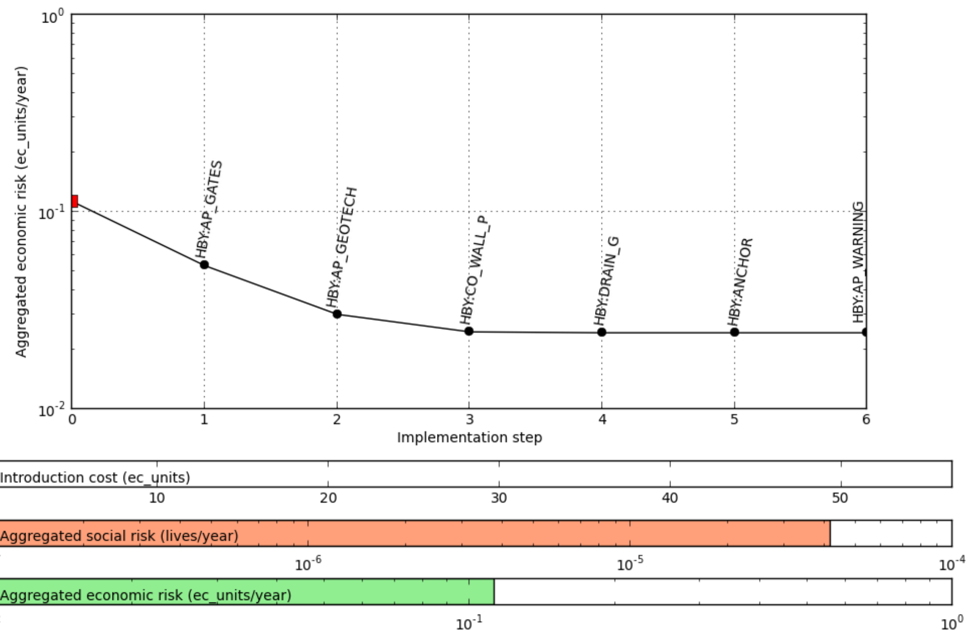


Figure 3. Optimum sequence given by Indicators focused on cost per prevented failure and cost benefit ratio: CSFP, ACSFP and CBR

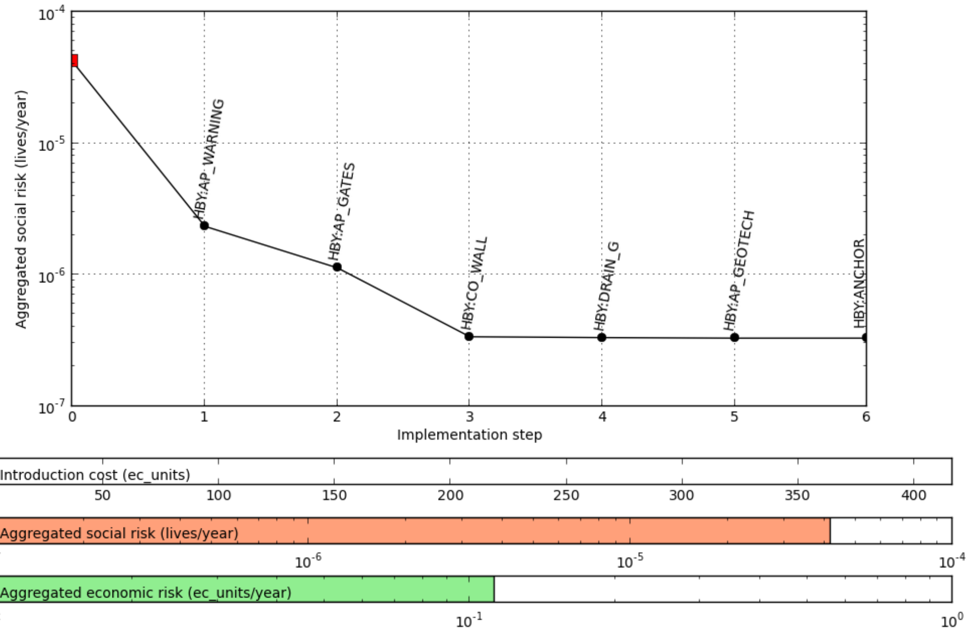


Figure 4. Optimum sequence given by minimization of social risk

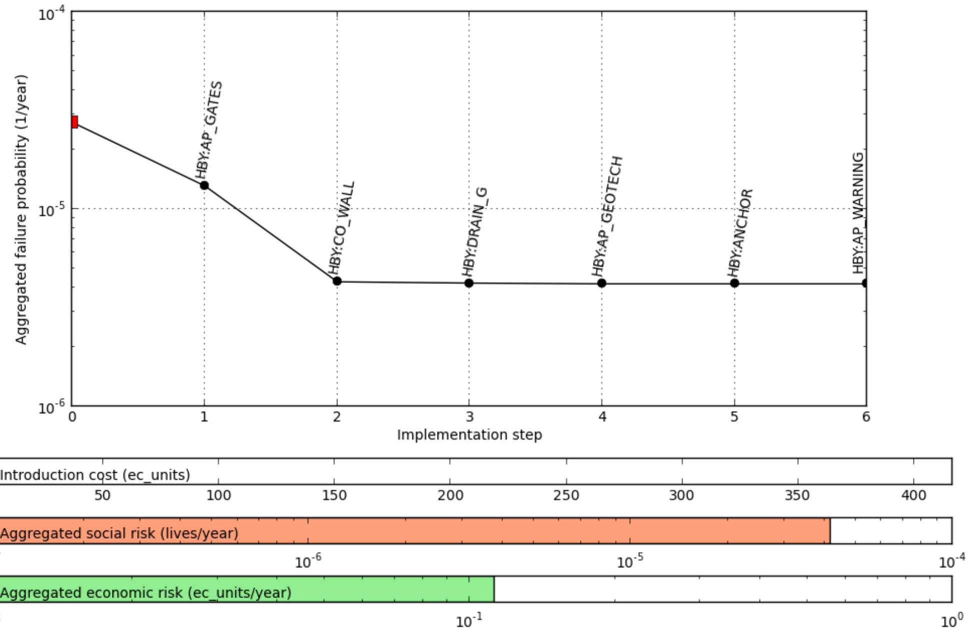


Figure 5. Optimum sequence given by minimization of failure probability and economic risk

Finally, the two higher level files, from where new calculation options or prioritization schemes could be derived in the future are also given:

- file `13 Risk model deliverable 6.rsk`
- file `14 Prioritization.prio`

ANNEX 5: HYPOTHESIS AND CALCULATION OF CONSEQUENCE ESTIMATES

The objective of this ANNEX is to describe the hypotheses and calculations performed for the estimation of potential consequences in case of failure of Hällby dam.

Available and used information and references are presented in the Table 1. A summary of the methodology for estimating consequences is presented as well as an overview of the main hypotheses and data used for calculations, followed by the obtained results.

Note: The detailed results of the consequences estimations related to the specific dam have been excluded from this annex as requested by the dam owner.

Table 1. List of references used for consequence estimation

Ref	*Document Title*
1	*SUFRI Methodology for pluvial and river flooding risk assessment in urban areas to inform decision-making*. SUFRI project 2009-2011. Final report, July 2011. Attachment 1. Full methodology. Pages 1-164. http://www.sufri.tugraz.at/
2	Report 2007 2604300-1 "Dam-break Flood Simulation and Consequence Analysis for Hällby Dam Facilities"
3	Email Jeanette Stenman 2012/05/15 *General comments on consequence estimation in paragraph 5 and 6*
4	Email Jeanette Stenman 2012/07/05 *Notes translated to English from E.On report and other data.* *Attached files: Refs 7-10.*
5	Plan of Alarm
6	Deliverable 5 (Sweden, 2012/06/26 to 2012/06/27)
7	E.ONs report on consequence classification for the Hällby dam Submitted by J.Stenman in Ref. [4] *Based on Hällby dambreak report* 2004 (not available) It is the same report (2007) in Ref. [2]
8	Hällby dambreak report 2007 p13. *Notes on number of flooded houses*
9	Hällby dambreak report 2007 p25. *Notes on arrival wave times at secondary dams*
10	Hällby dambreak report 2004 p24. *Notes on arrival wave times at secondary dams*
11	Inundation maps
12	*Johansson and Kristrom: Modern Cost-Benefit Analysis of Hydropower conflicts, 2011.*
13	SCB, Statistics Sweden, Population and housing, census 1960-1990 (TPR), www.scb.se
14	http://enipedia.tudelft.nl/wiki/Gulsele_Powerplant

Ref. 1 provides the conceptual basis for all assumptions and calculations performed, and it is the result of a European Project under the CRUE-ERA-Net programme, which was finished in 2011 and has been already applied in several sites in Europe (Austria, Germany, Italy and Spain).

Among all the other references, Ref. 2 has been used as the main source of information in order to characterize and estimate potential consequences. More in detail:

- It includes a summary of consequences that result from a dam breach on the right dam: from Hällby dam down to the sea. The dam failure scenario is described and it corresponds with the failure of Hällby Right Dam under Normal Flow Conditions (Sunny Day Failure) with a peak discharge of 6,495 m^3/s.

- It includes a summary of inundated areas, number of damaged objects (houses) and affected infrastructures. Concerning power facilities, data on loss of hydroelectric production or rebuilding costs of power plants are not included.

- It provides flood-wave arrival times. However, the hydraulic model used for the analysis and the corresponding inundation maps are not available.

OVERVIEW OF THE PROCESS FOR ESTIMATING CONSEQUENCES

Potential consequences are divided into two categories, potential loss of life and potential economic damages, and are estimated, first, to analyze the current consequences in case of dam failure.

This situation will be denoted as Base Case which is characterized by:

- Definition of warning times for two types of failure modes: those which require a flood to happen and those which not necessarily require of a simultaneous flood (Ref.6).

- Definition of four time categories for estimating population at risk and warning times: summer/day, summer/night, winter/day and winter/night.

- No Emergency Action Plan (EAP) is currently implemented.

- Flood-wave arrival times are considered with the berm wall in place.

- All population in Gulsele is considered as population at risk in case of dam failure (100 inhabitants).

Other case scenarios are considered for both alternative and sensitivity analysis. In particular:

- Situation with an implemented Emergency Action Plan (EAP) (alternative analysis “AP_Warning”).

- Flood-wave arrival times are considered without the berm wall (sensitivity analysis).

- Definition of different warning times: lower and larger T2-T3-T4 rates. (sensitivity analysis).

- Population in Gulsele is not considered (sensitivity analysis).

Estimation on loss of life is based on the methodology proposed in Ref. 1, which includes the following phases:

- Estimation of population at risk based on density rates and affected houses downstream the dam (Ref.1, p.46).
- Estimation of flood severity levels associated with the hydraulic characteristics of the flood due to dam failure (Ref.1, p.47-48).

- Estimation of warning times at different locations (Ref.1, p.47).

- Estimation of fatality rates based on available warning times and flood severity levels (Ref.1, Table A.1.1).

- Estimation of potential fatalities based on *population at risk* and resulting *fatality rates* (Ref.1, p.49).

The *number of potential fatalities* is obtained by multiplying *population at risk* and *fatality rates* at each considered location (e.g. river section, town, region...).

In order to perform the estimation of economic consequences, also according to the methodology of Ref.1, Ref. 2 provides the sum of inundated areas, buildings and infrastructures in case of dam failure. In addition to these costs, loss of hydroelectric production at secondary dams has also been estimated (Ref. 14).

Next, input data and results for the Base Case and the Alternative and cases of Sensitivity Analysis are summarized.

Note: The detailed results of the consequences estimations related to the specific dam have been excluded from this annex as requested by the dam owner.

ANNEX 6: FULL QUANTITATIVE INPUTS FOR THE RISK MODEL

OVERALL RISK MODEL SCHEME

Note 1: nodes Flood AEP, Ecomom_△ and Societal_△, are set within the software and do not require input data.

Note 2: all input data files, preceed by the label given in the above risk model, are given in the following pages of ANNEX 5.

Model Parameter

0_D6_Sensitivity.txt: Bloc de notas

Archivo Edición Formato Ver Ayuda

#i	Prob	Probability_Case	Berm
	1	best_estimate	yes

Winter/Summer

1_D6_Expousure_WinterSummer.txt: Bloc de notas

Archivo Edición Formato Ver Ayuda

#i	Winter_Summer	Prob
	winter	0.83
	summer	0.17

Day/Night

2_D6_Expousure_DayNight.txt: Bloc de notas

Archivo Edición Formato Ver Ayuda

#i	Day_Night	Prob
	day	0.67
	night	0.33

Previous Pool Level

4_D6_Previous_Pool_Level.txt: Bloc de notas

Archivo Edición Formato Ver Ayuda

#i	Previous_Pool_Level	Prob
	291.20	0.0016
	291.30	0.0155
	291.40	0.0422
	291.50	0.0825
	291.60	0.1498
	291.70	0.2321
	291.80	0.2718
	291.90	0.1813
	292.00	0.0233

Spillway availability

	A	B	C
1	AP_GATES	SpAv	Prob
2	Base	2	0.9481
3	Base	1	0.0512
4	Base	0	0.0007
5	Implemented	2	0.9900
6	Implemented	1	0.0100
7	Implemented	0	0.0000

Log spillway availability

	A	B
1	LSpAv	Prob
2	1	0.9737
3	0	0.0263

Turbine availability

	A	B
1	TurbAv	Prob
2	1	0.99
3	0	0.01

Routing

Previous_Pool_Level	T	TurbAv	SpAv	LSpAv	AEP	MaxWL	OvH	OvT	QSp	QLog	QOv	QTurb	QOut
291.20	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	405.00	521.74	159.42	1385.64	0.00	2066.79
291.30	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	405.50	521.74	159.42	1385.66	0.00	2066.82
291.40	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	406.25	521.74	159.42	1385.69	0.00	2066.85
291.50	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	406.75	521.75	159.42	1385.72	0.00	2066.89
291.60	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	407.50	521.75	159.42	1385.74	0.00	2066.92
291.70	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	408.25	521.75	159.43	1385.77	0.00	2066.95
291.80	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	408.75	521.76	159.43	1385.79	0.00	2066.98
291.90	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	409.50	521.76	159.43	1385.82	0.00	2067.01
292.00	10000.00	0.00	0.00	0.00	0.00	296.27	1.77	410.25	521.77	159.43	1385.84	0.00	2067.03
291.20	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	404.00	509.17	155.58	1297.83	0.00	1962.58
291.30	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	404.50	509.17	155.58	1297.86	0.00	1962.61
291.40	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	405.25	509.18	155.58	1297.89	0.00	1962.65
291.50	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	406.00	509.18	155.58	1297.92	0.00	1962.68
291.60	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	406.50	509.19	155.58	1297.94	0.00	1962.71
291.70	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	407.25	509.19	155.59	1297.97	0.00	1962.75
291.80	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	408.00	509.19	155.59	1298.00	0.00	1962.78
291.90	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	408.75	509.20	155.59	1298.03	0.00	1962.81
292.00	5000.00	0.00	0.00	0.00	0.00	296.20	1.70	409.50	509.20	155.59	1298.05	0.00	1962.84
291.20	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	401.50	479.02	146.37	1095.20	0.00	1720.59
291.30	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	402.25	479.02	146.37	1095.24	0.00	1720.63
291.40	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	402.75	479.03	146.37	1095.28	0.00	1720.68
291.50	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	403.50	479.03	146.37	1095.31	0.00	1720.72
291.60	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	404.25	479.04	146.37	1095.35	0.00	1720.76
291.70	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	405.00	479.05	146.37	1095.38	0.00	1720.80

291.80	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	405.75	479.05	146.38	1095.41	0.00	1720.84
291.90	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	406.50	479.05	146.38	1095.45	0.00	1720.88
292.00	1000.00	0.00	0.00	0.00	0.00	296.04	1.54	407.50	479.06	146.38	1095.48	0.00	1720.92
291.20	500.00	0.00	0.00	0.00	0.00	295.97	1.47	400.25	465.96	142.38	1009.45	0.00	1617.80
291.30	500.00	0.00	0.00	0.00	0.00	295.97	1.47	401.00	465.97	142.38	1009.49	0.00	1617.84
291.40	500.00	0.00	0.00	0.00	0.00	295.97	1.47	401.50	465.98	142.38	1009.53	0.00	1617.89
291.50	500.00	0.00	0.00	0.00	0.00	295.97	1.47	402.25	465.98	142.38	1009.57	0.00	1617.94
291.60	500.00	0.00	0.00	0.00	0.00	295.98	1.48	403.00	465.99	142.39	1009.61	0.00	1617.98
291.70	500.00	0.00	0.00	0.00	0.00	295.98	1.48	404.00	465.99	142.39	1009.65	0.00	1618.03
291.80	500.00	0.00	0.00	0.00	0.00	295.98	1.48	404.75	466.00	142.39	1009.69	0.00	1618.07
291.90	500.00	0.00	0.00	0.00	0.00	295.98	1.48	405.50	466.01	142.39	1009.72	0.00	1618.12
292.00	500.00	0.00	0.00	0.00	0.00	295.98	1.48	406.25	466.01	142.39	1009.76	0.00	1618.16
291.20	100.00	0.00	0.00	0.00	0.01	295.81	1.31	396.75	434.72	132.83	811.49	0.00	1379.04
291.30	100.00	0.00	0.00	0.00	0.01	295.81	1.31	397.50	434.73	132.83	811.54	0.00	1379.10
291.40	100.00	0.00	0.00	0.00	0.01	295.81	1.31	398.25	434.74	132.84	811.59	0.00	1379.17
291.50	100.00	0.00	0.00	0.00	0.01	295.81	1.31	399.00	434.75	132.84	811.64	0.00	1379.23
291.60	100.00	0.00	0.00	0.00	0.01	295.81	1.31	400.00	434.75	132.84	811.69	0.00	1379.29
291.70	100.00	0.00	0.00	0.00	0.01	295.81	1.31	400.75	434.76	132.84	811.74	0.00	1379.35
291.80	100.00	0.00	0.00	0.00	0.01	295.81	1.31	401.75	434.77	132.85	811.79	0.00	1379.41
291.90	100.00	0.00	0.00	0.00	0.01	295.81	1.31	402.50	434.78	132.85	811.84	0.00	1379.47
292.00	100.00	0.00	0.00	0.00	0.01	295.81	1.31	403.50	434.78	132.85	811.89	0.00	1379.52
291.20	50.00	0.00	0.00	0.00	0.02	295.70	1.20	394.25	416.15	127.16	700.00	0.00	1243.30
291.30	50.00	0.00	0.00	0.00	0.02	295.70	1.20	395.00	416.16	127.16	700.06	0.00	1243.38
291.40	50.00	0.00	0.00	0.00	0.02	295.71	1.21	396.00	416.17	127.16	700.12	0.00	1243.45
291.50	50.00	0.00	0.00	0.00	0.02	295.71	1.21	396.75	416.18	127.17	700.18	0.00	1243.53
291.60	50.00	0.00	0.00	0.00	0.02	295.71	1.21	397.75	416.19	127.17	700.24	0.00	1243.60

291.70	50.00	0.00	0.00	0.00	0.02	295.71	1.21	398.50	416.20	127.17	700.30	0.00	1243.67
291.80	50.00	0.00	0.00	0.00	0.02	295.71	1.21	399.50	416.21	127.17	700.36	0.00	1243.74
291.90	50.00	0.00	0.00	0.00	0.02	295.71	1.21	400.50	416.22	127.18	700.42	0.00	1243.81
292.00	50.00	0.00	0.00	0.00	0.02	295.71	1.21	401.50	416.23	127.18	700.47	0.00	1243.88
291.20	10.00	0.00	0.00	0.00	0.10	295.45	0.95	386.25	370.32	113.15	444.30	0.00	927.77
291.30	10.00	0.00	0.00	0.00	0.10	295.45	0.95	387.25	370.34	113.16	444.41	0.00	927.91
291.40	10.00	0.00	0.00	0.00	0.10	295.45	0.95	388.25	370.36	113.17	444.53	0.00	928.05
291.50	10.00	0.00	0.00	0.00	0.10	295.45	0.95	389.25	370.38	113.17	444.64	0.00	928.19
291.60	10.00	0.00	0.00	0.00	0.10	295.45	0.95	390.25	370.40	113.18	444.75	0.00	928.33
291.70	10.00	0.00	0.00	0.00	0.10	295.45	0.95	391.50	370.42	113.18	444.85	0.00	928.46
291.80	10.00	0.00	0.00	0.00	0.10	295.45	0.95	392.50	370.44	113.19	444.96	0.00	928.59
291.90	10.00	0.00	0.00	0.00	0.10	295.45	0.95	393.75	370.46	113.20	445.06	0.00	928.71
292.00	10.00	0.00	0.00	0.00	0.10	295.45	0.95	394.75	370.48	113.20	445.15	0.00	928.84
291.20	5.00	0.00	0.00	0.00	0.20	295.32	0.82	381.00	348.59	106.51	335.93	0.00	791.03
291.30	5.00	0.00	0.00	0.00	0.20	295.32	0.82	382.25	348.62	106.52	336.10	0.00	791.25
291.40	5.00	0.00	0.00	0.00	0.20	295.32	0.82	383.25	348.66	106.53	336.27	0.00	791.46
291.50	5.00	0.00	0.00	0.00	0.20	295.32	0.82	384.50	348.69	106.54	336.44	0.00	791.67
291.60	5.00	0.00	0.00	0.00	0.20	295.32	0.82	385.50	348.72	106.55	336.60	0.00	791.88
291.70	5.00	0.00	0.00	0.00	0.20	295.32	0.82	386.75	348.76	106.56	336.75	0.00	792.08
291.80	5.00	0.00	0.00	0.00	0.20	295.32	0.82	388.00	348.79	106.57	336.91	0.00	792.27
291.90	5.00	0.00	0.00	0.00	0.20	295.32	0.82	389.25	348.82	106.58	337.06	0.00	792.46
292.00	5.00	0.00	0.00	0.00	0.20	295.32	0.82	390.50	348.85	106.59	337.20	0.00	792.64
291.20	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	332.50	481.35	147.08	1110.76	325.00	2064.20
291.30	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	332.75	481.36	147.08	1110.79	325.00	2064.23
291.40	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	333.00	481.36	147.08	1110.82	325.00	2064.26
291.50	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	333.00	481.36	147.08	1110.84	325.00	2064.29

291.60	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	333.25	481.37	147.08	1110.87	325.00	2064.32
291.70	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	333.50	481.37	147.09	1110.89	325.00	2064.35
291.80	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	333.75	481.38	147.09	1110.91	325.00	2064.38
291.90	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	334.00	481.38	147.09	1110.94	325.00	2064.41
292.00	10000.00	1.00	0.00	0.00	0.00	296.06	1.56	334.25	481.38	147.09	1110.96	325.00	2064.43
291.20	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	329.00	468.15	143.04	1023.42	325.00	1959.61
291.30	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	329.25	468.15	143.05	1023.45	325.00	1959.65
291.40	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	329.50	468.16	143.05	1023.48	325.00	1959.68
291.50	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	329.75	468.16	143.05	1023.51	325.00	1959.72
291.60	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	330.00	468.17	143.05	1023.54	325.00	1959.75
291.70	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	330.00	468.17	143.05	1023.56	325.00	1959.79
291.80	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	330.25	468.17	143.05	1023.59	325.00	1959.82
291.90	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	330.50	468.18	143.05	1023.62	325.00	1959.85
292.00	5000.00	1.00	0.00	0.00	0.00	295.99	1.49	330.75	468.18	143.06	1023.64	325.00	1959.88
291.20	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	318.75	436.36	133.33	821.81	325.00	1716.51
291.30	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	319.00	436.37	133.33	821.85	325.00	1716.55
291.40	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	319.25	436.37	133.34	821.88	325.00	1716.60
291.50	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	319.50	436.38	133.34	821.93	325.00	1716.65
291.60	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	319.75	436.39	133.34	821.96	325.00	1716.69
291.70	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	320.00	436.39	133.34	822.00	325.00	1716.74
291.80	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	320.25	436.40	133.34	822.04	325.00	1716.78
291.90	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	320.50	436.41	133.35	822.07	325.00	1716.83
292.00	1000.00	1.00	0.00	0.00	0.00	295.82	1.32	320.50	436.41	133.35	822.11	325.00	1716.87
291.20	500.00	1.00	0.00	0.00	0.00	295.74	1.24	313.50	422.29	129.03	736.78	325.00	1613.10
291.30	500.00	1.00	0.00	0.00	0.00	295.74	1.24	313.75	422.30	129.04	736.82	325.00	1613.16
291.40	500.00	1.00	0.00	0.00	0.00	295.74	1.24	314.00	422.31	129.04	736.86	325.00	1613.21

291.50	500.00	1.00	0.00	0.00	0.00	295.74	1.24	314.25	422.32	129.04	736.91	325.00	1613.27
291.60	500.00	1.00	0.00	0.00	0.00	295.74	1.24	314.50	422.32	129.04	736.95	325.00	1613.32
291.70	500.00	1.00	0.00	0.00	0.00	295.74	1.24	314.75	422.33	129.05	737.00	325.00	1613.37
291.80	500.00	1.00	0.00	0.00	0.00	295.74	1.24	315.00	422.34	129.05	737.04	325.00	1613.42
291.90	500.00	1.00	0.00	0.00	0.00	295.74	1.24	315.25	422.34	129.05	737.08	325.00	1613.47
292.00	500.00	1.00	0.00	0.00	0.00	295.74	1.24	315.50	422.35	129.05	737.12	325.00	1613.52
291.20	100.00	1.00	0.00	0.00	0.01	295.55	1.05	298.00	388.13	118.60	539.84	325.00	1371.57
291.30	100.00	1.00	0.00	0.00	0.01	295.55	1.05	298.25	388.15	118.60	539.92	325.00	1371.66
291.40	100.00	1.00	0.00	0.00	0.01	295.55	1.05	298.50	388.16	118.60	539.99	325.00	1371.76
291.50	100.00	1.00	0.00	0.00	0.01	295.55	1.05	298.75	388.17	118.61	540.07	325.00	1371.85
291.60	100.00	1.00	0.00	0.00	0.01	295.55	1.05	299.00	388.19	118.61	540.14	325.00	1371.94
291.70	100.00	1.00	0.00	0.00	0.01	295.55	1.05	299.25	388.20	118.62	540.22	325.00	1372.03
291.80	100.00	1.00	0.00	0.00	0.01	295.55	1.05	299.50	388.21	118.62	540.29	325.00	1372.12
291.90	100.00	1.00	0.00	0.00	0.01	295.55	1.05	299.75	388.23	118.63	540.36	325.00	1372.21
292.00	100.00	1.00	0.00	0.00	0.01	295.55	1.05	300.00	388.24	118.63	540.43	325.00	1372.30
291.20	50.00	1.00	0.00	0.00	0.02	295.43	0.93	286.00	367.22	112.21	428.01	325.00	1232.44
291.30	50.00	1.00	0.00	0.00	0.02	295.43	0.93	286.25	367.24	112.21	428.12	325.00	1232.57
291.40	50.00	1.00	0.00	0.00	0.02	295.43	0.93	286.50	367.26	112.22	428.24	325.00	1232.72
291.50	50.00	1.00	0.00	0.00	0.02	295.43	0.93	286.75	367.28	112.23	428.34	325.00	1232.84
291.60	50.00	1.00	0.00	0.00	0.02	295.43	0.93	287.00	367.30	112.23	428.44	325.00	1232.98
291.70	50.00	1.00	0.00	0.00	0.02	295.43	0.93	287.25	367.32	112.24	428.56	325.00	1233.12
291.80	50.00	1.00	0.00	0.00	0.02	295.43	0.93	287.75	367.34	112.24	428.66	325.00	1233.25
291.90	50.00	1.00	0.00	0.00	0.02	295.43	0.93	288.00	367.36	112.25	428.77	325.00	1233.38
292.00	50.00	1.00	0.00	0.00	0.02	295.43	0.93	288.25	367.38	112.26	428.87	325.00	1233.51
291.20	10.00	1.00	0.00	0.00	0.10	295.08	0.58	235.00	307.77	94.04	165.99	325.00	892.80
291.30	10.00	1.00	0.00	0.00	0.10	295.08	0.58	235.50	307.84	94.06	166.24	325.00	893.15

291.40	10.00	1.00	0.00	0.00	0.10	295.08	0.58	235.75	307.91	94.08	166.45	325.00	893.44
291.50	10.00	1.00	0.00	0.00	0.10	295.08	0.58	236.00	307.98	94.11	166.68	325.00	893.77
291.60	10.00	1.00	0.00	0.00	0.10	295.08	0.58	236.50	308.05	94.13	166.91	325.00	894.09
291.70	10.00	1.00	0.00	0.00	0.10	295.08	0.58	236.75	308.12	94.15	167.14	325.00	894.41
291.80	10.00	1.00	0.00	0.00	0.10	295.08	0.58	237.25	308.20	94.17	167.37	325.00	894.74
291.90	10.00	1.00	0.00	0.00	0.10	295.08	0.58	237.50	308.27	94.19	167.61	325.00	895.07
292.00	10.00	1.00	0.00	0.00	0.10	295.08	0.58	238.00	308.34	94.21	167.84	325.00	895.39
291.20	5.00	1.00	0.00	0.00	0.20	294.83	0.33	186.50	268.43	82.02	68.05	325.00	743.50
291.30	5.00	1.00	0.00	0.00	0.20	294.83	0.33	187.00	268.55	82.06	68.30	325.00	743.91
291.40	5.00	1.00	0.00	0.00	0.20	294.83	0.33	187.25	268.67	82.09	68.55	325.00	744.32
291.50	5.00	1.00	0.00	0.00	0.20	294.83	0.33	187.75	268.80	82.13	68.81	325.00	744.74
291.60	5.00	1.00	0.00	0.00	0.20	294.83	0.33	188.25	268.92	82.17	69.06	325.00	745.15
291.70	5.00	1.00	0.00	0.00	0.20	294.83	0.33	188.50	269.04	82.21	69.31	325.00	745.56
291.80	5.00	1.00	0.00	0.00	0.20	294.83	0.33	189.00	269.17	82.25	69.57	325.00	745.99
291.90	5.00	1.00	0.00	0.00	0.20	294.83	0.33	189.50	269.30	82.29	69.84	325.00	746.42
292.00	5.00	1.00	0.00	0.00	0.20	294.83	0.33	190.00	269.42	82.32	70.09	325.00	746.83
291.20	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.30	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.40	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.50	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.60	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.70	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.80	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.90	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
292.00	10000.00	0.00	1.00	0.00	0.00	295.64	1.14	231.25	1290.75	123.79	635.66	0.00	2050.20
291.20	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90

291.30	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.40	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.50	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.60	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.70	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.80	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.90	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
292.00	5000.00	0.00	1.00	0.00	0.00	295.56	1.06	222.50	1275.40	119.02	547.48	0.00	1941.90
291.20	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.30	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.40	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.50	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.60	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.70	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.80	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.90	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
292.00	1000.00	0.00	1.00	0.00	0.00	295.32	0.82	194.00	1235.16	106.72	339.26	0.00	1681.14
291.20	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.30	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.40	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.50	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.60	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.70	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.80	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
291.90	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75
292.00	500.00	0.00	1.00	0.00	0.00	295.20	0.70	175.50	1214.60	100.59	247.56	0.00	1562.75

291.20	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.30	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.40	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.50	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.60	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.70	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.80	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.90	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
292.00	100.00	0.00	1.00	0.00	0.01	294.79	0.29	102.00	1143.77	80.10	55.78	0.00	1279.66
291.20	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.30	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.40	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.50	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.60	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.70	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.80	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.90	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
292.00	50.00	0.00	1.00	0.00	0.02	294.37	0.00	0.00	1074.80	61.31	0.00	0.00	1136.11
291.20	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.30	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.40	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.50	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.60	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.70	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.80	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.90	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30

292.00	10.00	0.00	1.00	0.00	0.10	293.08	0.00	0.00	869.15	15.15	0.00	0.00	884.30
291.20	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.30	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.40	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.50	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.60	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.70	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.80	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.90	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
292.00	5.00	0.00	1.00	0.00	0.20	292.43	0.00	0.00	771.23	1.65	0.00	0.00	772.88
291.20	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.30	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.40	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.50	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.60	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.70	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.80	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.90	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
292.00	10000.00	1.00	1.00	0.00	0.00	295.33	0.83	169.25	1236.45	107.11	345.45	325.00	2014.01
291.20	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.30	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.40	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.50	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.60	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.70	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.80	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11

291.90	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
292.00	5000.00	1.00	1.00	0.00	0.00	295.21	0.71	150.75	1215.01	100.71	249.39	325.00	1890.11
291.20	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.30	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.40	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.50	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.60	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.70	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.80	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.90	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
292.00	1000.00	1.00	1.00	0.00	0.00	294.77	0.27	84.00	1140.36	79.14	50.33	325.00	1594.84
291.20	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.30	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.40	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.50	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.60	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.70	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.80	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.90	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
292.00	500.00	1.00	1.00	0.00	0.00	294.46	0.00	0.00	1089.62	65.24	0.00	325.00	1479.86
291.20	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.30	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.40	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.50	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.60	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.70	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25

291.80	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.90	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
292.00	100.00	1.00	1.00	0.00	0.01	293.55	0.00	0.00	941.01	29.24	0.00	325.00	1295.25
291.20	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.30	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.40	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.50	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.60	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.70	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.80	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.90	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
292.00	50.00	1.00	1.00	0.00	0.02	292.96	0.00	0.00	850.78	12.00	0.00	325.00	1187.78
291.20	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.30	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.40	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.50	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.60	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.70	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.80	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.90	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
292.00	10.00	1.00	1.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.20	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.30	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.40	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.50	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.60	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90

291.70	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.80	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.90	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
292.00	5.00	1.00	1.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.20	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.30	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.40	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.50	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.60	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.70	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.80	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.90	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
292.00	10000.00	0.00	2.00	0.00	0.00	293.81	0.00	0.00	1965.62	38.57	0.00	0.00	2004.19
291.20	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.30	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.40	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.50	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.60	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.70	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.80	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.90	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
292.00	5000.00	0.00	2.00	0.00	0.00	293.54	0.00	0.00	1880.94	29.13	0.00	0.00	1910.07
291.20	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.30	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.40	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.50	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34

291.60	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.70	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.80	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.90	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
292.00	1000.00	0.00	2.00	0.00	0.00	292.89	0.00	0.00	1679.11	10.23	0.00	0.00	1689.34
291.20	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.30	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.40	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.50	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.60	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.70	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.80	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.90	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
292.00	500.00	0.00	2.00	0.00	0.00	292.60	0.00	0.00	1591.14	4.07	0.00	0.00	1595.21
291.20	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.30	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.40	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.50	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.60	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.70	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.80	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.90	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
292.00	100.00	0.00	2.00	0.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.20	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.30	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.40	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00

291.50	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.60	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.70	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.80	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.90	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
292.00	50.00	0.00	2.00	0.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.20	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.30	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.40	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.50	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.60	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.70	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.80	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.90	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
292.00	10.00	0.00	2.00	0.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.20	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.30	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.40	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.50	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.60	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.70	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.80	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.90	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
292.00	5.00	0.00	2.00	0.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.20	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.30	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83

291.40	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.50	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.60	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.70	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.80	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.90	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
292.00	10000.00	1.00	2.00	0.00	0.00	292.93	0.00	0.00	1692.54	11.29	0.00	325.00	2028.83
291.20	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.30	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.40	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.50	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.60	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.70	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.80	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.90	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
292.00	5000.00	1.00	2.00	0.00	0.00	292.64	0.00	0.00	1604.66	4.96	0.00	325.00	1934.61
291.20	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.30	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.40	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.50	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.60	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.70	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.80	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.90	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
292.00	1000.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.20	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14

291.30	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.40	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.50	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.60	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.70	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.80	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.90	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
292.00	500.00	1.00	2.00	0.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.20	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.30	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.40	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.50	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.60	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.70	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.80	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.90	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
292.00	100.00	1.00	2.00	0.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.20	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.30	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.40	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.50	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.60	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.70	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.80	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.90	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
292.00	50.00	1.00	2.00	0.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00

291.20	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.30	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.40	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.50	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.60	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.70	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.80	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.90	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
292.00	10.00	1.00	2.00	0.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.20	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.30	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.40	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.50	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.60	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.70	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.80	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.90	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
292.00	5.00	1.00	2.00	0.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.20	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	368.50	488.05	422.17	1155.38	0.00	2065.59
291.30	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	369.00	488.05	422.17	1155.40	0.00	2065.62
291.40	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	369.25	488.05	422.17	1155.43	0.00	2065.66
291.50	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	369.75	488.06	422.17	1155.46	0.00	2065.69
291.60	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	370.00	488.06	422.18	1155.48	0.00	2065.72
291.70	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	370.25	488.07	422.18	1155.51	0.00	2065.75
291.80	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	370.75	488.07	422.18	1155.53	0.00	2065.78
291.90	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	371.00	488.07	422.18	1155.56	0.00	2065.81

292.00	10000.00	0.00	0.00	1.00	0.00	296.09	1.59	371.50	488.08	422.18	1155.59	0.00	2065.84
291.20	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	365.25	475.08	417.23	1068.98	0.00	1961.30
291.30	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	365.75	475.09	417.24	1069.01	0.00	1961.33
291.40	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	366.00	475.09	417.24	1069.04	0.00	1961.37
291.50	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	366.25	475.10	417.24	1069.07	0.00	1961.40
291.60	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	366.75	475.10	417.24	1069.10	0.00	1961.44
291.70	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	367.00	475.11	417.24	1069.13	0.00	1961.48
291.80	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	367.50	475.11	417.25	1069.15	0.00	1961.51
291.90	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	367.75	475.11	417.25	1069.18	0.00	1961.54
292.00	5000.00	0.00	0.00	1.00	0.00	296.02	1.52	368.25	475.12	417.25	1069.21	0.00	1961.58
291.20	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	356.75	443.93	405.33	869.41	0.00	1718.67
291.30	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	357.00	443.94	405.33	869.45	0.00	1718.72
291.40	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	357.50	443.95	405.33	869.49	0.00	1718.77
291.50	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	357.75	443.95	405.34	869.53	0.00	1718.82
291.60	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	358.25	443.96	405.34	869.56	0.00	1718.86
291.70	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	358.50	443.97	405.34	869.60	0.00	1718.91
291.80	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	359.00	443.97	405.34	869.64	0.00	1718.95
291.90	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	359.50	443.98	405.35	869.67	0.00	1719.00
292.00	1000.00	0.00	0.00	1.00	0.00	295.86	1.36	359.75	443.98	405.35	869.71	0.00	1719.04
291.20	500.00	0.00	0.00	1.00	0.00	295.78	1.28	352.25	430.37	400.08	785.08	0.00	1615.53
291.30	500.00	0.00	0.00	1.00	0.00	295.78	1.28	352.75	430.37	400.09	785.12	0.00	1615.58
291.40	500.00	0.00	0.00	1.00	0.00	295.78	1.28	353.00	430.38	400.09	785.16	0.00	1615.63
291.50	500.00	0.00	0.00	1.00	0.00	295.78	1.28	353.50	430.39	400.09	785.21	0.00	1615.69
291.60	500.00	0.00	0.00	1.00	0.00	295.78	1.28	353.75	430.40	400.09	785.25	0.00	1615.74
291.70	500.00	0.00	0.00	1.00	0.00	295.78	1.28	354.25	430.40	400.10	785.29	0.00	1615.79
291.80	500.00	0.00	0.00	1.00	0.00	295.78	1.28	354.50	430.41	400.10	785.34	0.00	1615.84

291.90	500.00	0.00	0.00	1.00	0.00	295.78	1.28	355.00	430.42	400.10	785.38	0.00	1615.90
292.00	500.00	0.00	0.00	1.00	0.00	295.78	1.28	355.50	430.42	400.11	785.42	0.00	1615.95
291.20	100.00	0.00	0.00	1.00	0.01	295.60	1.10	339.50	397.45	387.24	590.87	0.00	1375.55
291.30	100.00	0.00	0.00	1.00	0.01	295.60	1.10	340.00	397.46	387.24	590.93	0.00	1375.64
291.40	100.00	0.00	0.00	1.00	0.01	295.60	1.10	340.25	397.47	387.24	591.00	0.00	1375.72
291.50	100.00	0.00	0.00	1.00	0.01	295.60	1.10	340.75	397.48	387.25	591.07	0.00	1375.80
291.60	100.00	0.00	0.00	1.00	0.01	295.60	1.10	341.25	397.49	387.25	591.13	0.00	1375.88
291.70	100.00	0.00	0.00	1.00	0.01	295.60	1.10	341.75	397.50	387.26	591.19	0.00	1375.95
291.80	100.00	0.00	0.00	1.00	0.01	295.60	1.10	342.00	397.52	387.26	591.25	0.00	1376.03
291.90	100.00	0.00	0.00	1.00	0.01	295.60	1.10	342.50	397.53	387.27	591.31	0.00	1376.11
292.00	100.00	0.00	0.00	1.00	0.01	295.60	1.10	343.00	397.54	387.27	591.37	0.00	1376.18
291.20	50.00	0.00	0.00	1.00	0.02	295.49	0.99	330.00	377.44	379.35	481.78	0.00	1238.57
291.30	50.00	0.00	0.00	1.00	0.02	295.49	0.99	330.50	377.46	379.36	481.87	0.00	1238.68
291.40	50.00	0.00	0.00	1.00	0.02	295.49	0.99	330.75	377.48	379.36	481.96	0.00	1238.80
291.50	50.00	0.00	0.00	1.00	0.02	295.49	0.99	331.25	377.49	379.37	482.04	0.00	1238.91
291.60	50.00	0.00	0.00	1.00	0.02	295.49	0.99	331.75	377.51	379.38	482.13	0.00	1239.01
291.70	50.00	0.00	0.00	1.00	0.02	295.49	0.99	332.25	377.53	379.38	482.21	0.00	1239.12
291.80	50.00	0.00	0.00	1.00	0.02	295.49	0.99	332.75	377.54	379.39	482.29	0.00	1239.23
291.90	50.00	0.00	0.00	1.00	0.02	295.49	0.99	333.25	377.56	379.40	482.38	0.00	1239.33
292.00	50.00	0.00	0.00	1.00	0.02	295.49	0.99	333.75	377.57	379.40	482.46	0.00	1239.44
291.20	10.00	0.00	0.00	1.00	0.10	295.18	0.68	294.00	324.92	358.14	230.39	0.00	913.45
291.30	10.00	0.00	0.00	1.00	0.10	295.18	0.68	294.50	324.98	358.16	230.61	0.00	913.75
291.40	10.00	0.00	0.00	1.00	0.10	295.18	0.68	295.00	325.03	358.18	230.82	0.00	914.03
291.50	10.00	0.00	0.00	1.00	0.10	295.18	0.68	295.50	325.08	358.20	231.03	0.00	914.32
291.60	10.00	0.00	0.00	1.00	0.10	295.18	0.68	296.25	325.14	358.22	231.24	0.00	914.60
291.70	10.00	0.00	0.00	1.00	0.10	295.18	0.68	296.75	325.19	358.25	231.46	0.00	914.89

291.80	10.00	0.00	0.00	1.00	0.10	295.18	0.68	297.25	325.24	358.27	231.66	0.00	915.17
291.90	10.00	0.00	0.00	1.00	0.10	295.18	0.68	298.00	325.30	358.29	231.87	0.00	915.45
292.00	10.00	0.00	0.00	1.00	0.10	295.18	0.68	298.50	325.35	358.31	232.07	0.00	915.73
291.20	5.00	0.00	0.00	1.00	0.20	295.00	0.50	264.25	295.00	345.74	125.48	0.00	766.22
291.30	5.00	0.00	0.00	1.00	0.20	295.00	0.50	264.75	295.10	345.79	125.71	0.00	766.60
291.40	5.00	0.00	0.00	1.00	0.20	295.00	0.50	265.50	295.20	345.83	125.94	0.00	766.97
291.50	5.00	0.00	0.00	1.00	0.20	295.00	0.50	266.00	295.30	345.87	126.17	0.00	767.34
291.60	5.00	0.00	0.00	1.00	0.20	295.00	0.50	266.75	295.41	345.91	126.39	0.00	767.71
291.70	5.00	0.00	0.00	1.00	0.20	295.00	0.50	267.50	295.51	345.96	126.63	0.00	768.09
291.80	5.00	0.00	0.00	1.00	0.20	295.00	0.50	268.00	295.61	346.00	126.85	0.00	768.46
291.90	5.00	0.00	0.00	1.00	0.20	295.00	0.50	268.75	295.71	346.04	127.13	0.00	768.88
292.00	5.00	0.00	0.00	1.00	0.20	295.00	0.50	269.50	295.81	346.08	127.44	0.00	769.32
291.20	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.39	325.00	2060.74
291.30	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.39	325.00	2060.74
291.40	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
291.50	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
291.60	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
291.70	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
291.80	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
291.90	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
292.00	10000.00	1.00	0.00	1.00	0.00	295.87	1.37	278.25	446.16	406.19	883.40	325.00	2060.75
291.20	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.30	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.40	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.50	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.60	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46

291.70	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.80	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.90	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
292.00	5000.00	1.00	0.00	1.00	0.00	295.79	1.29	272.75	432.39	400.87	797.20	325.00	1955.46
291.20	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.30	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.58
291.40	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.50	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.60	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.70	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.80	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.90	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
292.00	1000.00	1.00	0.00	1.00	0.00	295.61	1.11	256.50	398.70	387.73	598.16	325.00	1709.59
291.20	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.80	325.00	1603.89
291.30	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.40	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.50	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.60	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.70	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.80	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.90	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
292.00	500.00	1.00	0.00	1.00	0.00	295.52	1.02	247.75	383.38	381.70	513.81	325.00	1603.89
291.20	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.30	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.40	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.50	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21

291.60	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.70	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.80	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.90	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
292.00	100.00	1.00	0.00	1.00	0.01	295.29	0.79	220.50	344.19	366.02	315.00	325.00	1350.21
291.20	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.30	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.40	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.50	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.60	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.70	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.80	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.90	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
292.00	50.00	1.00	0.00	1.00	0.02	295.13	0.63	197.00	317.15	354.96	199.97	325.00	1197.08
291.20	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.30	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.40	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.50	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.60	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.70	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.80	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.90	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
292.00	10.00	1.00	0.00	1.00	0.10	294.42	0.00	0.00	207.29	307.65	0.00	325.00	839.95
291.20	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.30	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.40	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29

291.50	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.60	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.70	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.80	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.90	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
292.00	5.00	1.00	0.00	1.00	0.20	293.86	0.00	0.00	132.96	272.33	0.00	325.00	730.29
291.20	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.30	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.40	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.50	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.60	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.70	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.80	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.90	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
292.00	10000.00	0.00	1.00	1.00	0.00	295.41	0.91	188.75	1249.60	373.82	409.22	0.00	2032.65
291.20	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.30	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.40	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.50	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.60	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.70	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.80	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.90	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
292.00	5000.00	0.00	1.00	1.00	0.00	295.30	0.80	173.50	1230.98	366.40	319.19	0.00	1916.57
291.20	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.30	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98

291.40	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.50	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.60	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.70	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.80	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.90	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
292.00	1000.00	0.00	1.00	1.00	0.00	294.96	0.46	120.75	1172.94	343.36	112.69	0.00	1628.98
291.20	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.30	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.40	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.50	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.60	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.70	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.80	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.90	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
292.00	500.00	0.00	1.00	1.00	0.00	294.75	0.25	85.00	1136.88	329.11	44.78	0.00	1510.76
291.20	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.30	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.40	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.50	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.60	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.70	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.80	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.90	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
292.00	100.00	0.00	1.00	1.00	0.01	293.98	0.00	0.00	1011.16	279.88	0.00	0.00	1291.03
291.20	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69

291.30	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.40	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.50	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.60	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.70	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.80	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.90	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
292.00	50.00	0.00	1.00	1.00	0.02	293.49	0.00	0.00	931.57	249.12	0.00	0.00	1180.69
291.20	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.30	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.40	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.50	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.60	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.70	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.80	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.90	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
292.00	10.00	0.00	1.00	1.00	0.10	292.23	0.00	0.00	740.98	177.16	0.00	0.00	918.14
291.20	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.30	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.40	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.50	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.60	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.70	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.80	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
291.90	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90
292.00	5.00	0.00	1.00	1.00	0.20	292.00	0.00	0.00	708.01	94.89	0.00	0.00	802.90

291.20	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.30	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.40	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.50	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.60	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.70	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.80	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.90	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
292.00	10000.00	1.00	1.00	1.00	0.00	294.96	0.46	107.50	1173.67	343.65	114.24	325.00	1956.56
291.20	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.30	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.40	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.50	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.60	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.70	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.80	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.90	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
292.00	5000.00	1.00	1.00	1.00	0.00	294.75	0.25	75.25	1136.60	329.00	44.34	325.00	1834.94
291.20	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.30	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.40	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.50	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.60	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.70	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.80	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.90	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93

292.00	1000.00	1.00	1.00	1.00	0.00	293.98	0.00	0.00	1010.36	279.57	0.00	325.00	1614.93
291.20	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.30	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.40	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.50	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.60	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.70	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.80	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.90	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
292.00	500.00	1.00	1.00	1.00	0.00	293.61	0.00	0.00	951.43	256.76	0.00	325.00	1533.19
291.20	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.30	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.40	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.50	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.60	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.70	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.80	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.90	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
292.00	100.00	1.00	1.00	1.00	0.01	292.70	0.00	0.00	811.27	203.38	0.00	325.00	1339.65
291.20	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.30	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.40	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.50	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.60	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.70	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.80	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03

291.90	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
292.00	50.00	1.00	1.00	1.00	0.02	292.18	0.00	0.00	733.61	174.43	0.00	325.00	1233.03
291.20	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.30	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.40	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.50	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.60	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.70	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.80	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.90	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
292.00	10.00	1.00	1.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.20	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.30	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.40	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.50	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.60	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.70	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.80	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.90	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
292.00	5.00	1.00	1.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.20	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.30	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.40	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.50	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.60	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.70	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42

291.80	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.90	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
292.00	10000.00	0.00	2.00	1.00	0.00	293.26	0.00	0.00	1791.94	235.48	0.00	0.00	2027.42
291.20	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.30	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.40	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.50	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.60	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.70	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.80	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.90	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
292.00	5000.00	0.00	2.00	1.00	0.00	293.00	0.00	0.00	1711.38	220.15	0.00	0.00	1931.52
291.20	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.30	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.40	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.50	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.60	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.70	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.80	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.90	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
292.00	1000.00	0.00	2.00	1.00	0.00	292.37	0.00	0.00	1523.61	184.88	0.00	0.00	1708.49
291.20	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.30	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.40	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.50	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.60	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47

291.70	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.80	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.90	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
292.00	500.00	0.00	2.00	1.00	0.00	292.11	0.00	0.00	1446.80	170.67	0.00	0.00	1617.47
291.20	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.30	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.40	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.50	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.60	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.70	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.80	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.90	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
292.00	100.00	0.00	2.00	1.00	0.01	292.00	0.00	0.00	1395.00	0.00	0.00	0.00	1395.00
291.20	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.30	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.40	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.50	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.60	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.70	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.80	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.90	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
292.00	50.00	0.00	2.00	1.00	0.02	292.00	0.00	0.00	1258.00	0.00	0.00	0.00	1258.00
291.20	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.30	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.40	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.50	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90

291.60	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.70	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.80	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.90	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
292.00	10.00	0.00	2.00	1.00	0.10	292.00	0.00	0.00	939.90	0.00	0.00	0.00	939.90
291.20	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.30	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.40	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.50	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.60	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.70	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.80	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.90	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
292.00	5.00	0.00	2.00	1.00	0.20	292.00	0.00	0.00	802.90	0.00	0.00	0.00	802.90
291.20	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.30	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.40	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.50	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.60	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.70	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.80	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.90	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
292.00	10000.00	1.00	2.00	1.00	0.00	292.42	0.00	0.00	1538.43	187.64	0.00	325.00	2051.07
291.20	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.30	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.40	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08

291.50	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.60	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.70	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.80	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.90	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
292.00	5000.00	1.00	2.00	1.00	0.00	292.16	0.00	0.00	1460.83	173.25	0.00	325.00	1959.08
291.20	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.30	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.40	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.50	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.60	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.70	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.80	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.90	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
292.00	1000.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1415.00	0.00	0.00	325.00	1740.00
291.20	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.30	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.40	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.50	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.60	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.70	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.80	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.90	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
292.00	500.00	1.00	2.00	1.00	0.00	292.00	0.00	0.00	1311.14	0.00	0.00	325.00	1636.14
291.20	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.30	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00

291.40	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.50	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.60	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.70	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.80	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.90	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
292.00	100.00	1.00	2.00	1.00	0.01	292.00	0.00	0.00	1070.00	0.00	0.00	325.00	1395.00
291.20	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.30	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.40	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.50	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.60	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.70	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.80	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.90	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
292.00	50.00	1.00	2.00	1.00	0.02	292.00	0.00	0.00	933.00	0.00	0.00	325.00	1258.00
291.20	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.30	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.40	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.50	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.60	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.70	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.80	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.90	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
292.00	10.00	1.00	2.00	1.00	0.10	292.00	0.00	0.00	614.90	0.00	0.00	325.00	939.90
291.20	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90

291.30	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.40	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.50	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.60	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.70	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.80	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
291.90	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90
292.00	5.00	1.00	2.00	1.00	0.20	292.00	0.00	0.00	477.90	0.00	0.00	325.00	802.90

Failure Mode 1

1.

CO_WALL	Probability_Case	MaxWL	FM1_n1
Base	best_estimate	273.78	0.000
Base	best_estimate	292.00	0.07996998
Base	best_estimate	293.70	0.18828127
Base	best_estimate	294.50	0.23691918
Base	lowest_probability	270.33	0.000
Base	lowest_probability	292.00	0.02674885
Base	lowest_probability	293.70	0.06271245
Base	lowest_probability	294.50	0.09116058
Base	highest_probability	274.89	0.000
Base	highest_probability	292.00	0.16500212
Base	highest_probability	293.70	0.26702887
Base	highest_probability	294.50	0.33183575
Implemented	best_estimate	273.78	0.000
Implemented	best_estimate	292.00	0.0007997
Implemented	best_estimate	293.70	0.00188281
Implemented	best_estimate	294.50	0.00236919
Implemented	lowest_probability	270.33	0.000
Implemented	lowest_probability	292.00	0.00026749
Implemented	lowest_probability	293.70	0.00062712
Implemented	lowest_probability	294.50	0.00091161
Implemented	highest_probability	274.89	0.000
Implemented	highest_probability	292.00	0.00165002
Implemented	highest_probability	293.70	0.00267029
Implemented	highest_probability	294.50	0.00331836
Implemented_P	best_estimate	273.78	0.000
Implemented_P	best_estimate	292.00	0.03998499
Implemented_P	best_estimate	293.70	0.09414063
Implemented_P	best_estimate	294.50	0.11845959
Implemented_P	lowest_probability	270.33	0.000
Implemented_P	lowest_probability	292.00	0.01337442
Implemented_P	lowest_probability	293.70	0.03135622
Implemented_P	lowest_probability	294.50	0.04558029
Implemented_P	highest_probability	274.89	0.000
Implemented_P	highest_probability	292.00	0.08250106
Implemented_P	highest_probability	293.70	0.13351444
Implemented_P	highest_probability	294.50	0.16591787

2.

Probability_Case	MaxWL	FM1_n2
best_estimate	271.43	0.000
best_estimate	292.00	0.1654532
best_estimate	293.70	0.35577323
best_estimate	294.50	0.4728521
lowest_probability	266.00	0.000
lowest_probability	292.00	0.054
lowest_probability	293.70	0.140
lowest_probability	294.50	0.206
highest_probability	275.86	0.000
highest_probability	292.00	0.28156453
highest_probability	293.70	0.48070788
highest_probability	294.50	0.61889414

3.

Probability_Case	FM1_n3	Cond_Prob
best_estimate	1.00	0.900
lowest_probability	1.00	0.766
highest_probability	1.00	0.973

4.

Probability_Case	FM1_n4	Cond_Prob
best_estimate	1.00	0.116
lowest_probability	1.00	0.030
highest_probability	1.00	0.231

5.

AP_GEOTECH	Probability_Case	QSp	FM1_n5
Base	best_estimate	399.00	0.184
Base	best_estimate	401.00	0.666
Base	lowest_probability	399.00	0.068
Base	lowest_probability	401.00	0.521
Base	highest_probability	399.00	0.299
Base	highest_probability	401.00	0.751
Implemented	best_estimate	399.00	0.133
Implemented	best_estimate	401.00	0.480
Implemented	lowest_probability	399.00	0.049
Implemented	lowest_probability	401.00	0.375
Implemented	highest_probability	399.00	0.215
Implemented	highest_probability	401.00	0.541

6.

Probability_Case	MaxWL	FM1_n6
best_estimate	275.00	0.000
best_estimate	292.00	0.33824671
best_estimate	293.70	0.39211774
best_estimate	294.50	0.3933603
lowest_probability	269.67	0.000
lowest_probability	292.00	0.15587755
lowest_probability	293.70	0.20417205
lowest_probability	294.50	0.2090161
highest_probability	280.33	0.000
highest_probability	292.00	0.5472481
highest_probability	293.70	0.57724958
highest_probability	294.50	0.58773264

7.

Probability_Case	FM1_n7	Cond_Prob
best_estimate	1.00	0.412
lowest_probability	1.00	0.208
highest_probability	1.00	0.575

8.

AP_GEOTECH	Probability_Case	QSp	MaxWL	FM1_n8
Base	best_estimate	399.00	273.00	0.000
Base	best_estimate	399.00	292.00	0.077
Base	best_estimate	399.00	293.70	0.128
Base	best_estimate	399.00	294.50	0.154
Base	best_estimate	401.00	273.00	0.000
Base	best_estimate	401.00	292.00	0.182
Base	best_estimate	401.00	293.70	0.251
Base	best_estimate	401.00	294.50	0.296
Base	lowest_probability	399.00	266.80	0.000
Base	lowest_probability	399.00	292.00	0.025
Base	lowest_probability	399.00	293.70	0.045
Base	lowest_probability	399.00	294.50	0.059
Base	lowest_probability	401.00	266.80	0.000
Base	lowest_probability	401.00	292.00	0.081
Base	lowest_probability	401.00	293.70	0.157
Base	lowest_probability	401.00	294.50	0.184
Base	highest_probability	399.00	280.00	0.000
Base	highest_probability	399.00	292.00	0.156
Base	highest_probability	399.00	293.70	0.204
Base	highest_probability	399.00	294.50	0.235
Base	highest_probability	401.00	280.00	0.000
Base	highest_probability	401.00	292.00	0.264
Base	highest_probability	401.00	293.70	0.335
Base	highest_probability	401.00	294.50	0.384
Implemented	best_estimate	399.00	273.00	0.000
Implemented	best_estimate	399.00	292.00	0.039
Implemented	best_estimate	399.00	293.70	0.064
Implemented	best_estimate	399.00	294.50	0.077
Implemented	best_estimate	401.00	273.00	0.000
Implemented	best_estimate	401.00	292.00	0.091
Implemented	best_estimate	401.00	293.70	0.125
Implemented	best_estimate	401.00	294.50	0.148
Implemented	lowest_probability	399.00	266.80	0.000
Implemented	lowest_probability	399.00	292.00	0.012
Implemented	lowest_probability	399.00	293.70	0.022
Implemented	lowest_probability	399.00	294.50	0.030
Implemented	lowest_probability	401.00	266.80	0.000
Implemented	lowest_probability	401.00	292.00	0.041
Implemented	lowest_probability	401.00	293.70	0.079
Implemented	lowest_probability	401.00	294.50	0.092
Implemented	highest_probability	399.00	280.00	0.000
Implemented	highest_probability	399.00	292.00	0.078
Implemented	highest_probability	399.00	293.70	0.102
Implemented	highest_probability	399.00	294.50	0.118
Implemented	highest_probability	401.00	280.00	0.000
Implemented	highest_probability	401.00	292.00	0.132
Implemented	highest_probability	401.00	293.70	0.167
Implemented	highest_probability	401.00	294.50	0.192

Failure FM1

Probability_Case	MaxWL	Failure
best_estimate	275.00	0.000
best_estimate	292.00	0.207619202
best_estimate	293.70	0.312606394
best_estimate	294.50	0.408921162
lowest_probability	270.80	0.000
lowest_probability	292.00	0.07867623
lowest_probability	293.70	0.135259965
lowest_probability	294.50	0.1695028
highest_probability	282.00	0.000
highest_probability	292.00	0.343744183
highest_probability	293.70	0.462244216
highest_probability	294.50	0.57091667

Failure Mode 2

1.

CO_WALL	Probability_Case	MaxWL	FM2_n1
Base	best_estimate	246.44	0.000
Base	best_estimate	292.00	0.05262691
Base	best_estimate	294.50	0.09850612
Base	lowest_probability	242.22	0.000
Base	lowest_probability	292.00	0.01178769
Base	lowest_probability	294.50	0.02131663
Base	highest_probability	249.83	0.000
Base	highest_probability	292.00	0.19470094
Base	highest_probability	294.50	0.25970236
Implemented	best_estimate	246.44	0.000
Implemented	best_estimate	292.00	0.001
Implemented	best_estimate	294.50	0.001
Implemented	lowest_probability	242.22	0.000
Implemented	lowest_probability	292.00	0.000
Implemented	lowest_probability	294.50	0.000
Implemented	highest_probability	249.83	0.000
Implemented	highest_probability	292.00	0.002
Implemented	highest_probability	294.50	0.003
Implemented_P	best_estimate	246.44	0
Implemented_P	best_estimate	292.00	0.02631345
Implemented_P	best_estimate	294.50	0.04925306
Implemented_P	lowest_probability	242.22	0
Implemented_P	lowest_probability	292.00	0.00589384
Implemented_P	lowest_probability	294.50	0.01065832
Implemented_P	highest_probability	249.83	0
Implemented_P	highest_probability	292.00	0.09735047
Implemented_P	highest_probability	294.50	0.12985118

2.

Probability_Case	MaxWL	FM2_n2
best_estimate	278.00	0.000
best_estimate	292.00	0.18010888
best_estimate	294.50	0.26866059
lowest_probability	271.00	0.000
lowest_probability	292.00	0.05692302
lowest_probability	294.50	0.10084486
highest_probability	283.20	0.000
highest_probability	292.00	0.37963707
highest_probability	294.50	0.58233877

3.

Probability_Case	FM2_n3	Cond_Prob
best_estimate	1.00	0.790
lowest_probability	1.00	0.562
highest_probability	1.00	0.908

4.

Probability_Case	FM2_n4	Cond_Prob
best_estimate	1.00	0.307
lowest_probability	1.00	0.099
highest_probability	1.00	0.515

5.

AP_GEOTECH	Probability_Case	QSp	FM2_n5
Base	best_estimate	399.00	0.198
Base	best_estimate	401.00	0.838
Base	lowest_probability	399.00	0.081
Base	lowest_probability	401.00	0.594
Base	highest_probability	399.00	0.350
Base	highest_probability	401.00	0.946
Implemented	best_estimate	399.00	0.143
Implemented	best_estimate	401.00	0.603
Implemented	lowest_probability	399.00	0.058
Implemented	lowest_probability	401.00	0.428
Implemented	highest_probability	399.00	0.252
Implemented	highest_probability	401.00	0.681

6.

Probability_Case	MaxWL	FM2_n6
best_estimate	280.00	0.000
best_estimate	292.00	0.297
best_estimate	294.50	0.347
lowest_probability	272.50	0.000
lowest_probability	292.00	0.124
lowest_probability	294.50	0.170
highest_probability	285.50	0.000
highest_probability	292.00	0.478
highest_probability	294.50	0.542

7.

Probability_Case	FM2_n7	Cond_Prob
best_estimate	1.00	0.366
lowest_probability	1.00	0.201
highest_probability	1.00	0.548

8.

AP_GEOTECH	Probability_Case	QSp	MaxWL	FM2_n8
Base	best_estimate	399.00	275.00	0.000
Base	best_estimate	399.00	292.00	0.063
Base	best_estimate	399.00	294.50	0.106
Base	best_estimate	401.00	275.00	0.000
Base	best_estimate	401.00	292.00	0.159
Base	best_estimate	401.00	294.50	0.268
Base	lowest_probability	399.00	267.50	0.000
Base	lowest_probability	399.00	292.00	0.019
Base	lowest_probability	399.00	294.50	0.050
Base	lowest_probability	401.00	267.50	0.000
Base	lowest_probability	401.00	292.00	0.067
Base	lowest_probability	401.00	294.50	0.161
Base	highest_probability	399.00	282.50	0.000
Base	highest_probability	399.00	292.00	0.134
Base	highest_probability	399.00	294.50	0.162
Base	highest_probability	401.00	282.50	0.000
Base	highest_probability	401.00	292.00	0.237
Base	highest_probability	401.00	294.50	0.354
Implemented	best_estimate	399.00	275.00	0.000
Implemented	best_estimate	399.00	292.00	0.032
Implemented	best_estimate	399.00	294.50	0.053
Implemented	best_estimate	401.00	275.00	0.000
Implemented	best_estimate	401.00	292.00	0.079
Implemented	best_estimate	401.00	294.50	0.134
Implemented	lowest_probability	399.00	267.50	0.000
Implemented	lowest_probability	399.00	292.00	0.009
Implemented	lowest_probability	399.00	294.50	0.025
Implemented	lowest_probability	401.00	267.50	0.000
Implemented	lowest_probability	401.00	292.00	0.033
Implemented	lowest_probability	401.00	294.50	0.080
Implemented	highest_probability	399.00	282.50	0.000
Implemented	highest_probability	399.00	292.00	0.067
Implemented	highest_probability	399.00	294.50	0.081
Implemented	highest_probability	401.00	282.50	0.000
Implemented	highest_probability	401.00	292.00	0.118
Implemented	highest_probability	401.00	294.50	0.177

Failure FM2

Probability_Case	MaxWL	Failure
best_estimate	277.50	0.000
best_estimate	292.00	0.197
best_estimate	294.50	0.404
lowest_probability	272.50	0.000
lowest_probability	292.00	0.067
lowest_probability	294.50	0.154
highest_probability	285.00	0.000
highest_probability	292.00	0.325
highest_probability	294.50	0.565

Failure Mode 3

1.

CO_WALL	Probability_Case	MaxWL	FM3_n1
Base	best_estimate	280.33	0.000
Base	best_estimate	292.00	0.121
Base	best_estimate	294.50	0.242
Base	lowest_probability	275.00	0.000
Base	lowest_probability	292.00	0.038
Base	lowest_probability	294.50	0.085
Base	highest_probability	285.33	0.000
Base	highest_probability	292.00	0.360
Base	highest_probability	294.50	0.482
Implemented	best_estimate	275.00	0
Implemented	best_estimate	292.00	0.060670353
Implemented	best_estimate	294.50	0.120753936
Implemented	lowest_probability	270.00	0
Implemented	lowest_probability	292.00	0.019129789
Implemented	lowest_probability	294.50	0.042355979
Implemented	highest_probability	280.00	0
Implemented	highest_probability	292.00	0.1801234
Implemented	highest_probability	294.50	0.241093962
Implemented_P	best_estimate	275.00	0.000
Implemented_P	best_estimate	292.00	0.121
Implemented_P	best_estimate	294.50	0.242
Implemented_P	lowest_probability	270.00	0.000
Implemented_P	lowest_probability	292.00	0.038
Implemented_P	lowest_probability	294.50	0.085
Implemented_P	highest_probability	280.00	0.000
Implemented_P	highest_probability	292.00	0.360
Implemented_P	highest_probability	294.50	0.482

2.

Probability_Case	MaxWL	FM3_n2
best_estimate	280.00	0.000
best_estimate	292.00	0.236
best_estimate	294.50	0.326
lowest_probability	273.33	0.000
lowest_probability	292.00	0.068
lowest_probability	294.50	0.093
highest_probability	285.33	0.000
highest_probability	292.00	0.510
highest_probability	294.50	0.590

3.

Probability_Case	FM3_n3	Cond_Prob
best_estimate	1.00	0.638
lowest_probability	1.00	0.364
highest_probability	1.00	0.859

4.

Probability_Case	FM3_n4	Cond_Prob
best_estimate	1.00	0.224
lowest_probability	1.00	0.071
highest_probability	1.00	0.555

5.

Probability_Case	QSp	FM3_n5
best_estimate	399.00	0.35929809
best_estimate	401.00	0.50772975
lowest_probability	399.00	0.167
lowest_probability	401.00	0.226
highest_probability	399.00	0.541
highest_probability	401.00	0.684

6.

Probability_Case	MaxWL	FM3_n6
best_estimate	285.00	0.000
best_estimate	292.00	0.11580333
best_estimate	294.50	0.14984372
lowest_probability	275.00	0.000
lowest_probability	292.00	0.03594034
lowest_probability	294.50	0.04054432
highest_probability	291.00	0.000
highest_probability	292.00	0.24953182
highest_probability	294.50	0.36797532

7.

Probability_Case	QSp	MaxWL	FM3_n7
best_estimate	399.00	277.50	0.000
best_estimate	399.00	292.00	0.135
best_estimate	399.00	294.50	0.240
best_estimate	401.00	277.50	0.000
best_estimate	401.00	292.00	0.298
best_estimate	401.00	294.50	0.387
lowest_probability	399.00	270.00	0.000
lowest_probability	399.00	292.00	0.070
lowest_probability	399.00	294.50	0.113
lowest_probability	401.00	270.00	0.000
lowest_probability	401.00	292.00	0.160
lowest_probability	401.00	294.50	0.214
highest_probability	399.00	282.50	0.000
highest_probability	399.00	292.00	0.277
highest_probability	399.00	294.50	0.407
highest_probability	401.00	282.50	0.000
highest_probability	401.00	292.00	0.452
highest_probability	401.00	294.50	0.591

8.

Probability_Case	MaxWL	FM3_n8
best_estimate	275.00	0.000
best_estimate	292.00	0.121
best_estimate	294.50	0.168
lowest_probability	270.00	0.000
lowest_probability	292.00	0.053
lowest_probability	294.50	0.067
highest_probability	280.00	0.000
highest_probability	292.00	0.404
highest_probability	294.50	0.478

Failure FM3

Probability_Case	MaxWL	Failure
best_estimate	275.00	0.000
best_estimate	292.00	0.188901645
best_estimate	294.50	0.373300326
lowest_probability	270.00	0.000
lowest_probability	292.00	0.058836357
lowest_probability	294.50	0.148023899
highest_probability	280.00	0.000
highest_probability	292.00	0.371774515
highest_probability	294.50	0.587921992

Failure Mode 4

1.

DRAIN_G	Probability_Case	FM4_n1	Cond_Prob
Base	best_estimate	1.00	0.095
Base	lowest_probability	1.00	0.039
Base	highest_probability	1.00	0.277
Implemented	best_estimate	1.00	0.001
Implemented	lowest_probability	1.00	0.000
Implemented	highest_probability	1.00	0.003

2.

Probability_Case	FM4_n2	Cond_Prob
best_estimate	1.00	0.117
lowest_probability	1.00	0.045
highest_probability	1.00	0.298

5.

Probability_Case	MaxWL	FM4_n5
best_estimate	280.00	0.000
best_estimate	292.00	0.302
best_estimate	294.50	0.527
lowest_probability	270.00	0.000
lowest_probability	292.00	0.097
lowest_probability	294.50	0.243
highest_probability	285.00	0.000
highest_probability	292.00	0.585
highest_probability	294.50	0.738

7.

Probability_Case	FM4_n7	Cond_Prob
best_estimate	1.00	0.508
lowest_probability	1.00	0.290
highest_probability	1.00	0.719

Failure FM4

ANCHOR	Probability_Case	MaxWL	Failure
Base	best_estimate	260.00	0
Base	best_estimate	290	0
Base	best_estimate	290.1	0
Base	best_estimate	290.2	0
Base	best_estimate	290.3	0
Base	best_estimate	290.4	0
Base	best_estimate	290.5	0
Base	best_estimate	290.6	0
Base	best_estimate	290.7	0
Base	best_estimate	290.8	0
Base	best_estimate	290.9	0
Base	best_estimate	291	0
Base	best_estimate	291.1	0
Base	best_estimate	291.2	0
Base	best_estimate	291.3	0
Base	best_estimate	291.4	0
Base	best_estimate	291.5	0
Base	best_estimate	291.6	0
Base	best_estimate	291.7	0
Base	best_estimate	291.8	0
Base	best_estimate	291.9	0
Base	best_estimate	292	0
Base	best_estimate	292.1	0
Base	best_estimate	292.2	0
Base	best_estimate	292.3	0
Base	best_estimate	292.4	0
Base	best_estimate	292.5	6.2289E-05
Base	best_estimate	292.6	0.0002017
Base	best_estimate	292.7	0.00040548
Base	best_estimate	292.8	0.0006992
Base	best_estimate	292.9	0.00111707
Base	best_estimate	293	0.00170629
Base	best_estimate	293.1	0.00251889
Base	best_estimate	293.2	0.00363697
Base	best_estimate	293.3	0.00514506
Base	best_estimate	293.4	0.00715209
Base	best_estimate	293.5	0.00980163
Base	best_estimate	293.6	0.0139424
Base	best_estimate	293.7	0.0181254
Base	best_estimate	293.8	0.02361722
Base	best_estimate	293.9	0.03021334
Base	best_estimate	294	0.03891216
Base	best_estimate	294.1	0.04932468
Base	best_estimate	294.2	0.06195475
Base	best_estimate	294.3	0.07691604
Base	best_estimate	294.4	0.0944121
Base	best_estimate	294.5	0.11464763
Base	best_estimate	294.6	0.1194618
Base	best_estimate	294.7	0.1245487
Base	best_estimate	294.8	0.1296647
Base	best_estimate	294.9	0.13505679
Base	best_estimate	295	0.14048728
Base	best_estimate	295.1	0.14617739
Base	best_estimate	295.2	0.15195271
Base	best_estimate	295.3	0.15790979
Base	best_estimate	295.4	0.16403532
Base	best_estimate	295.5	0.17025902
Base	best_estimate	295.6	0.17672558
Base	best_estimate	295.7	0.18330852
Base	best_estimate	295.8	0.19001146

Failure Mode 6

1.

DRAIN_G	Probability_Case	FM6_n1	Cond_Prob
Base	best_estimate	1.00	0.137
Base	lowest_probability	1.00	0.037
Base	highest_probability	1.00	0.328
Implemented	best_estimate	1.00	0.001
Implemented	lowest_probability	1.00	0.000
Implemented	highest_probability	1.00	0.003

2.

Probability_Case	FM6_n2	Cond_Prob
best_estimate	1.00	0.683
lowest_probability	1.00	0.427
highest_probability	1.00	0.877

4.

Probability_Case	MaxWL	FM6_n4
best_estimate	275.00	0.000
best_estimate	292.00	0.492698003
best_estimate	294.50	0.734158445
lowest_probability	270.00	0.000
lowest_probability	292.00	0.300846534
lowest_probability	294.50	0.517600505
highest_probability	280.00	0.000
highest_probability	292.00	0.739578063
highest_probability	294.50	0.891625889

7.

Probability_Case	FM6_n7	Cond_Prob
best_estimate	1.00	0.508
lowest_probability	1.00	0.282
highest_probability	1.00	0.725

Failure FM6

ANCHOR	Probability_Case	MaxWL	Failure
Base	best_estimate	270.00	0
Base	best_estimate	290.00	0
Base	best_estimate	290.10	0
Base	best_estimate	290.20	0
Base	best_estimate	290.30	0
Base	best_estimate	290.40	0
Base	best_estimate	290.50	0
Base	best_estimate	290.60	0
Base	best_estimate	290.70	0
Base	best_estimate	290.80	0
Base	best_estimate	290.90	0
Base	best_estimate	291.00	0
Base	best_estimate	291.10	0
Base	best_estimate	291.20	0
Base	best_estimate	291.30	0
Base	best_estimate	291.40	0
Base	best_estimate	291.50	0
Base	best_estimate	291.60	0
Base	best_estimate	291.70	0
Base	best_estimate	291.80	0
Base	best_estimate	291.90	0
Base	best_estimate	292.00	0
Base	best_estimate	292.10	0
Base	best_estimate	292.20	0
Base	best_estimate	292.30	0
Base	best_estimate	292.40	0
Base	best_estimate	292.50	0.00047735
Base	best_estimate	292.60	0.00189328
Base	best_estimate	292.70	0.00328717
Base	best_estimate	292.80	0.00465949
Base	best_estimate	292.90	0.00601072
Base	best_estimate	293.00	0.00734132
Base	best_estimate	293.10	0.00865172
Base	best_estimate	293.20	0.00994237
Base	best_estimate	293.30	0.0126087
Base	best_estimate	293.40	0.01530057
Base	best_estimate	293.50	0.01795263
Base	best_estimate	293.60	0.02093916
Base	best_estimate	293.70	0.02521396
Base	best_estimate	293.80	0.02942668
Base	best_estimate	293.90	0.03492319
Base	best_estimate	294.00	0.04069807
Base	best_estimate	294.10	0.04770167
Base	best_estimate	294.20	0.05552844
Base	best_estimate	294.30	0.06429599
Base	best_estimate	294.40	0.074145
Base	best_estimate	294.50	0.08514723
Base	best_estimate	294.60	0.09733246
Base	best_estimate	294.70	0.11075939
Base	best_estimate	294.80	0.12562081
Base	best_estimate	294.90	0.1417393
Base	best_estimate	295.00	0.15925775
Base	best_estimate	295.10	0.17820535
Base	best_estimate	295.20	0.19851836
Base	best_estimate	295.30	0.22018585
Base	best_estimate	295.40	0.24323118
Base	best_estimate	295.50	0.26751286
Base	best_estimate	295.60	0.29299635
Base	best_estimate	295.70	0.31956434
Base	best_estimate	295.80	0.34715256

Failure Mode 7

1.

Probability_Case	QSp	FM7_n1
best_estimate	633.33	0.000
best_estimate	1400.00	0.143
best_estimate	2000.00	0.410
best_estimate	2400.00	0.589
lowest_probability	675.00	0.000
lowest_probability	1400.00	0.060
lowest_probability	2000.00	0.220
lowest_probability	2400.00	0.324
highest_probability	300.00	0.000
highest_probability	1400.00	0.340
highest_probability	2000.00	0.656
highest_probability	2400.00	0.836

2.

Probability_Case	QSp	FM7_n2
best_estimate	500.00	0.000
best_estimate	1400.00	0.252
best_estimate	2000.00	0.455
best_estimate	2400.00	0.577
lowest_probability	700.00	0.000
lowest_probability	1400.00	0.140
lowest_probability	2000.00	0.262
lowest_probability	2400.00	0.338
highest_probability	300.00	0.000
highest_probability	1400.00	0.474
highest_probability	2000.00	0.655
highest_probability	2400.00	0.759

3.

Probability_Case	QSp	FM7_n3
best_estimate	300.00	0.000
best_estimate	1400.00	0.378
best_estimate	2000.00	0.488
best_estimate	2400.00	0.577
lowest_probability	500.00	0.000
lowest_probability	1400.00	0.198
lowest_probability	2000.00	0.338
lowest_probability	2400.00	0.424
highest_probability	100.00	0.000
highest_probability	1400.00	0.467
highest_probability	2000.00	0.652
highest_probability	2400.00	0.755

4.

Probability_Case	QSp	FM7_n4
best_estimate	750.00	0.000
best_estimate	1400.00	0.198
best_estimate	2000.00	0.325
best_estimate	2400.00	0.453
lowest_probability	1000.00	0.000
lowest_probability	1400.00	0.092
lowest_probability	2000.00	0.145
lowest_probability	2400.00	0.233
highest_probability	500.00	0.000
highest_probability	1400.00	0.362
highest_probability	2000.00	0.530
highest_probability	2400.00	0.674

Failure FM7

Probability_Case	QSp	Failure
best_estimate	750.00	0.000
best_estimate	1400.00	0.233
best_estimate	2000.00	0.323
best_estimate	2400.00	0.403
lowest_probability	1000.00	0.000
lowest_probability	1400.00	0.114
lowest_probability	2000.00	0.181
lowest_probability	2400.00	0.227
highest_probability	500.00	0.000
highest_probability	1400.00	0.382
highest_probability	2000.00	0.521
highest_probability	2400.00	0.647

Failure Mode 8

1.

Probability_Case	OvH	OvT	FM8_n1
best_estimate	0.50	6.00	0.199
best_estimate	1.00	6.00	0.394
best_estimate	0.50	48.00	0.431
best_estimate	1.00	48.00	0.657
lowest_probability	0.50	6.00	0.096
lowest_probability	1.00	6.00	0.218
lowest_probability	0.50	48.00	0.257
lowest_probability	1.00	48.00	0.465
highest_probability	0.50	6.00	0.417
highest_probability	1.00	6.00	0.574
highest_probability	0.50	48.00	0.676
highest_probability	1.00	48.00	0.824

2.

Probability_Case	OvH	OvT	FM8_n2
best_estimate	0.50	6.00	0.367
best_estimate	1.00	6.00	0.525
best_estimate	0.50	48.00	0.528
best_estimate	1.00	48.00	0.659
lowest_probability	0.50	6.00	0.207
lowest_probability	1.00	6.00	0.323
lowest_probability	0.50	48.00	0.334
lowest_probability	1.00	48.00	0.480
highest_probability	0.50	6.00	0.575
highest_probability	1.00	6.00	0.735
highest_probability	0.50	48.00	0.738
highest_probability	1.00	48.00	0.848

Failure FM8

Probability_Case	OvH	OvT	Failure
best_estimate	0.10	0.000	0
best_estimate	0.50	0.000	0
best_estimate	1.00	0.000	0
best_estimate	0.10	6.000	0
best_estimate	0.50	6.000	0.601
best_estimate	1.00	6.000	0.719
best_estimate	0.10	48.000	0
best_estimate	0.50	48.000	0.689
best_estimate	1.00	48.000	0.804
lowest_probability	0.10	0.000	0
lowest_probability	0.50	0.000	0
lowest_probability	1.00	0.000	0
lowest_probability	0.10	6.000	0
lowest_probability	0.50	6.000	0.433
lowest_probability	1.00	6.000	0.531
lowest_probability	0.10	48.000	0
lowest_probability	0.50	48.000	0.542
lowest_probability	1.00	48.000	0.632
highest_probability	0.10	0.000	0
highest_probability	0.50	0.000	0
highest_probability	1.00	0.000	0
highest_probability	0.10	6.000	0
highest_probability	0.50	6.000	0.675
highest_probability	1.00	6.000	0.815
highest_probability	0.10	48.000	0
highest_probability	0.50	48.000	0.78
highest_probability	1.00	48.000	0.9

Q Br Embankment

MaxWL	QBr
285.00	2000
292.00	6495
295.50	10426

Q Br Concrete

MaxWL	QBr
285.00	2000
292.00	6495
295.50	10426

T1

Failure_Mode	T1	Prob
FM1	12	1
FM2	12	1
FM3	12	1
FM4	0.25	1
FM6	0.25	1
FM7	6	1
FM8	6	1

T2

AP_WARNING	Failure_Mode	T2	Prob
Base	FM1	1.00	1
Base	FM2	1.00	1
Base	FM3	1.00	1
Base	FM4	0.00	1
Base	FM6	0.00	1
Base	FM7	0.00	1
Base	FM8	0.00	1
Implemented	FM1	1.00	1
Implemented	FM2	1.00	1
Implemented	FM3	1.00	1
Implemented	FM4	0.00	1
Implemented	FM6	0.00	1
Implemented	FM7	0.00	1
Implemented	FM8	0.00	1

T3

AP_WARNING	Failure_Mode	T3	Prob
Base	FM1	1.00	1
Base	FM2	1.00	1
Base	FM3	1.00	1
Base	FM4	0.00	1
Base	FM6	0.00	1
Base	FM7	0.00	1
Base	FM8	0.00	1
Implemented	FM1	0.25	1
Implemented	FM2	0.25	1
Implemented	FM3	0.25	1
Implemented	FM4	0.00	1
Implemented	FM6	0.00	1
Implemented	FM7	0.00	1
Implemented	FM8	0.00	1

T4

AP_WARNING	Failure_Mode	T4	Prob
Base	FM1	2.00	1
Base	FM2	2.00	1
Base	FM3	2.00	1
Base	FM4	0.50	1
Base	FM6	0.50	1
Base	FM7	0.50	1
Base	FM8	0.50	1
Implemented	FM1	1.00	1
Implemented	FM2	1.00	1
Implemented	FM3	1.00	1
Implemented	FM4	0.25	1
Implemented	FM6	0.25	1
Implemented	FM7	0.25	1
Implemented	FM8	0.25	1

T5

AP_WARNING	Day_Night	T5	Prob
Base	day	0.00	1
Base	night	0.25	1
Implemented	day	0.00	1
Implemented	night	0.03	1

B Warning T

23_D6_Basic_Warning_Time.txt: Bloc de notas

Archivo Edición Formato Ver Ayuda

```
#f T2345 = v['T2'] + v['T3'] + v['T4'] + v['T5']
```

Econom:YES

QBr	MSEK_Yes
325.00	0.00
2100.00	916.96
6495.00	7474.54
10426.00	9712.35

Econom:NO

QOut	MSEK_No
325.00	0.00
2100.00	916.96
6495.00	7107.40
10426.00	9345.20

Lives: YES

AP_WARNING	Berm	T2345	Winter_Summer	Day_Night	Lives_Yes	QBr
Base	yes	0.00	summer	day	0.0000	325.00
Base	yes	0.00	summer	night	0.0000	325.00
Base	yes	0.00	winter	day	0.0000	325.00
Base	yes	0.00	winter	night	0.0000	325.00
Base	yes	0.50	summer	day	0.0000	325.00
Base	yes	0.50	summer	night	0.0000	325.00

Base	yes	0.50	winter	day	0.0000	325.00
Base	yes	0.50	winter	night	0.0000	325.00
Base	yes	1.00	summer	day	0.0000	325.00
Base	yes	1.00	summer	night	0.0000	325.00
Base	yes	1.00	winter	day	0.0000	325.00
Base	yes	1.00	winter	night	0.0000	325.00
Base	yes	1.50	summer	day	0.0000	325.00
Base	yes	1.50	summer	night	0.0000	325.00
Base	yes	1.50	winter	day	0.0000	325.00
Base	yes	1.50	winter	night	0.0000	325.00
Base	yes	2.00	summer	day	0.0000	325.00
Base	yes	2.00	summer	night	0.0000	325.00
Base	yes	2.00	winter	day	0.0000	325.00
Base	yes	2.00	winter	night	0.0000	325.00
Base	yes	2.50	summer	day	0.0000	325.00
Base	yes	2.50	summer	night	0.0000	325.00
Base	yes	2.50	winter	day	0.0000	325.00
Base	yes	2.50	winter	night	0.0000	325.00
Base	yes	3.00	summer	day	0.0000	325.00
Base	yes	3.00	summer	night	0.0000	325.00
Base	yes	3.00	winter	day	0.0000	325.00
Base	yes	3.00	winter	night	0.0000	325.00
Base	yes	3.50	summer	day	0.0000	325.00
Base	yes	3.50	summer	night	0.0000	325.00
Base	yes	3.50	winter	day	0.0000	325.00
Base	yes	3.50	winter	night	0.0000	325.00
Base	yes	4.00	summer	day	0.0000	325.00
Base	yes	4.00	summer	night	0.0000	325.00
Base	yes	4.00	winter	day	0.0000	325.00
Base	yes	4.00	winter	night	0.0000	325.00
Base	yes	4.50	summer	day	0.0000	325.00
Base	yes	4.50	summer	night	0.0000	325.00
Base	yes	4.50	winter	day	0.0000	325.00
Base	yes	4.50	winter	night	0.0000	325.00
Base	yes	5.00	summer	day	0.0000	325.00
Base	yes	5.00	summer	night	0.0000	325.00
Base	yes	5.00	winter	day	0.0000	325.00
Base	yes	5.00	winter	night	0.0000	325.00
Base	yes	5.50	summer	day	0.0000	325.00
Base	yes	5.50	summer	night	0.0000	325.00
Base	yes	5.50	winter	day	0.0000	325.00
Base	yes	5.50	winter	night	0.0000	325.00
Base	yes	6.00	summer	day	0.0000	325.00
Base	yes	6.00	summer	night	0.0000	325.00
Base	yes	6.00	winter	day	0.0000	325.00
Base	yes	6.00	winter	night	0.0000	325.00

Base	yes	6.50	summer	day	0.0000	325.00
Base	yes	6.50	summer	night	0.0000	325.00
Base	yes	6.50	winter	day	0.0000	325.00
Base	yes	6.50	winter	night	0.0000	325.00
Base	yes	7.00	summer	day	0.0000	325.00
Base	yes	7.00	summer	night	0.0000	325.00
Base	yes	7.00	winter	day	0.0000	325.00
Base	yes	7.00	winter	night	0.0000	325.00
Base	yes	7.50	summer	day	0.0000	325.00
Base	yes	7.50	summer	night	0.0000	325.00
Base	yes	7.50	winter	day	0.0000	325.00
Base	yes	7.50	winter	night	0.0000	325.00
Implemented_P	yes	0.00	summer	day	0.0000	325.00
Implemented_P	yes	0.00	summer	night	0.0000	325.00
Implemented_P	yes	0.00	winter	day	0.0000	325.00
Implemented_P	yes	0.00	winter	night	0.0000	325.00
Implemented_P	yes	0.50	summer	day	0.0000	325.00
Implemented_P	yes	0.50	summer	night	0.0000	325.00
Implemented_P	yes	0.50	winter	day	0.0000	325.00
Implemented_P	yes	0.50	winter	night	0.0000	325.00
Implemented_P	yes	1.00	summer	day	0.0000	325.00
Implemented_P	yes	1.00	summer	night	0.0000	325.00
Implemented_P	yes	1.00	winter	day	0.0000	325.00
Implemented_P	yes	1.00	winter	night	0.0000	325.00
Implemented_P	yes	1.50	summer	day	0.0000	325.00
Implemented_P	yes	1.50	summer	night	0.0000	325.00
Implemented_P	yes	1.50	winter	day	0.0000	325.00
Implemented_P	yes	1.50	winter	night	0.0000	325.00
Implemented_P	yes	2.00	summer	day	0.0000	325.00
Implemented_P	yes	2.00	summer	night	0.0000	325.00
Implemented_P	yes	2.00	winter	day	0.0000	325.00
Implemented_P	yes	2.00	winter	night	0.0000	325.00
Implemented_P	yes	2.50	summer	day	0.0000	325.00
Implemented_P	yes	2.50	summer	night	0.0000	325.00
Implemented_P	yes	2.50	winter	day	0.0000	325.00
Implemented_P	yes	2.50	winter	night	0.0000	325.00
Implemented_P	yes	3.00	summer	day	0.0000	325.00
Implemented_P	yes	3.00	summer	night	0.0000	325.00
Implemented_P	yes	3.00	winter	day	0.0000	325.00
Implemented_P	yes	3.00	winter	night	0.0000	325.00
Implemented_P	yes	3.50	summer	day	0.0000	325.00
Implemented_P	yes	3.50	summer	night	0.0000	325.00
Implemented_P	yes	3.50	winter	day	0.0000	325.00
Implemented_P	yes	3.50	winter	night	0.0000	325.00
Implemented_P	yes	4.00	summer	day	0.0000	325.00
Implemented_P	yes	4.00	summer	night	0.0000	325.00

Implemented_P	yes	4.00	winter	day	0.0000	325.00
Implemented_P	yes	4.00	winter	night	0.0000	325.00
Implemented_P	yes	4.50	summer	day	0.0000	325.00
Implemented_P	yes	4.50	summer	night	0.0000	325.00
Implemented_P	yes	4.50	winter	day	0.0000	325.00
Implemented_P	yes	4.50	winter	night	0.0000	325.00
Implemented_P	yes	5.00	summer	day	0.0000	325.00
Implemented_P	yes	5.00	summer	night	0.0000	325.00
Implemented_P	yes	5.00	winter	day	0.0000	325.00
Implemented_P	yes	5.00	winter	night	0.0000	325.00
Implemented_P	yes	5.50	summer	day	0.0000	325.00
Implemented_P	yes	5.50	summer	night	0.0000	325.00
Implemented_P	yes	5.50	winter	day	0.0000	325.00
Implemented_P	yes	5.50	winter	night	0.0000	325.00
Implemented_P	yes	6.00	summer	day	0.0000	325.00
Implemented_P	yes	6.00	summer	night	0.0000	325.00
Implemented_P	yes	6.00	winter	day	0.0000	325.00
Implemented_P	yes	6.00	winter	night	0.0000	325.00
Implemented_P	yes	6.50	summer	day	0.0000	325.00
Implemented_P	yes	6.50	summer	night	0.0000	325.00
Implemented_P	yes	6.50	winter	day	0.0000	325.00
Implemented_P	yes	6.50	winter	night	0.0000	325.00
Implemented_P	yes	7.00	summer	day	0.0000	325.00
Implemented_P	yes	7.00	summer	night	0.0000	325.00
Implemented_P	yes	7.00	winter	day	0.0000	325.00
Implemented_P	yes	7.00	winter	night	0.0000	325.00
Implemented_P	yes	7.50	summer	day	0.0000	325.00
Implemented_P	yes	7.50	summer	night	0.0000	325.00
Implemented_P	yes	7.50	winter	day	0.0000	325.00
Implemented_P	yes	7.50	winter	night	0.0000	325.00
Implemented	yes	0.00	summer	day	0.0000	325.00
Implemented	yes	0.00	summer	night	0.0000	325.00
Implemented	yes	0.00	winter	day	0.0000	325.00
Implemented	yes	0.00	winter	night	0.0000	325.00
Implemented	yes	0.50	summer	day	0.0000	325.00
Implemented	yes	0.50	summer	night	0.0000	325.00
Implemented	yes	0.50	winter	day	0.0000	325.00
Implemented	yes	0.50	winter	night	0.0000	325.00
Implemented	yes	1.00	summer	day	0.0000	325.00
Implemented	yes	1.00	summer	night	0.0000	325.00
Implemented	yes	1.00	winter	day	0.0000	325.00
Implemented	yes	1.00	winter	night	0.0000	325.00
Implemented	yes	1.50	summer	day	0.0000	325.00
Implemented	yes	1.50	summer	night	0.0000	325.00
Implemented	yes	1.50	winter	day	0.0000	325.00
Implemented	yes	1.50	winter	night	0.0000	325.00

Implemented	yes	2.00	summer	day	0.0000	325.00
Implemented	yes	2.00	summer	night	0.0000	325.00
Implemented	yes	2.00	winter	day	0.0000	325.00
Implemented	yes	2.00	winter	night	0.0000	325.00
Implemented	yes	2.50	summer	day	0.0000	325.00
Implemented	yes	2.50	summer	night	0.0000	325.00
Implemented	yes	2.50	winter	day	0.0000	325.00
Implemented	yes	2.50	winter	night	0.0000	325.00
Implemented	yes	3.00	summer	day	0.0000	325.00
Implemented	yes	3.00	summer	night	0.0000	325.00
Implemented	yes	3.00	winter	day	0.0000	325.00
Implemented	yes	3.00	winter	night	0.0000	325.00
Implemented	yes	3.50	summer	day	0.0000	325.00
Implemented	yes	3.50	summer	night	0.0000	325.00
Implemented	yes	3.50	winter	day	0.0000	325.00
Implemented	yes	3.50	winter	night	0.0000	325.00
Implemented	yes	4.00	summer	day	0.0000	325.00
Implemented	yes	4.00	summer	night	0.0000	325.00
Implemented	yes	4.00	winter	day	0.0000	325.00
Implemented	yes	4.00	winter	night	0.0000	325.00
Implemented	yes	4.50	summer	day	0.0000	325.00
Implemented	yes	4.50	summer	night	0.0000	325.00
Implemented	yes	4.50	winter	day	0.0000	325.00
Implemented	yes	4.50	winter	night	0.0000	325.00
Implemented	yes	5.00	summer	day	0.0000	325.00
Implemented	yes	5.00	summer	night	0.0000	325.00
Implemented	yes	5.00	winter	day	0.0000	325.00
Implemented	yes	5.00	winter	night	0.0000	325.00
Implemented	yes	5.50	summer	day	0.0000	325.00
Implemented	yes	5.50	summer	night	0.0000	325.00
Implemented	yes	5.50	winter	day	0.0000	325.00
Implemented	yes	5.50	winter	night	0.0000	325.00
Implemented	yes	6.00	summer	day	0.0000	325.00
Implemented	yes	6.00	summer	night	0.0000	325.00
Implemented	yes	6.00	winter	day	0.0000	325.00
Implemented	yes	6.00	winter	night	0.0000	325.00
Implemented	yes	6.50	summer	day	0.0000	325.00
Implemented	yes	6.50	summer	night	0.0000	325.00
Implemented	yes	6.50	winter	day	0.0000	325.00
Implemented	yes	6.50	winter	night	0.0000	325.00
Implemented	yes	7.00	summer	day	0.0000	325.00
Implemented	yes	7.00	summer	night	0.0000	325.00
Implemented	yes	7.00	winter	day	0.0000	325.00
Implemented	yes	7.00	winter	night	0.0000	325.00
Implemented	yes	7.50	summer	day	0.0000	325.00
Implemented	yes	7.50	summer	night	0.0000	325.00

Implemented	yes	7.50	winter	day	0.0000	325.00
Implemented	yes	7.50	winter	night	0.0000	325.00
Base	no	0.00	summer	day	0.0000	325.00
Base	no	0.00	summer	night	0.0000	325.00
Base	no	0.00	winter	day	0.0000	325.00
Base	no	0.00	winter	night	0.0000	325.00
Base	no	0.50	summer	day	0.0000	325.00
Base	no	0.50	summer	night	0.0000	325.00
Base	no	0.50	winter	day	0.0000	325.00
Base	no	0.50	winter	night	0.0000	325.00
Base	no	1.00	summer	day	0.0000	325.00
Base	no	1.00	summer	night	0.0000	325.00
Base	no	1.00	winter	day	0.0000	325.00
Base	no	1.00	winter	night	0.0000	325.00
Base	no	1.50	summer	day	0.0000	325.00
Base	no	1.50	summer	night	0.0000	325.00
Base	no	1.50	winter	day	0.0000	325.00
Base	no	1.50	winter	night	0.0000	325.00
Base	no	2.00	summer	day	0.0000	325.00
Base	no	2.00	summer	night	0.0000	325.00
Base	no	2.00	winter	day	0.0000	325.00
Base	no	2.00	winter	night	0.0000	325.00
Base	no	2.50	summer	day	0.0000	325.00
Base	no	2.50	summer	night	0.0000	325.00
Base	no	2.50	winter	day	0.0000	325.00
Base	no	2.50	winter	night	0.0000	325.00
Base	no	3.00	summer	day	0.0000	325.00
Base	no	3.00	summer	night	0.0000	325.00
Base	no	3.00	winter	day	0.0000	325.00
Base	no	3.00	winter	night	0.0000	325.00
Base	no	3.50	summer	day	0.0000	325.00
Base	no	3.50	summer	night	0.0000	325.00
Base	no	3.50	winter	day	0.0000	325.00
Base	no	3.50	winter	night	0.0000	325.00
Base	no	4.00	summer	day	0.0000	325.00
Base	no	4.00	summer	night	0.0000	325.00
Base	no	4.00	winter	day	0.0000	325.00
Base	no	4.00	winter	night	0.0000	325.00
Base	no	4.50	summer	day	0.0000	325.00
Base	no	4.50	summer	night	0.0000	325.00
Base	no	4.50	winter	day	0.0000	325.00
Base	no	4.50	winter	night	0.0000	325.00
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Base	no	5.00	summer	night	0.0000	325.00
Base	no	5.00	winter	day	0.0000	325.00
Base	no	5.00	winter	night	0.0000	325.00

Base	no	5.50	summer	day	0.0000	325.00
Base	no	5.50	summer	night	0.0000	325.00
Base	no	5.50	winter	day	0.0000	325.00
Base	no	5.50	winter	night	0.0000	325.00
Base	no	6.00	summer	day	0.0000	325.00
Base	no	6.00	summer	night	0.0000	325.00
Base	no	6.00	winter	day	0.0000	325.00
Base	no	6.00	winter	night	0.0000	325.00
Base	no	6.50	summer	day	0.0000	325.00
Base	no	6.50	summer	night	0.0000	325.00
Base	no	6.50	winter	day	0.0000	325.00
Base	no	6.50	winter	night	0.0000	325.00
Base	no	7.00	summer	day	0.0000	325.00
Base	no	7.00	summer	night	0.0000	325.00
Base	no	7.00	winter	day	0.0000	325.00
Base	no	7.00	winter	night	0.0000	325.00
Base	no	7.50	summer	day	0.0000	325.00
Base	no	7.50	summer	night	0.0000	325.00
Base	no	7.50	winter	day	0.0000	325.00
Base	no	7.50	winter	night	0.0000	325.00
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Implemented_P	no	0.50	winter	day	0.0000	325.00
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Implemented_P	no	1.50	summer	day	0.0000	325.00
Implemented_P	no	1.50	summer	night	0.0000	325.00
Implemented_P	no	1.50	winter	day	0.0000	325.00
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Implemented_P	no	3.00	summer	night	0.0000	325.00

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Implemented_P	no	5.00	winter	night	0.0000	325.00
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Implemented_P	no	6.00	winter	day	0.0000	325.00
Implemented_P	no	6.00	winter	night	0.0000	325.00
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Implemented_P	no	6.50	summer	night	0.0000	325.00
Implemented_P	no	6.50	winter	day	0.0000	325.00
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Implemented_P	no	7.00	winter	day	0.0000	325.00
Implemented_P	no	7.00	winter	night	0.0000	325.00
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Implemented_P	no	7.50	summer	night	0.0000	325.00
Implemented_P	no	7.50	winter	day	0.0000	325.00
Implemented_P	no	7.50	winter	night	0.0000	325.00
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Implemented	no	0.00	summer	night	0.0000	325.00
Implemented	no	0.00	winter	day	0.0000	325.00
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Implemented	no	0.50	winter	day	0.0000	325.00
Implemented	no	0.50	winter	night	0.0000	325.00

Implemented	no	1.00	summer	day	0.0000	325.00
Implemented	no	1.00	summer	night	0.0000	325.00
Implemented	no	1.00	winter	day	0.0000	325.00
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Implemented	no	1.50	summer	night	0.0000	325.00
Implemented	no	1.50	winter	day	0.0000	325.00
Implemented	no	1.50	winter	night	0.0000	325.00
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Implemented	no	2.00	summer	night	0.0000	325.00
Implemented	no	2.00	winter	day	0.0000	325.00
Implemented	no	2.00	winter	night	0.0000	325.00
Implemented	no	2.50	summer	day	0.0000	325.00
Implemented	no	2.50	summer	night	0.0000	325.00
Implemented	no	2.50	winter	day	0.0000	325.00
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Implemented	no	3.00	summer	day	0.0000	325.00
Implemented	no	3.00	summer	night	0.0000	325.00
Implemented	no	3.00	winter	day	0.0000	325.00
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Implemented	no	3.50	summer	day	0.0000	325.00
Implemented	no	3.50	summer	night	0.0000	325.00
Implemented	no	3.50	winter	day	0.0000	325.00
Implemented	no	3.50	winter	night	0.0000	325.00
Implemented	no	4.00	summer	day	0.0000	325.00
Implemented	no	4.00	summer	night	0.0000	325.00
Implemented	no	4.00	winter	day	0.0000	325.00
Implemented	no	4.00	winter	night	0.0000	325.00
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Implemented	no	4.50	summer	night	0.0000	325.00
Implemented	no	4.50	winter	day	0.0000	325.00
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Implemented	no	5.00	summer	night	0.0000	325.00
Implemented	no	5.00	winter	day	0.0000	325.00
Implemented	no	5.00	winter	night	0.0000	325.00
Implemented	no	5.50	summer	day	0.0000	325.00
Implemented	no	5.50	summer	night	0.0000	325.00
Implemented	no	5.50	winter	day	0.0000	325.00
Implemented	no	5.50	winter	night	0.0000	325.00
Implemented	no	6.00	summer	day	0.0000	325.00
Implemented	no	6.00	summer	night	0.0000	325.00
Implemented	no	6.00	winter	day	0.0000	325.00
Implemented	no	6.00	winter	night	0.0000	325.00
Implemented	no	6.50	summer	day	0.0000	325.00
Implemented	no	6.50	summer	night	0.0000	325.00

Implemented	no	6.50	winter	day	0.0000	325.00
Implemented	no	6.50	winter	night	0.0000	325.00
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Implemented	no	7.00	summer	night	0.0000	325.00
Implemented	no	7.00	winter	day	0.0000	325.00
Implemented	no	7.00	winter	night	0.0000	325.00
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Implemented	no	7.50	summer	night	0.0000	325.00
Implemented	no	7.50	winter	day	0.0000	325.00
Implemented	no	7.50	winter	night	0.0000	325.00
Base	yes	0.00	summer	day	0.0977	6495.00
Base	yes	0.00	summer	night	0.0977	6495.00
Base	yes	0.00	winter	day	0.0977	6495.00
Base	yes	0.00	winter	night	0.0977	6495.00
Base	yes	0.50	summer	day	0.0977	6495.00
Base	yes	0.50	summer	night	0.0977	6495.00
Base	yes	0.50	winter	day	0.0977	6495.00
Base	yes	0.50	winter	night	0.0977	6495.00
Base	yes	1.00	summer	day	0.0977	6495.00
Base	yes	1.00	summer	night	0.0977	6495.00
Base	yes	1.00	winter	day	0.0977	6495.00
Base	yes	1.00	winter	night	0.0977	6495.00
Base	yes	1.50	summer	day	0.0977	6495.00
Base	yes	1.50	summer	night	0.0977	6495.00
Base	yes	1.50	winter	day	0.0977	6495.00
Base	yes	1.50	winter	night	0.0977	6495.00
Base	yes	2.00	summer	day	0.0977	6495.00
Base	yes	2.00	summer	night	0.0977	6495.00
Base	yes	2.00	winter	day	0.0977	6495.00
Base	yes	2.00	winter	night	0.0977	6495.00
Base	yes	2.50	summer	day	0.0977	6495.00
Base	yes	2.50	summer	night	0.0977	6495.00
Base	yes	2.50	winter	day	0.0977	6495.00
Base	yes	2.50	winter	night	0.0977	6495.00
Base	yes	3.00	summer	day	0.0977	6495.00
Base	yes	3.00	summer	night	0.0977	6495.00
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Base	yes	3.00	winter	night	0.0977	6495.00
Base	yes	3.50	summer	day	0.0977	6495.00
Base	yes	3.50	summer	night	0.0977	6495.00
Base	yes	3.50	winter	day	0.0977	6495.00
Base	yes	3.50	winter	night	0.0977	6495.00
Base	yes	4.00	summer	day	3.6335	6495.00
Base	yes	4.00	summer	night	3.6335	6495.00
Base	yes	4.00	winter	day	3.6335	6495.00
Base	yes	4.00	winter	night	3.6335	6495.00

Base	yes	4.50	summer	day	9.0626	6495.00
Base	yes	4.50	summer	night	9.0626	6495.00
Base	yes	4.50	winter	day	9.0626	6495.00
Base	yes	4.50	winter	night	9.0626	6495.00
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Base	yes	5.00	summer	night	28.4693	6495.00
Base	yes	5.00	winter	day	28.4693	6495.00
Base	yes	5.00	winter	night	28.4693	6495.00
Base	yes	5.50	summer	day	42.6693	6495.00
Base	yes	5.50	summer	night	42.6693	6495.00
Base	yes	5.50	winter	day	42.6693	6495.00
Base	yes	5.50	winter	night	42.6693	6495.00
Base	yes	6.00	summer	day	43.1085	6495.00
Base	yes	6.00	summer	night	43.1085	6495.00
Base	yes	6.00	winter	day	43.1085	6495.00
Base	yes	6.00	winter	night	43.1085	6495.00
Base	yes	6.50	summer	day	43.5320	6495.00
Base	yes	6.50	summer	night	43.5320	6495.00
Base	yes	6.50	winter	day	43.5320	6495.00
Base	yes	6.50	winter	night	43.5320	6495.00
Base	yes	7.00	summer	day	45.6908	6495.00
Base	yes	7.00	summer	night	45.6908	6495.00
Base	yes	7.00	winter	day	45.6908	6495.00
Base	yes	7.00	winter	night	45.6908	6495.00
Base	yes	7.50	summer	day	46.4468	6495.00
Base	yes	7.50	summer	night	46.4468	6495.00
Base	yes	7.50	winter	day	46.4468	6495.00
Base	yes	7.50	winter	night	46.4468	6495.00
Implemented_P	yes	0.00	summer	day	0.0977	6495.00
Implemented_P	yes	0.00	summer	night	0.0977	6495.00
Implemented_P	yes	0.00	winter	day	0.0977	6495.00
Implemented_P	yes	0.00	winter	night	0.0977	6495.00
Implemented_P	yes	0.50	summer	day	0.0977	6495.00
Implemented_P	yes	0.50	summer	night	0.0977	6495.00
Implemented_P	yes	0.50	winter	day	0.0977	6495.00
Implemented_P	yes	0.50	winter	night	0.0977	6495.00
Implemented_P	yes	1.00	summer	day	0.0977	6495.00
Implemented_P	yes	1.00	summer	night	0.0977	6495.00
Implemented_P	yes	1.00	winter	day	0.0977	6495.00
Implemented_P	yes	1.00	winter	night	0.0977	6495.00
Implemented_P	yes	1.50	summer	day	0.0977	6495.00
Implemented_P	yes	1.50	summer	night	0.0977	6495.00
Implemented_P	yes	1.50	winter	day	0.0977	6495.00
Implemented_P	yes	1.50	winter	night	0.0977	6495.00
Implemented_P	yes	2.00	summer	day	0.0977	6495.00
Implemented_P	yes	2.00	summer	night	0.0977	6495.00

Implemented_P	yes	2.00	winter	day	0.0977	6495.00
Implemented_P	yes	2.00	winter	night	0.0977	6495.00
Implemented_P	yes	2.50	summer	day	0.0977	6495.00
Implemented_P	yes	2.50	summer	night	0.0977	6495.00
Implemented_P	yes	2.50	winter	day	0.0977	6495.00
Implemented_P	yes	2.50	winter	night	0.0977	6495.00
Implemented_P	yes	3.00	summer	day	0.0977	6495.00
Implemented_P	yes	3.00	summer	night	0.0977	6495.00
Implemented_P	yes	3.00	winter	day	0.0977	6495.00
Implemented_P	yes	3.00	winter	night	0.0977	6495.00
Implemented_P	yes	3.50	summer	day	0.0977	6495.00
Implemented_P	yes	3.50	summer	night	0.0977	6495.00
Implemented_P	yes	3.50	winter	day	0.0977	6495.00
Implemented_P	yes	3.50	winter	night	0.0977	6495.00
Implemented_P	yes	4.00	summer	day	2.2135	6495.00
Implemented_P	yes	4.00	summer	night	2.2135	6495.00
Implemented_P	yes	4.00	winter	day	2.2135	6495.00
Implemented_P	yes	4.00	winter	night	2.2135	6495.00
Implemented_P	yes	4.50	summer	day	5.2760	6495.00
Implemented_P	yes	4.50	summer	night	5.2760	6495.00
Implemented_P	yes	4.50	winter	day	5.2760	6495.00
Implemented_P	yes	4.50	winter	night	5.2760	6495.00
Implemented_P	yes	5.00	summer	day	21.3693	6495.00
Implemented_P	yes	5.00	summer	night	21.3693	6495.00
Implemented_P	yes	5.00	winter	day	21.3693	6495.00
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Implemented_P	yes	5.50	winter	night	42.6693	6495.00
Implemented_P	yes	6.00	summer	day	42.9321	6495.00
Implemented_P	yes	6.00	summer	night	42.9321	6495.00
Implemented_P	yes	6.00	winter	day	42.9321	6495.00
Implemented_P	yes	6.00	winter	night	42.9321	6495.00
Implemented_P	yes	6.50	summer	day	43.1624	6495.00
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Implemented_P	yes	6.50	winter	night	43.1624	6495.00
Implemented_P	yes	7.00	summer	day	45.3128	6495.00
Implemented_P	yes	7.00	summer	night	45.3128	6495.00
Implemented_P	yes	7.00	winter	day	45.3128	6495.00
Implemented_P	yes	7.00	winter	night	45.3128	6495.00
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Implemented_P	yes	7.50	winter	night	46.4468	6495.00

Implemented	yes	0.00	summer	day	0.0977	6495.00
Implemented	yes	0.00	summer	night	0.0977	6495.00
Implemented	yes	0.00	winter	day	0.0977	6495.00
Implemented	yes	0.00	winter	night	0.0977	6495.00
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Implemented	yes	0.50	summer	night	0.0977	6495.00
Implemented	yes	0.50	winter	day	0.0977	6495.00
Implemented	yes	0.50	winter	night	0.0977	6495.00
Implemented	yes	1.00	summer	day	0.0977	6495.00
Implemented	yes	1.00	summer	night	0.0977	6495.00
Implemented	yes	1.00	winter	day	0.0977	6495.00
Implemented	yes	1.00	winter	night	0.0977	6495.00
Implemented	yes	1.50	summer	day	0.0977	6495.00
Implemented	yes	1.50	summer	night	0.0977	6495.00
Implemented	yes	1.50	winter	day	0.0977	6495.00
Implemented	yes	1.50	winter	night	0.0977	6495.00
Implemented	yes	2.00	summer	day	0.0977	6495.00
Implemented	yes	2.00	summer	night	0.0977	6495.00
Implemented	yes	2.00	winter	day	0.0977	6495.00
Implemented	yes	2.00	winter	night	0.0977	6495.00
Implemented	yes	2.50	summer	day	0.0977	6495.00
Implemented	yes	2.50	summer	night	0.0977	6495.00
Implemented	yes	2.50	winter	day	0.0977	6495.00
Implemented	yes	2.50	winter	night	0.0977	6495.00
Implemented	yes	3.00	summer	day	0.0977	6495.00
Implemented	yes	3.00	summer	night	0.0977	6495.00
Implemented	yes	3.00	winter	day	0.0977	6495.00
Implemented	yes	3.00	winter	night	0.0977	6495.00
Implemented	yes	3.50	summer	day	0.0977	6495.00
Implemented	yes	3.50	summer	night	0.0977	6495.00
Implemented	yes	3.50	winter	day	0.0977	6495.00
Implemented	yes	3.50	winter	night	0.0977	6495.00
Implemented	yes	4.00	summer	day	0.2255	6495.00
Implemented	yes	4.00	summer	night	0.2255	6495.00
Implemented	yes	4.00	winter	day	0.2255	6495.00
Implemented	yes	4.00	winter	night	0.2255	6495.00
Implemented	yes	4.50	summer	day	0.6373	6495.00
Implemented	yes	4.50	summer	night	0.6373	6495.00
Implemented	yes	4.50	winter	day	0.6373	6495.00
Implemented	yes	4.50	winter	night	0.6373	6495.00
Implemented	yes	5.00	summer	day	4.3293	6495.00
Implemented	yes	5.00	summer	night	4.3293	6495.00
Implemented	yes	5.00	winter	day	4.3293	6495.00
Implemented	yes	5.00	winter	night	4.3293	6495.00
Implemented	yes	5.50	summer	day	42.6693	6495.00
Implemented	yes	5.50	summer	night	42.6693	6495.00

Implemented	yes	5.50	winter	day	42.6693	6495.00
Implemented	yes	5.50	winter	night	42.6693	6495.00
Implemented	yes	6.00	summer	day	42.6852	6495.00
Implemented	yes	6.00	summer	night	42.6852	6495.00
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Implemented	no	7.50	winter	night	61.1430	6495.00

Note: Lives_No consists in the same file, with the only change of the heading of the column Lives_Yes by Lives_No

ANNEX 7: PHASE I OVERALL REPORT

OVERALL REPORT

"Quantitative risk analysis for Hällby – a case study". Phase I.

by

Prof.Dr. Ignacio Escuder-Bueno
Universidad Politécnica de Valencia (UPV) and iPresas (Spin Off-UPV)

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Universidad Politécnica de Valencia (UPV) and iPresas (Spin Off-UPV)

Dr. Armando Serrano-Lombillo
iPresas (Spin Off-UPV)

iPresas
Risk Analysis

VALENCIA, JANUARY 5th, 2012.

INDEX

ESTRUCTURE OF THE DOCUMENT

The Overall Report on "Quantitative risk analysis for Hällby – a case study. Phase I" has been structured in three different parts.

- **Part I** contains a concise conceptual introduction to risk analysis as applied to dam safety and the context and conditions under which it has been applied to Hällby Dam, under a contract between iPRESAS (an Spin Off Company emerged from Universidad Politecnica de Valencia, Spain) and ELFORSK (Sweden).

  The conceptual introduction is a very compact synthesis of a series of articles and other documents that have been provided by the authors of this report to all the participants in the project as "pre-readings" to the "working sessions". In particular, these references are:

  Serrano, A.; Escuder, I.; Membrillera, M.; Altarejos, L. Methodology for the calculation of annualized incremental risks in systems of dams. Article. Risk Analysis: an International Journal. DOI: 10.1111/j.1539-6924.2010.01547.x ISSN: 0272-4332. United Kingdom. 2010 (December)

  Ardiles, L.; Sanz, D.; Moreno, P.; Jenaro, E.; Fleitz, J.; Escuder, I. Risk assessment and management of 26 dams operated by the Duero River Authority in Spain. Article. PUBLICATION: DAM ENGINEERING. International papers of technical excellence. VOLUME: XXI. ISSUE: 4. ISSN: 0-617-00563-X. United Kingdom. 2011 (April)

  Escuder-Bueno, I.; Castillo-Rodríguez, J.T.; Petaccia, G.; Perales-Momparler, S. Application of a complete and quantitative tool for flood risk analysis in urban areas. Article. Third International Forum on Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management 3IWRDD. CRC-BALKEMA. ISBN: 978-0-415-62078-9. Valencia (Spain). 2011 (October).

  Altarejos-García, L.; Escuder-Bueno, I.; Serrano-Lombillo, A.; Morales-Torres, A. Factor of safety and probability of failure in concrete dams. Article. Third International Forum on Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management 3IWRDD. CRC-BALKEMA. ISBN: 978-0-415-62078-9. Valencia (Spain). 2011 (October).

  Serrano-Lombillo, A.; Morales-Torres, A.; García-Kabbabe, L.A. Consequence estimation in risk analysis. Article. Third International Forum on Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management 3IWRDD. CRC-BALKEMA. ISBN: 978-0-415-62078-9. Valencia (Spain). 2011 (October).

  Serrano-Lombillo, A.; Fluixá-Sanmartín, J.; Espert-Canet, V.J. Flood routing in risk analysis. Article. Third International Forum on Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management 3IWRDD. CRC-BALKEMA. ISBN: 978-0-415-62078-9. Valencia (Spain). 2011 (October).

  Escuder, I; Morales, A. and Perales, S. Urban flood risk characterization as a tool for planning and managing. USACE Workshop on Exploration of Tolerable Risk Guidelines for Levee Systems. March 2010.

Escuder, I. Concept and context of risk analysis as applied for dam safety and dam security. Unpublished paper. April 2010.

Serrano, A.; Escuder, I.; G. Membrillera, M., and Altarejos, L. Risk models as a tool to assist decision making on dam safety management. IX SPANCOLD Meeting. June, 2010. (Translated to English)
Escuder, I.; Meghella, M.; G. Membrillera, M. and Serrano, A. DAMSE: A european methodology for risk based security assessment of dams. BRASILIA ICOLD CONGRESS. May 2009.

Serrano, A.; Escuder, I.; G. Membrillera, M., and Altarejos, L. iPresas. SOFTWARE for Risk Analysis. BRASILIA ICOLD CONGRESS. May 2009.

G. de Membrillera, M.; Escuder, I.; Bowles, D.; Triana, E. and Altarejos, L. Justification for an operating restriction in Spain incorporating ANCOLD guidelines on risk assessment. ANCOLD Meeting, Nov. 2006.

Altarejos, L.; Escuder, I.; G. Membrillera, M., and Serrano, A. Risk analysis and probability of failure of a gravity dam. BRASILIA ICOLD CONGRESS. May 2009.

Castro, C.; Cabareda, L.; Escuder, I. and G. de Membrillera, M. Development of a risk based dam safety program for the Lower Caroni River Dams (Venezuela). SOFIA ICOLD Annual meeting. 2008.

Castro, C.; Martínez, E.; Cabareda, L.; Ramírez, O. and Escuder, I. Quantitative risk-model for Antonio Jose de Sucre-Macagua Dam (EDELCA, VENEZUELA). HANOI ICOLD Annual Meeting, 2010.

Ardiles, L.; Moreno, P.; Jenaro, E., Fleitz, J. and Escuder, I. Risk management at the Duero River Basin (Spain). IX SPANCOLD Meeting. June, 2010. (Translated to English)

- **Part II** explains the works developed, following the logic of risk analysis (see Figure 0.1), to end up with the final product of Phase I, the risk model architecture. It also contains an explanation of further steps to complete a full quantitative analysis and identifies the associated potential for research.

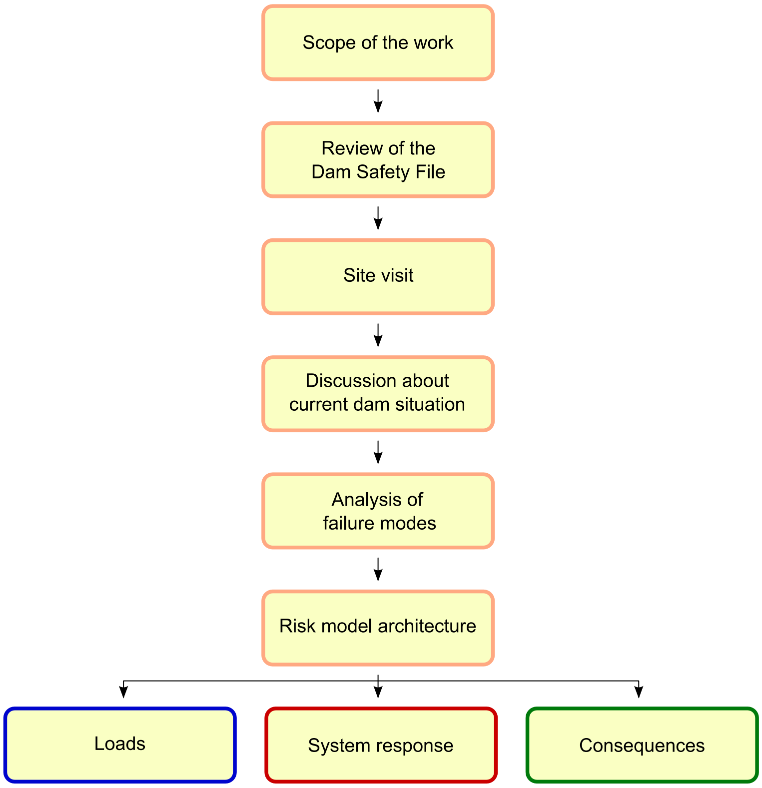


Figure 0.1. Risk analysis framework for Phase I.

- **Part III** comprises a list of appendixes, in particular: Terms of Reference, Deliverables 1, 2 and 3 (due in Phase I) and a Proposal for Phase II.

  In particular, appendixes 2, 3 and 4 (Deliverables 1, 2 and 3 respectively) show the full list of documents that have been delivered, which are all classified and available at the "Project Portal" (Figure 0.2).

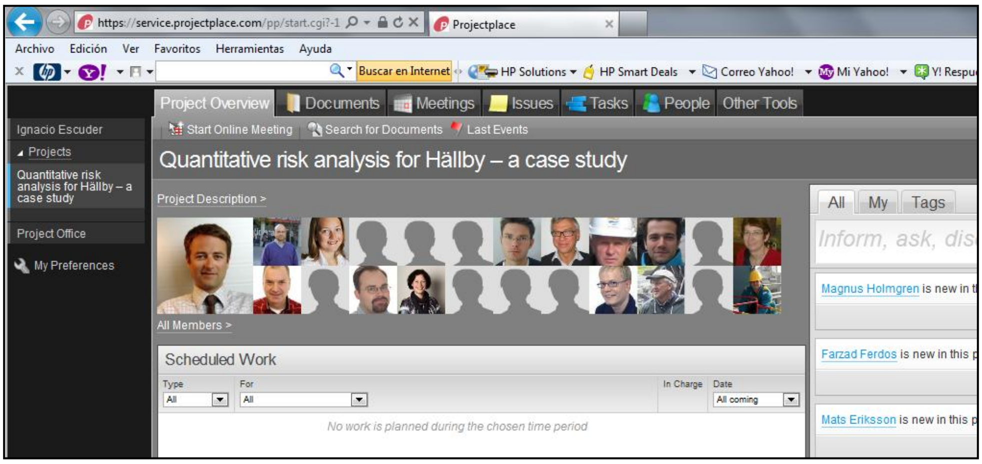


Figure 0.2. Project Portal main menu

It is worth to recall that the Project Portal contains all documents supporting this report in addition to those provided or listed in the Appendixes of Part III. In particular, contributions from all participants (mainly with regard to Potential Failure Mode Identification personal work) are also available, as well as those documents generated during review sessions with the Steering Committee.

PART I: RISK ANALYIS: OVERALL CONCEPTS AND CONTEXT OF APPLICATION TO HÄLLBY DAM WITH ELFORSK

RISK ANALYIS: OVERALL CONCEPTS AND CONTEXT OF APPLICATION TO HÄLLBY DAM WITH ELFORSK

Understanding and recognizing all the different risk components that are inherent in dam and reservoir safety management constitutes the conceptual basis to implement logic systems or models aimed to inform decision making.

Starting by day by day basic activities, many surveillance tasks such as visual inspections, monitoring of the behavior by means of instrumentation records or function tests on the electromechanical equipment are typically covered. In fact, if a failure mode has already started and is under progression, the capacity for detection and successful intervention relies on the efficacy of these activities.

Once any abnormal behavior affecting the safety of the facility has been detected, intervention is focused both to overcome the deficiency and in terms of emergency management aimed to protect the downstream population. The first of these actions would result in diminishing the probability of failure and the second one in the potential adverse consequences mitigation, typically by means of conducting the activities included in an emergency action plan.

Another of the core activities of any dam safety program is the periodical safety review, where load scenarios and system response in terms of safety factors are typically analyzed, together with other factors such as gate functionality, communication reliability, accessibility, etc.

In summary, all mentioned activities, studies and procedures linked to dam safety management that are usually mandatory to document in the Operation Rules, Emergency Action Plans and Safety Review Reports, are linked to the different components of risk: loads, system response, and consequences.

Thus, if all processes involved in dam safety management are integrated in a logic system or risk models capable to aggregate all risk components inherent to these infrastructures, the resulting information will be of great value to help in decision making.

In order to achieve this value, the inputs to the risk model have to be converted into information to allow the identification, characterization and quantification of risk. The process that starts with gathering data and leads to risk quantification implies the consolidation of the existing knowledge on the facility and has to be guaranteed with procedures to properly store and update such data that will be integrated in a necessarily dynamic management tool.

Consistency, robustness, efficacy and efficiency of risk models in order to provide valuable information in decision-making are reinforced by different means. One of the most important aspects is exchanging information, debating on different procedures, etc. preferably in events such as workshops or conferences that are typically oriented to owners and dam safety professionals. However, it also becomes critical that all personnel involved in dam safety activities is trained and educated adequately to guarantee reliable results thus providing by itself a better safety condition of the dams.

In any case, the capacity and the way of communicating with the public (and particularly with downstream residents), together with a clear legislation that integrates design standards, safety requirements, risk management and legal responsibilities, are two of the main pillars necessary to implement a modern, transparent, efficient and socially accepted procedure for decision making in dam safety.

The following (Figure I.1) conceptual scheme represents how risk models are linked to the contents of different legal documents (names are quite similar in world class safety legislation) and to scientific areas.

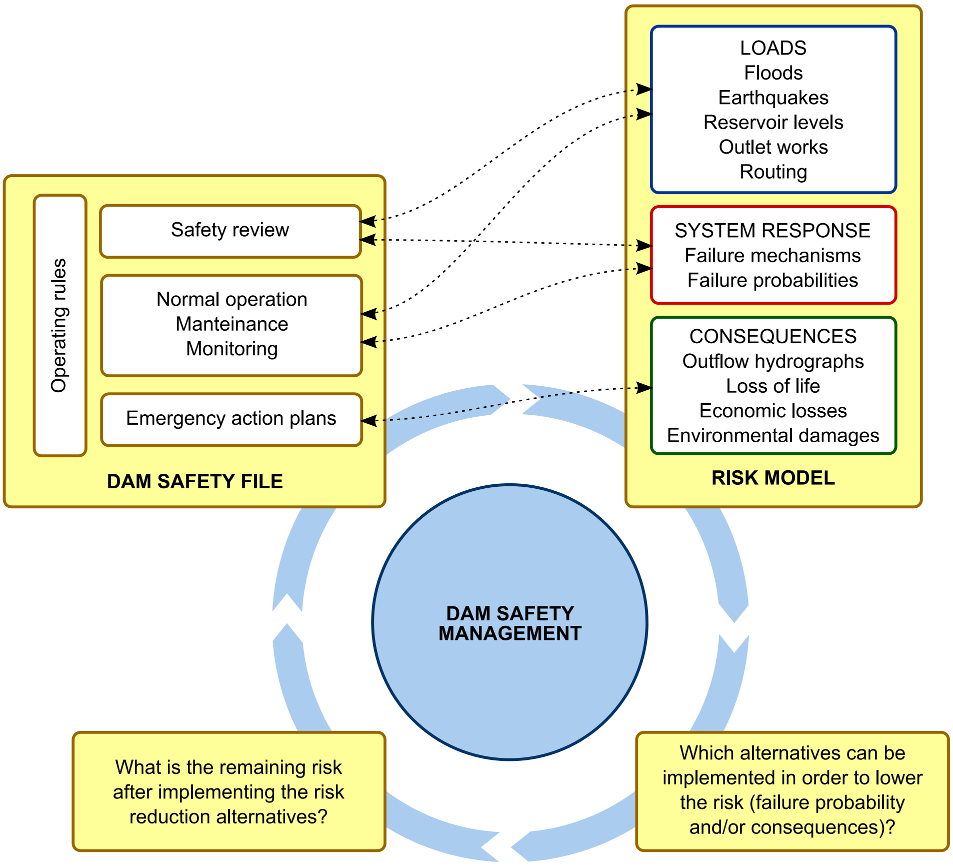


Figure I.1: Risk model links to the contents of different legal documents and to scientific areas. Dynamics involved in using the risk models as tools to inform decision making

The context for applying risk analysis to a pilot case study (Hällby Dam) was established in a working session between the first author of this report and representatives of ELFORSK in the December 9. Literally:

- *The Steering Committee (around 6 people, tentatively Carl-Oscar Nilsson, E.ON as Chairman, Lars Hammar, Vattenfall, Stefan Berntsson, Vattenfall, Ylva Helmfrid, Fortum, Martin Hansson, Statkraft and Maria Bartsch, Svenska Kraftnät) will participate in a "one day working session" every two months, so they can effectively assume the roles included in the "Terms of reference"*

- *The Project Manager and his team (around 3 people, tentatively Dr. Ignacio Escuder, UPV, as Project Manager, Dr. Armando Serrano, UPV and Dr. Luis Altarejos, UPV) will prepare the meetings, supervise/provide the tools to be used for the quantitative risk assessment and perform/assign tasks. They will facilitate the meetings typically divided in one day training (know-how* *transfer with the "working group" or an "extended working group" if it is preferred), one day work development with the "working group" and one day sharing/validating/reviewing the works with the Steering Committee. In summary, to be able to do the training, the working and the reviewing sessions, around three days will be needed (every two months).*

- *The Working Group will be composed by some "core members", tentatively technical staff from E.ON, Vattenfall and Elforsks plus may be two more people (around 5 people), that will attend all the working sessions and may co-develop part of the work. This last issue (co-develop part of the work) will not be a requirement as the selected dam, Hällby, has a lot of expertise, sound engineering and dam safety works (such as Emergency Action Plans or Dam Safety Reviews) already available and documented. However, it may be in the interest of the working group members to actively participate in all or some of the works in addition to receiving the training and participating in the working sessions. In addition, the group will have the possibility to invite experts in different areas (hydrology, geotechs, etc.) to some of the working sessions and/or tasks. So the working group may occasionally include around 10 people, with participants from consultancy firms, universities, and experts that may join either the "training sessions" and/or "working sessions".*

- *There could also be some "permeability" among groups, so if a member of the Steering Committee wants to get more involved in some of the technical works, that also reinforces the process.*

The scope of the work, working sessions schedules and overall resources for the project were estimated for Hällby Dam based on the previous experience of Professor Ignacio Escuder-Bueno as member of the Review Panel that performed a comprehensive study of the safety conditions of the dam in 2008. In order to cope with the fact that the project organization will incorporate representatives from different companies with different previous experience and expectations on risk analysis, the overall process has been understood as a learning experience and flexible enough to maximize the potential benefits of it.

Two detailed proposals were submitted by Professor Ignacio Escuder Bueno in January 12, 2011 (for the complete scope of the "Terms of Reference" see Appendix 1) and a second one, restricted to the so called "Phase I" by March 11, 2011. This second proposal was approved by ELFORSK and the works started by May 2011. Table I.1 shows the final composition of the Project Management Team and the Steering Committee:

Project management	
Prof. Ignacio Escuder-Bueno	Universidad Politecnica de Valencia and iPRESAS
Prof. Luis Altarejos-García	Universidad Politecnica de Valencia and iPRESAS
Dr. Armando Serrano-Lombillo	iPRESAS
Steering group	
Anders Isander	E.ON Vattenkraft Sverige AB
Maria Bartsch	Svenska Kraftnät
Jonas Birkedahl	Fortum Generation AB
Martin Hansson	Statkraft Sverige AB
Lars Hammar/Stefan Berntsson/Claes-Olof	Vattenfall AB Vattenkraft

Table I.1 Project Management Team and Steering Committee members

PART II. MEMORY OF THE WORKS

MEMORY OF THE WORKS

1. INTRODUCTION AND SCOPE

According to the update (March 2011) of the Terms of Reference of the Project following a working session held in Stockholm on December 9, 2010 (See **Appendix 1**), on the initiative of Elforsks R & D program on dam safety and in cooperation with Swedish HydroPower Centre, the Project ”Quantitative risk analysis for Hällby – a case study” was undertaken with Dr. Ignacio Escuder-Bueno as a project manager and Dr. Luis Altarejos García and Dr. Armando Serrano-Lombillo as members of the management team.

The project was divided in two phases. The first phase started in May 2011 and the optional second phase will preliminary be undertaken early in 2012.

The first phase (Phase I) comprises an initial elaboration of the scope of work, presentation and analysis of the information and current dam situation, identification of load scenarios, failure modes and consequences and building the architecture of a risk model for Hällby dam. The second phase (Phase II) is suggested to comprise risk calculations, risk evaluation and studies of risk mitigation measures in Hällby dam.

The project purpose is to:

- Provide common experience of a quantitative method for risk informed dam safety decisions (quantitative analysis of “risk reduction efficiency”).
- Suggest further initiatives to develop practical applicable risk based methods in dam safety management.
- Identify needs and initiate research and development concerning risk analysis, uncertainties, failure modes and probabilities of failure of relevance for dams and dam safety.

The overall idea is that Hällby Dam, as a practical case study, should be the driving force for knowledge transfer and a common fire place where experiences could be exchanged. Knowledge transfer and identification and initiation of research and development in the field shall also be stimulated through involvement of expertise and active researchers within Swedish HydroPower Center in the project.

In addition, it was acknowledged that processes involved in building Dam Safety Risk Models rely on sound engineering activities such as Failure Mode Identification which required the proper consistency and diversity of expertise within the working group.

To cope with such requirement, the following list of participants (Table II.1) shows how the Project Management Team and the Steering Committee was supported by the so called “working group” and “invited expertise for consultancies and universities”:

Working group	
Jeanette Stenman	E.ON Vattenkraft Sverige AB
Assar Svensson	E.ON Vattenkraft Sverige AB
Stefan Berntsson/Anders	Vattenfall AB Vattenkraft

Ylva Helmfrid	Fortum Generation AB
Sezar Moustafa	Fortum Generation AB
Ann-Marie Olofsson	Fortum Generation AB
Victor Carlsson	Skellefteå Kraft AB
Martin Hansson	Statkraft Sverige AB
Gjermund Molle	Statkraft Energi AS
Markus Hautakoski	Vattenregleringsföretagen
Birgitta Rådman	Vattenregleringsföretagen
Ragnar Asklund	Jämtkraft AB
Invited expertise from consultancies and universities	
Tommy Edeskär	Luleå tekniska universitet
Anders Wörman	Kungliga Tekniska högskolan
Fredrik Johansson	Kungliga Tekniska högskolan
Mats Eriksson	Vattenfall Power Consultant AB
Carl-Magnus Jewert	Vattenfall Power Consultant AB
Petter Stenström	WSP Samhällsbyggnad
Åke Nilsson	WSP Samhällsbyggnad
Hans Rönnqvist	WSP Samhällsbyggnad
Rolf Hultman	Sweco Infrastructure AB
Anders Gustafsson	Sweco Infrastructure AB
Marie Westberg	ÅF/Energo
Stefan Lagerholm	ÅF/Energo

Table II.1 Working group and invited expertise from consultancies and universities

The sequence of working sessions proposed for Phase I of the project (Table II.2) has been developed consistently with the process described in Figure II.1, including all the steps to build the "Risk Model Architecture".

DATE	ACCOMPLISHED TASKS
09/12/2010	Clarification and debate on the "Terms of Reference" to prepare the proposal (Pre-Study).
10/05/2011 11/05/2011 12/05/2011 (***DELIVERABLE 1***)	Working Group getting together and training on the overall process and procedures. Discussion on all relevant Hällby Dam Safety Documents. Site Visit. Discussion on current dam situation. Assigning tasks/commitments for the next working session.
06/09/2011 07/09/2011 08/09/2011 (***DELIVERABLE 2)***	Training on PFMI and links to risk model architecture. Potential Failure Mode Identification (PFMI). Assigning tasks/commitments for the next working session.
29/11/2011 30/11/2011 01/12/2011 (***DELIVERABLE 3)***	Consensus approach to Potential Failure Modes identification. Building together a complete architecture of the Risk Model. Research opportunities within the risk analysis framework.

12/01/2012	
	Final Review of Phase I and work session to explore a consistent proposal for Phase II
(***PHASE I REPORT***)	

Table II.2 Sequence of working sessions

As shown in Table II.2, each working session (May, September and November 2011) resulted in a DELIVERABLE (1, 2 and 3), each of one included a set of documents that are detailed as Appendixes in Part III of this document (**Appendix 2, Appendix 3 and Appendix 4**).

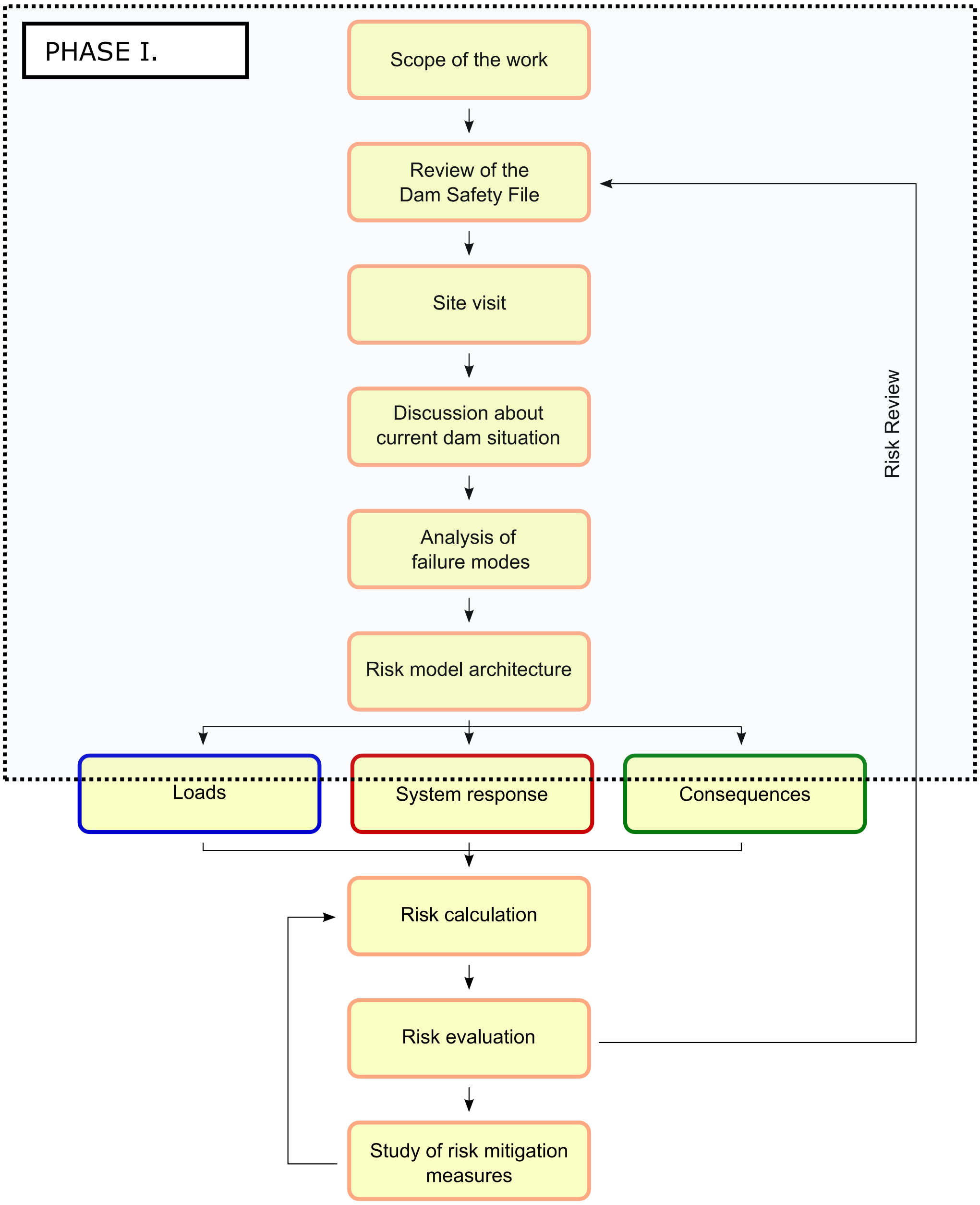


Figure II.1: Phases of risk model development (process)

It is important to remark the process itself of working together on the exploration of risk analysis and assessment goes beyond any methodology and, in fact, one of the challenges of developing processes like the one that has been undertaken is building capacities, knowledge transfer, through proper group dynamics, integrating the expertise of all participants.

2 REVIEW OF INFORMATION

In depth review of available information is a fundamental requirement in order to provide sound engineering basis to risk analysis techniques.

The most updated and relevant documents reviewed with regard to the safety of Hällby Dam have included (Table II.3):

DOCUMENT TITLE	YEAR	AUTHOR
Hällby - Status Assessment and Action Plan 2011	2011	WSP
Reliability Analyisis, Discharge Equipment, Hällby	2010	VATTENFALL
Special Dam Safety Review of Hällby Dam, Sweden	2008	Report of the Review Board

Table II.3 Main documents reviewed.

In addition, new tests on the embankment core material and on seepage response of the embankment dam downstream the core (by means of infiltration tests) were preliminary presented during the third working session (November 2011).

It is also important to remark that all documents that informed the "Special Dam Safety Review of Hällby Dam, Sweden" in 2008, that were made available in English to Prof. Escuder-Bueno as member of the Review Board, have also been reviewed and used during the process. In particular:

- Advanced Dam Safety Audit (FDU, 2001)
- Inspection 2003 according to RIDAS (Inspection Report, 2003).
- Stability calculations concrete structures (2003).
- Embankment dams. Slope stability and through-flow calculations (2003).
- Hällby Risk Analysis (2004; Updated 2008).
- Inspection 2006 according to RIDAS (Inspection Report, 2006).
- Supplementary stability calculations for concrete structures (2007).
- Inspection of dam measurements at Hällby Power Plant (period May-October 2007). Step 1. (2008).
- Inspection of dam measurements at Hällby Power Plant (period May-October 2007). Step 2. (2008).
- Dam-break Flood Simulation and Consequence Analysis for Hällby Dam Facilities (2007).
- Operation, Status Control and Maintenance Manual (DTU manual, 2008).

- Emergency preparedness plan Hällby Power Plant (2008, included in DTU manual).
- Dam safety operations within E.ON Vattenkraft Sverige AB (2008).
- Audience copies. Special examination – presentations made at the seminar held May 20, 21, 2008.
- Dam Safety in Sweden, Background, legislation and roles, Olle Mill, Svenska Kraftnät, Original 2005, Rev. (2008).
- RIDAS, Hydropower Industry Dam Safety Guidelines, Revised in 2002, Svensk Energi – Swedenenergy – AB, Translation in English of the Main Document (2002).
- Dam Safety-Pilot project "Special Examination" (Revision 5 Dec. 2007).
- Hydropower Industry Dam Safety Guidelines (RIDAS) (2002).
- Preliminary Design of Stabilizing Berm (2003).
- Measurement program proposal for Measurement at Hällby Power Plant (E.ON, 2008).
- Chapters 3.2.4 (Instrumentation), 3.3.10 (Instrumentation) and 4.5 (Dam Owner's status control) of the RIDAS - Embankment Dams – Implementation guidelines (G1). In Chapter 2 of the RIDAS Implementation Guidelines

Figure II.2 shows the group discussing on the available information.

Figure II.2. Working session on the review of available information

3 SITE INSPECTIONS

The visit was scheduled as one key step within the risk analysis process. As Prof. Escuder had visited the dam site in 2008 as part of the "special review" assignment, some brief notes are added to acknowledge some of the improvements since then:

- New rip-rap has been placed on the upstream shoulder of the embankment dams
- New instruments (stand pipes) have been installed to monitor downstream filter pore pressure in the embankment dams.
- Drainage system underneath the concrete structures has been rehabilitated.
- Uplift pressure underneath the log-spillway section is being monitored by a new piezometer (drilled from downstream with 45 degree inclination)
- Spillway gates control chamber has been fully rebuilt (it was under major reconstruction by 2008 visit).

Figure II.3 shows the group visiting Hällby dam.

Figure II.3 Site visit to Hällby dam (May, 2011)

As a preliminary evaluation, all improvements are clearly linked to prevent the three main failure modes identified by the panel review team in 2008: internal erosion through embankment dams, sliding of the log-spillway concrete section and overtopping due to inability to open the gates.

Finally, after the dam site visit, the group had the opportunity to visit the potentially affected downstream area in the case of a failure. This had not been done before (in 2008) and helped very much to understand the magnitude and location of the potential consequences.

4 CURRENT CONDITION OF THE DAM

After a proper level of discussion on the available information plus the site visit (as commented in the previous chapters), the group was asked to provide an overall judgment on what would be the current state of the dam by comparison with Swedish Legislation and best international practice on dam safety from a broad perspective.

The list of topics to evaluate were:

- Hydrologic adequacy.
- Spillway capacity and reliability.
- Reservoir slope stability.
- Stability of concrete and embankment sections.
- Internal erosion of different embankment sections and foundation.
- Instrumentation and monitoring.
- Drainage system performance.
- Emergency preparedness.

Table II.4 shows the assessment made on all these topics (many of them were decomposed in different subtopics as shown in the Table II.4) by 20 participants according to the following scale:

- P: pass the safety standards.
- AP: apparently pass the safety standards
- APN: apparently no pass the safety standards
- NP: no pass the safety standards.

It is important to remark that the only purpose of scaling the judgments was to facilitate a discussion on the current state of dam, linking the different "risk" components and the safety standards in a very qualitative way before a robust and consistent failure mode identification was undertaken.

• Stability																					
○ Left embankment dam	P	P	P	P	P	P	P	P	P	AP	AP	P	AP	P	P	P	P	P	P	P	P
○ Left embankment dam (rapid drawdown)	P	P	P	P	AP	-	-	P	P	AP	-		AP	P	P	P		-	-	-	-
○ Right embankment dam	P	P	P	P	P	P	P	P	P	AP	AP	P	AP	P	P	P	P	P	P	P	P
○ Right embankment dam (rapid drawdown)	P	P	P	P	AP	-	-	P	P	AP	-		AP	P	P	P		-	-	-	-
○ Concrete buttress dam section	P	P	P	P	P	P	AP	P	P	AP	AP	AP	AP	P	P	AP	P	P	P	AP	AP
○ Concrete log spillway section	AP	AP	P	P	AP	AP	AP	P	AP	AP	AP	AP	AP	AP	ANP	AP	P	P	AP		AP
○ Concrete spillway section	AP	P	P	P	P	P	AP	P	AP	AP	AP	AP	AP	P	AP	AP	P	P	P	P	AP
• Internal erosion																					
○ Left embankment dam	P	AP	P	P	ANP	AP	AP	AP	AP	AP	P	P	AP	AP	AP	P	AP	AP	ANP	ANP	ANP
○ Left embankment transition section	AP	ANP	ANP	ANP	ANP	ANP	ANP	P	ANP	AP	AP	AP	AP	AP	NP	NP	AP	ANP	ANP	ANP	ANP
○ Right embankment dam	P	AP	P	P	AP	AP	AP		AP	AP	P	P	AP	AP	AP	P	AP	AP	AP	ANP	ANP
○ Right embankment transition section	AP	AP	ANP	ANP	ANP	ANP	ANP		ANP	AP	AP	AP	AP	AP	NP	NP	AP	ANP	AP	ANP	ANP
○ Foundation	P	AP	P	P	AP	AP	AP	P	P	AP	AP	P	AP	P	AP	AP	AP	AP	AP	ANP	AP
• Hydrologic adequacy																					
Hydrologic adequacy	ANP	AP	AP	AP		P	AP		AP	AP			AP	AP	AP	AP	AP	P	P	P	P
• Spillway																					
○ Gates structural capacity	P	P	P	P	AP	AP	AP	P	P	AP		AP	AP	AP	AP	AP	P	P	P	P	P
○ Piers structural capacity	P	P	P	P	AP	P	AP	P	P	AP		AP	AP	AP	AP	P	P	P	P	P	P
○ Mechanical system	P	P	AP	AP	P	AP	?	P	AP	AP	P	P	AP	AP	AP	AP		P	AP	P	
○ Electrical system	P	P	P	P	P	P	P	-	P	AP	P	AP	AP	AP	AP	AP		P	P		AP
○ Obstruction (debris)	AP	P	NP	NP	AP	ANP	AP	-	AP	AP			AP	ANP	AP	NP	AP	AP	AP	AP	AP
○ Wall overtopping	AP	P	P	P	P	AP	P	P	AP	AP			AP	P	AP	AP	AP	AP	P		
○ Stilling basin performance	AP	P	P	P	AP	P	AP	-	AP	AP			AP	AP	AP	AP	AP	AP	P	P	AP
• Reservoir slope stability																					
Reservoir slope stability	P	P	P	P	AP	P	P	P	AP	AP			AP	P	AP	AP	AP	P	P	P	AP
• Instrumentation and monitoring																					
○ Gates, levels, mechanicals systems	AP	P	AP	P	AP	AP	AP	P	AP	AP			AP		AP	AP	AP	AP	P		AP
○ Dam body	P	AP	AP	P	P	P	AP	AP	P	AP			AP	AP	AP	NP	AP	AP	P	P	P
• Drainage system performance																					
○ Concrete sections	AP	AP	P		AP	P		P	P	AP	AP	AP	AP	P	ANP	AP	AP	P	P	P	AP
○ Embankment sections	P	AP	ANP		AP	AP		AP	P	AP	AP	AP	AP		ANP	ANP	AP	AP	ANP		AP
• Emergency preparedness																					
Emergency preparedness	ANP	ANP	NP	P		ANP	NP	AP	ANP	ANP	AP	AP	AP	ANP	ANP	AP	AP	ANP			

Table II.4. Overall subjective judgment on the current condition of Hällby Dam with regard risk and links to safety standards

5 FAILURE MODE IDENTIFICATION

After analyzing the existing relevant information, making a site inspection and ensuring a common ground in the understanding of the current condition of Hällby Dam, the process of Potential failure Mode Identification was started.

The overall methodology in order to address discussions and structure the individual definition of different failure modes was facilitated by the Management Team by providing a framework (Figure II.5) as well as supporting documents to help in defining and linking the failure process to the capacity to detect and intervene ("procedure for FMI", "aids for embankment dams" and "aids for concrete dams" included as part of DELIVERABLE 1).

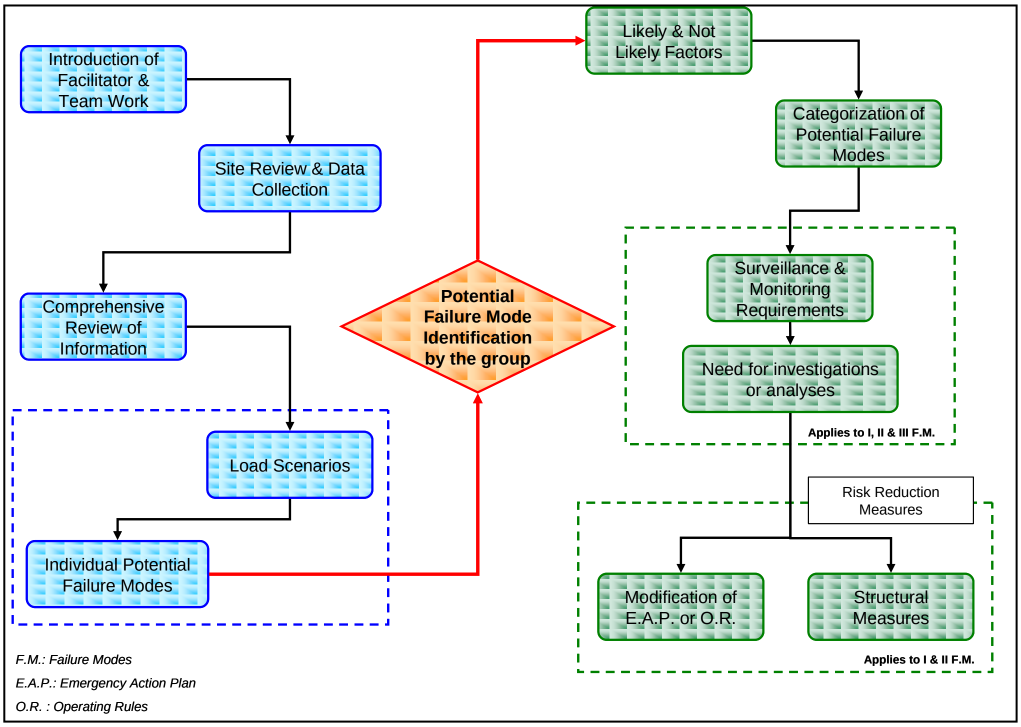


Figure II.5 General framework for a consensus approach on Potential Failure Mode Identification.

As shown in Figure II.5, once Individual Potential Failure Modes were formulated by each participant (it was a due task for participants in the Second Working Session), overall likely and not likely factors were discussed. It was the followed by identifying links to surveillance, further investigations or even suggestions on how each mechanism within a failure mode could imply upgrades, both non structural (such us modification of Emergency Action Planning or Operating Rules) and structural measures.

Total number of individual identifications was 55, which were later grouped and synthesized after in-depth group discussions to 8 Potential Failure Modes, that where fully analyzed according to the overall framework given in Figure II.5.

Figure II.6 shows different moments of the group discussion and the fashion resulting failure modes were commonly structured in a sequence of mechanism.

Figure II.6 Working Session on Potential Failure Mode Identification

Table II.4 includes the full definition of the agreed relevant failure modes for Hällby Dam.

DEFINICION
MF1. In a Normal or Hydrologic scenario, either concentrated leakage (due to poor compaction of the core, cracking), either suffosion or backwards erosion, initiates at the downstream side of the core. Continuation of the process causes core particles to migrate towards the downstream filter. The filter is unable to stop the core particles, and erosion of the core progresses upstream, forming a pipe with increasing diameter as erosion continues that reaches the upstream filter. Erosion progresses further upstream as the pipe is not clogged by upstream material, and finally the core collapses massively causing the dam failure.
MF2. In a Normal or Hydrologic scenario, either concentrated leakage (due to poor compaction of the filter, cracking), either suffosion or backwards erosion, initiates at the downstream part of the contact between core and foundation. Continuation of the process causes filter particles to migrate towards the soil foundation. The soil foundation is unable to stop the core particles, and erosion of the core progresses upstream, forming a pipe with increasing diameter as erosion continues that reaches the upstream filter. Erosion progresses further upstream as the pipe is not clogged by upstream material, and finally the core collapses massively causing the dam failure.
MF3. In a Normal or Hydrologic scenario, either concentrated leakage or backward erosion initiates at the foundation near the toe of the dam (due to the existance of a permeable layer of sand). Continuation of the process causes foundation particles to migrate towards an exit in the surface at the

downstream toe. The erosion progresses and a pipe is formed due to stable roof. The pipe progresses upstream in the foundation under the dam, reaching the reservoir. The process is thus boosted and the pipe is enlarged, until collapse of the roof of the pipe or heave at the toe occurs. This causes slope instability and a breach is formed that causes the dam failure.
MF4. In a Normal or Hydrologic scenario, an increase in uplift pressure happens due to drainage system ineffectiveness. Tensile stresses are developed at the heel of the dam-foundation contact, and a crack is initiated. Uplift pressures increase consequently and the crack propagates downstream, increasing the extent of the no compression zone and reducing the shear resistance of the contact. The section becomes unstable and additional resisting mechanisms, like the existing shear keys between monoliths are activated. Failure of this shear keys happens due to high stresses and finally failure takes place either or by a combination of sliding, compressive stresses at the toe and overturning.
MF5. In a Normal or Hydrologic scenario, concrete cracking is present due to thermal effects, ice loads and/or vibrations in gates. Continuation of the process takes place, spreading the cracking in the concrete, with increasing pore pressures in cracks due to water leakage. Loss of integrity of the concrete causes displacements and reinforcement yielding. Stress transfer causes extensive crack growth in the dam body. Displacements increase and reinforcement fails. After this, the upper part of the concrete section becomes unstable and sliding or overturning happens, causing dam failure.
MF6. In a Normal or Hydrologic scenario, a persistent joint exist in the foundation that makes it kinematically feasible the sliding of the upper part of the foundation. An increase in uplift pressure along the joint happens due to drainage system ineffectiveness. Shear and tensile stresses are developed along the joint and opening of the joint causes further increase in uplift pressure. Shear strength is reduced in the joint until it reaches residual values, and the dam and part of the foundation becomes unstable. Additional resisting mechanisms, like the existing shear keys between monoliths are activated. Failure of this shear keys happens due to high stresses and finally failure takes place by sliding of the dam together with the upper part of the foundation.
MF7. In a Hydrologic scenario, erosion in the stilling basin occurs (either due to the direct impact of the energy of the hydraulic jump in the stilling basin or by backwards erosion from a hydraulic jump washed downstream as a result of insufficient capacity of the stilling basin). Erosion progresses into foundation rock as the stilling basin is severely damaged. Erosion progresses further upstream under the toe of the embankment, causing instability.
MF8. In a Hydrologic scenario, due to a severe flood and/or inadequate spillway capacity and/or inability to open the gates, water level raises over the crest of the dam. Flow over downstream slopes of embankment parts of the dam causes erosion that progresses leading to slope instability, breach and dam failure.

Table II.4 Definition of all agreed relevant Potential Failure Modes

Each of these failure modes were decomposed in a series of mechanisms (which included all the way from initiation, through progression, to failure), incorporating potential for detection and intervention at different stages.

Figure II.7 shows the decomposition of each failure mode in different process, ending all of them in a final node of “failure”.

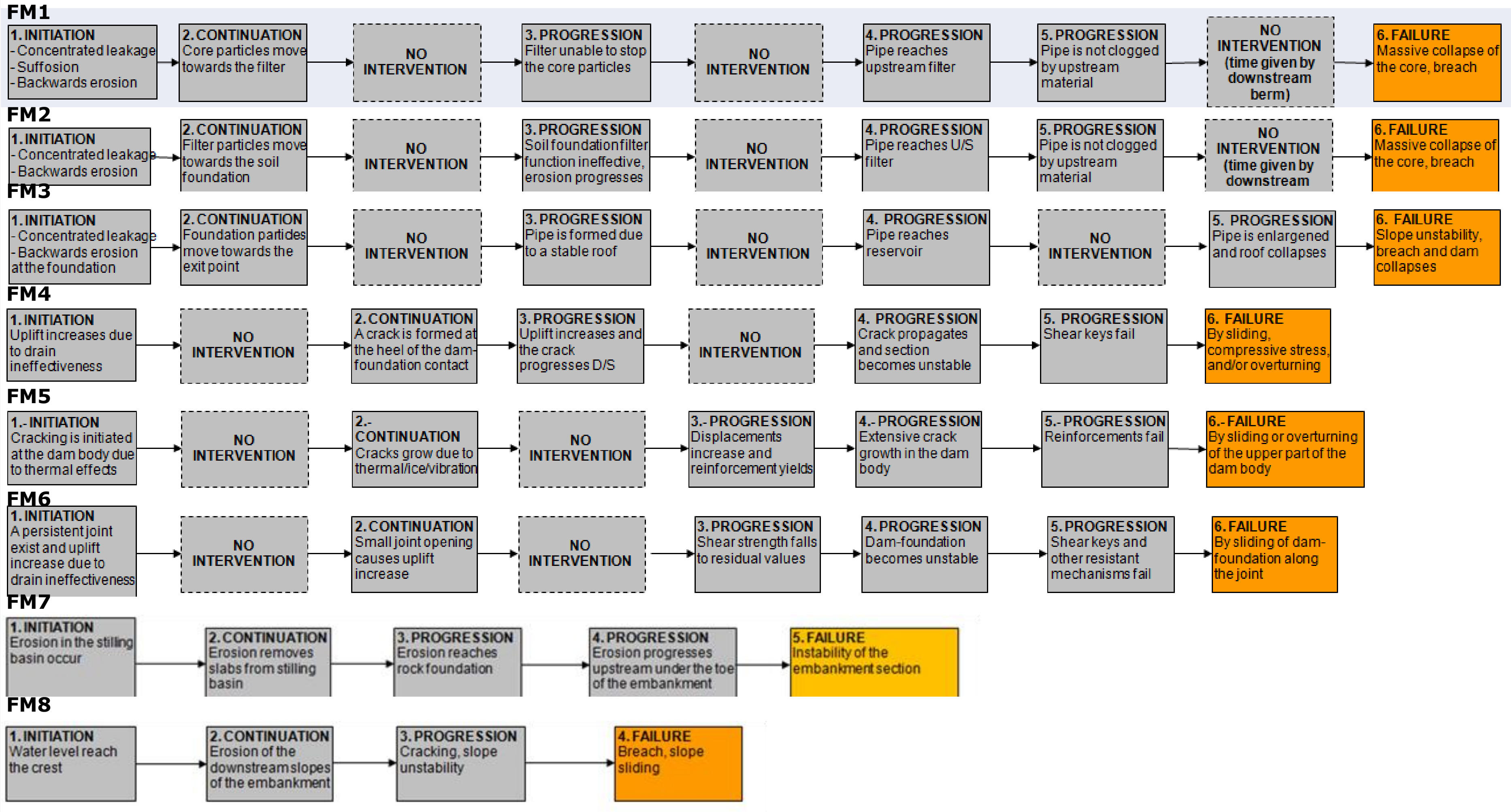


Figure II.7 Failure mode decomposition

Another type of failure, which is not considered to be a failure mode by itself but increases the probability of reaching higher pool levels under any flood scenario, thus increasing in some cases the likelihood of a particular failure mode to initiate or develop, has been defined as “not being able to operate a main spillway gate when intended”.

The logic to define and understand this particular type of failure has been given by building a complete fault tree, where the top event is the one just defined (not being able to operate a main spillway gate when intended).

The first level of events in which the top one was decomposed was:

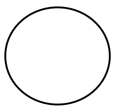
- Machinery break down (See Figure II.8)
- Power failure (See Figure II.9)
- Control system failure (See Figure II.9)
- Human factor (See Figure II.10)
- Environmental issues (See Figure II.11)

All of them are related to the top event by means of an OR gate, which implies that the top event happens if any of them happens.

When each of these first level events are further decomposed (Figures II.8 to II.11), some of the events are related to their immediate top event by an OR GATE or an AND GATE, this second one implying that all the related events have to happen in order to the immediate top event to happen.

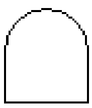
The level of detail of the fault tree has allowed the identification of 45 “basic events”, which have not been further develop.

The graphic legend included in the generated graphs is given bellow:

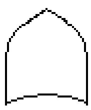


BASIC EVENT

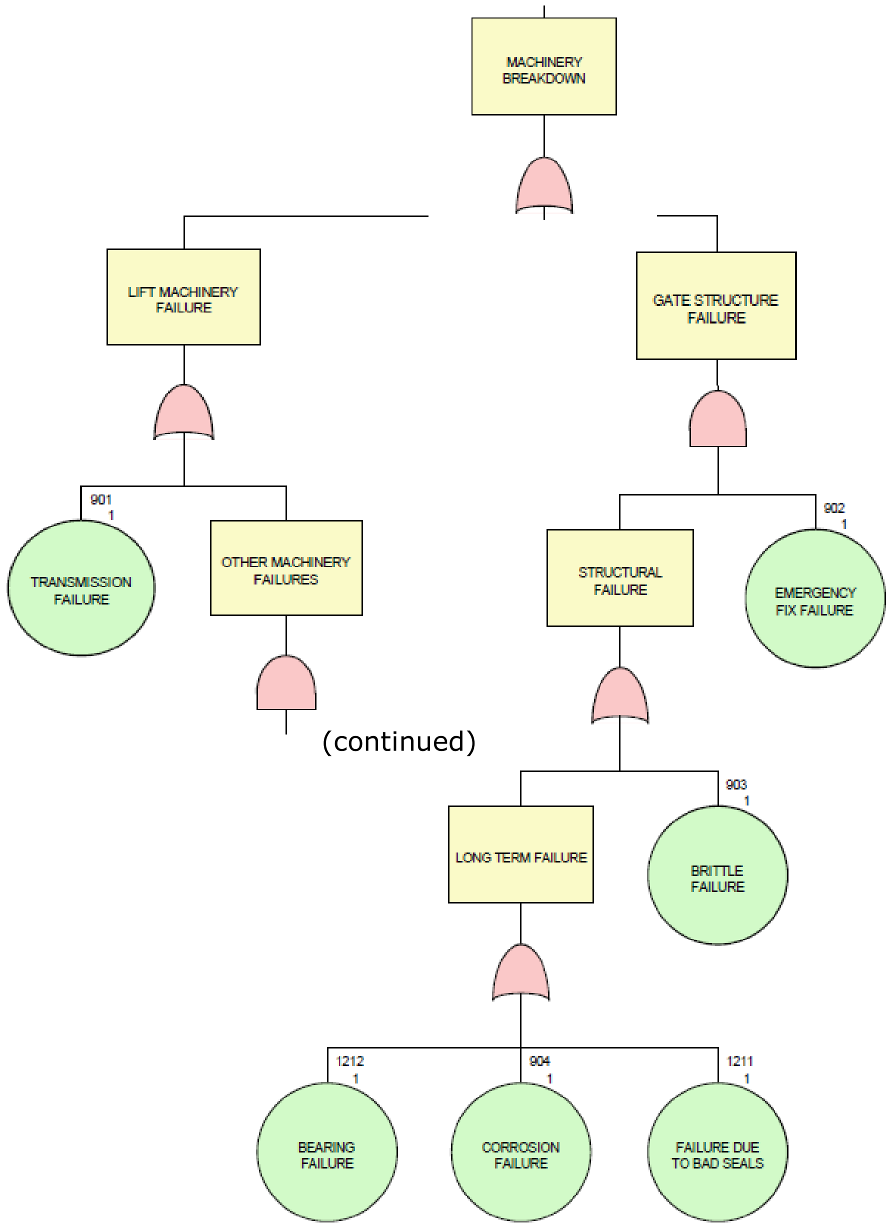
INTERMEDIATE EVENT



AND_GATE



OR_GATE



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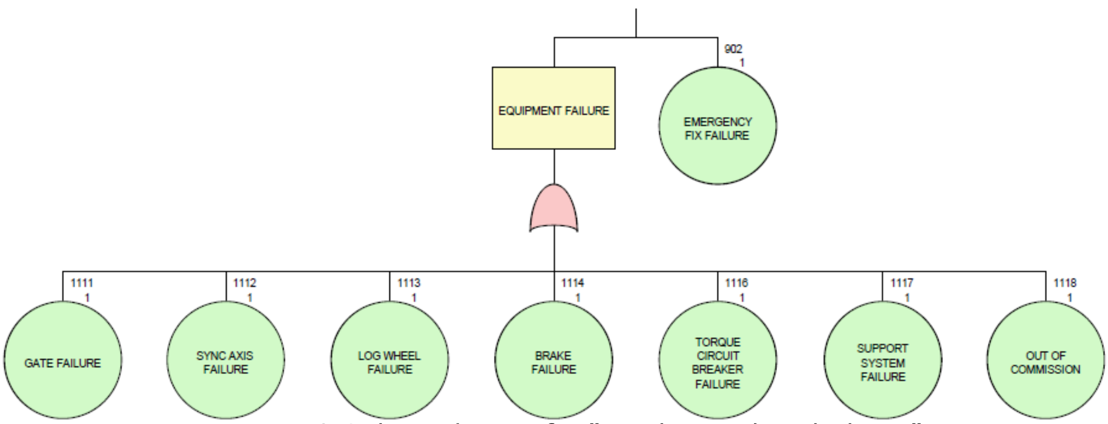
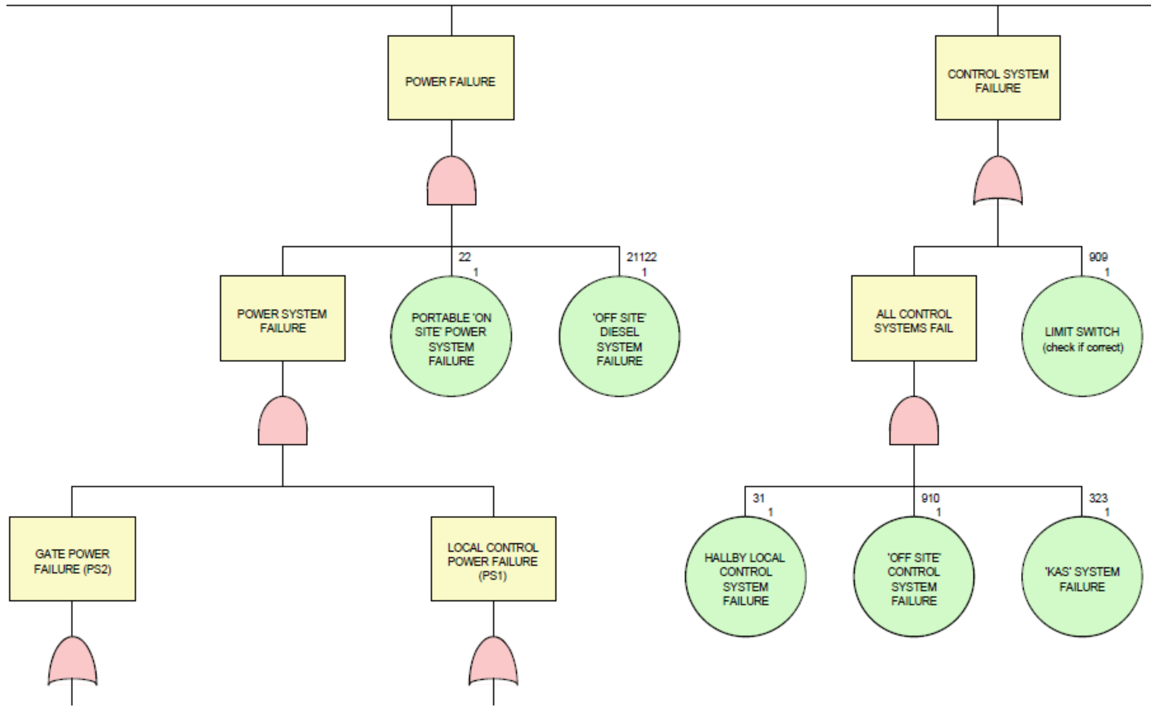


Figure II.8 Sub-Fault tree for “machinery break down”



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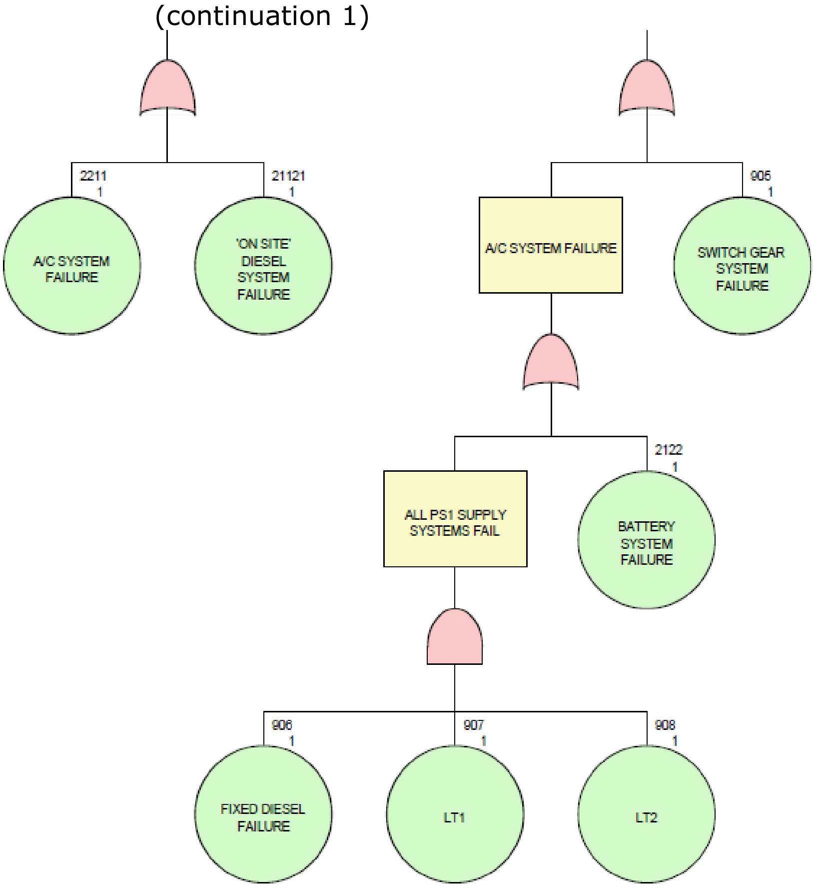
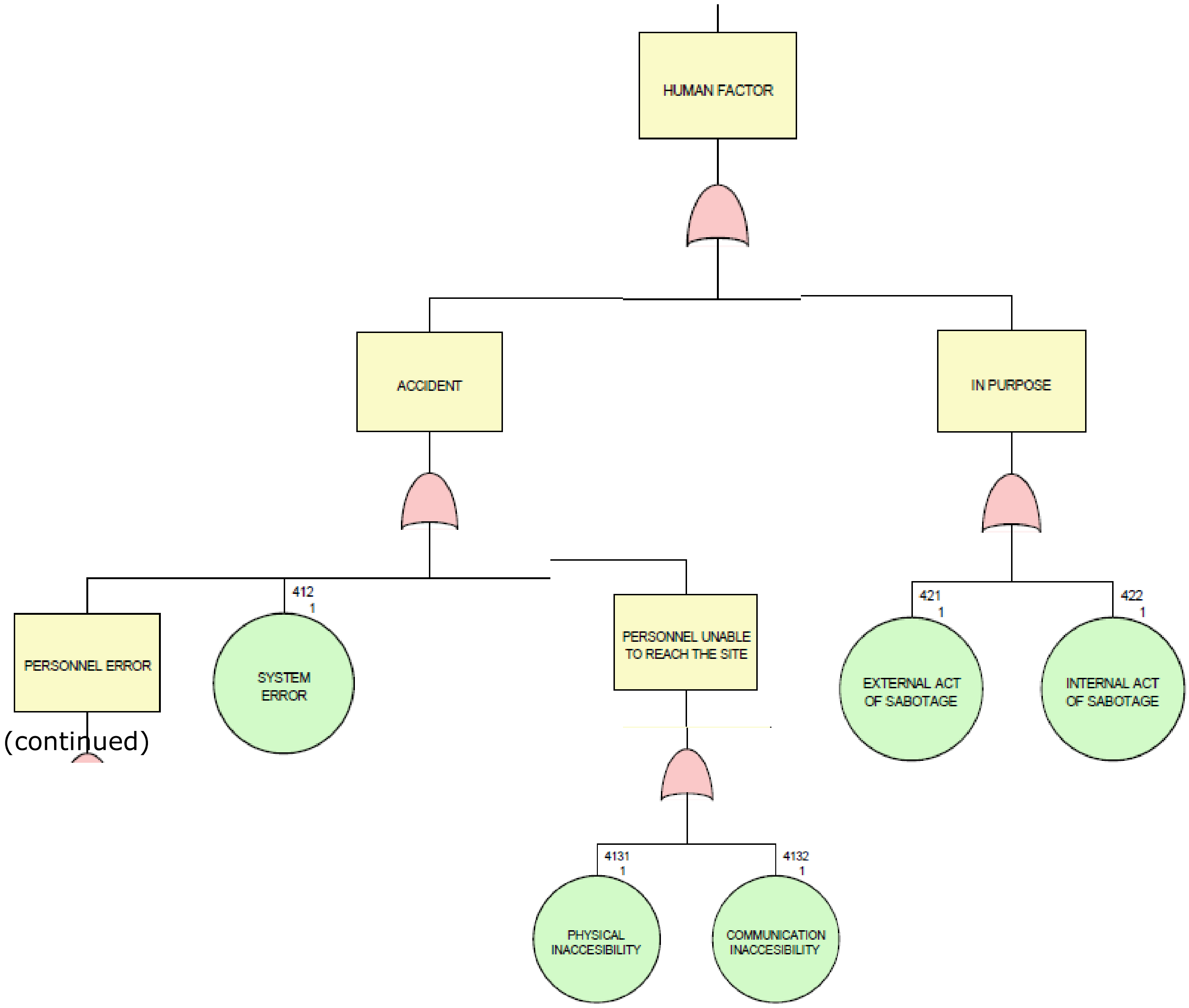


Figure II.9 Sub-Fault tree for “power failure” and “control system failure”



(continuation)

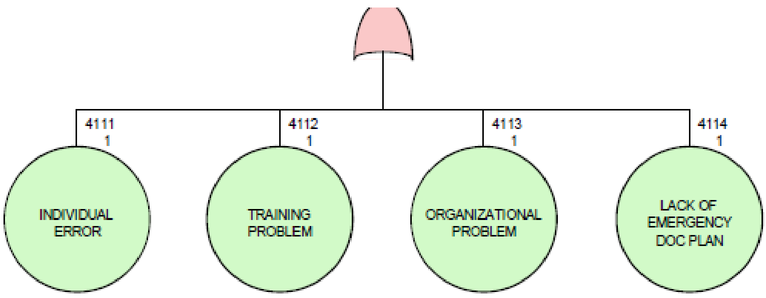


Figure II.10 Sub-Fault tree for “human factor”.

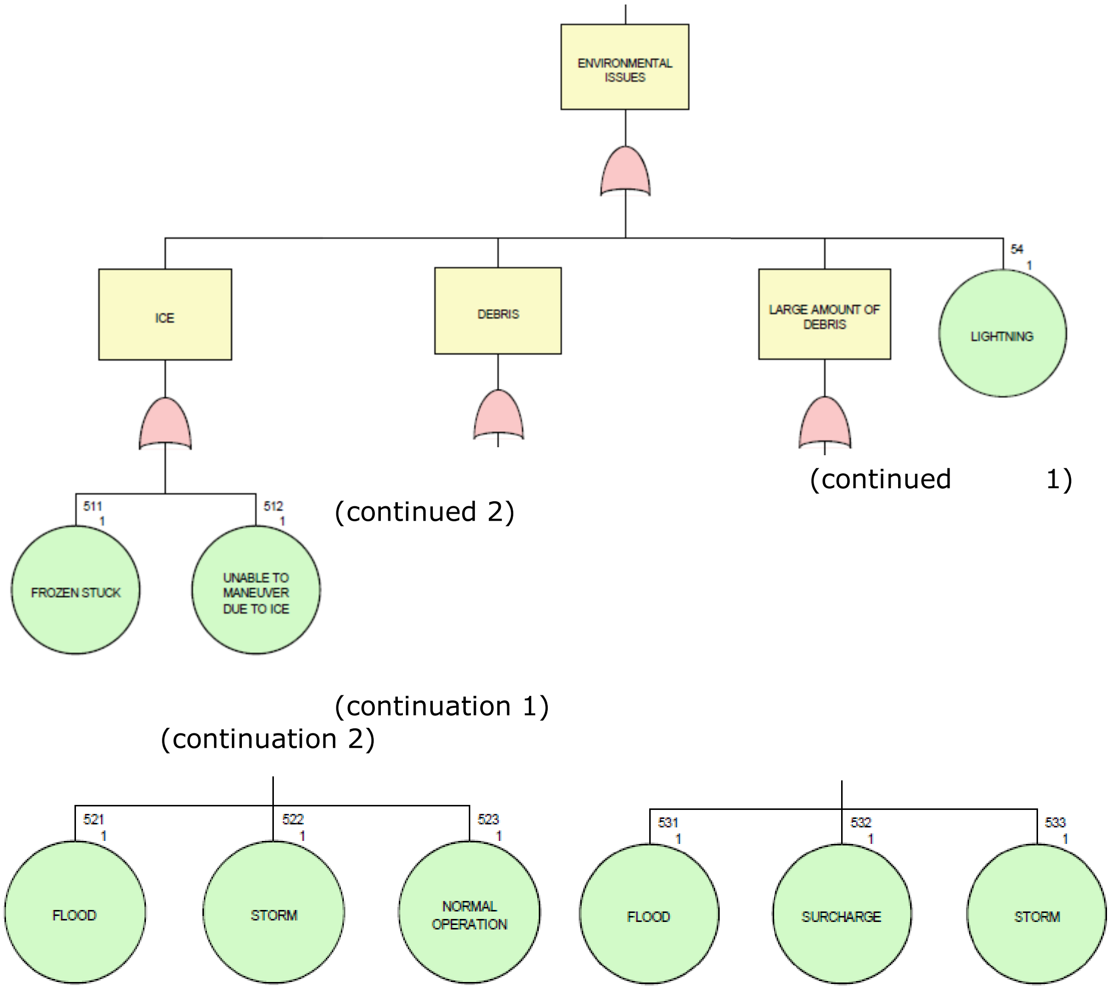


Figure II.11 Sub-Fault tree for "environmental uses".

The following picture (Figure II.12) shows the preliminary results of a working session where the overall fault tree was being built first by groups (second working session) and later by consensus approach (third working session).

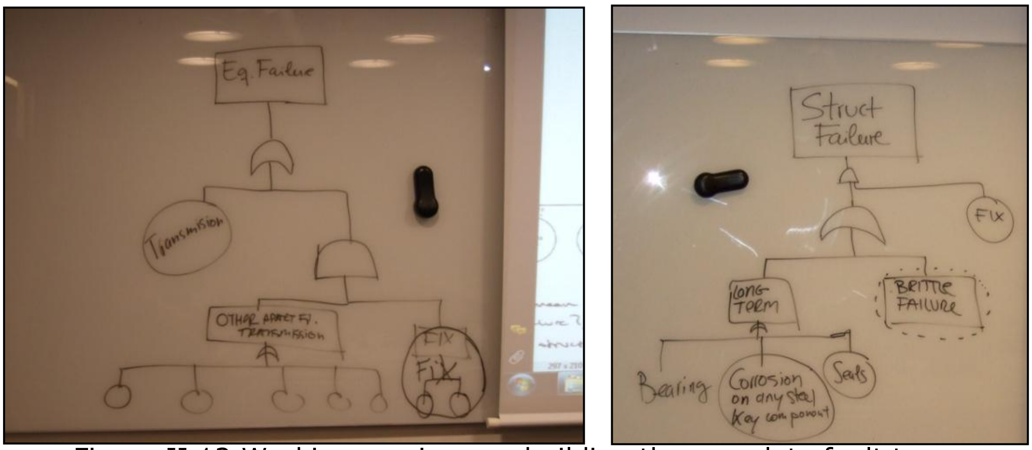


Figure II.12 Working sessions on building the complete fault tree.

6 RISK MODEL ARCHITECTURE

In order to carry out a risk analysis, a risk model of the dam must be set up including the loads of the system (hydrological, seismic or any other), the system response (failure modes) and the consequences (economic, loss of life or any other).

Nowadays, the logical tool which is usually used for risk analysis modeling is the event tree. An event tree is an exhaustive representation of all the events and possibilities which can lead to a final event. In the case of risk analysis as applied to dam safety, the main event will usually be the failure of the dam.

Though event trees can sometimes be relatively small, however, a typical event tree in dam safety risk analysis can easily have thousands of branches. As to manually specify all these individual branches would be impractical, so some type of abstraction must be used.

The way the risk model has been conceptually built for Hällby is by means of influence diagrams, which are a compact conceptual representation of a system's logic. Each node in the influence diagram represents a variable, and nodes are then connected to define the relationships between variables.

Later on in the process, the influence diagram should be expanded it into the equivalent event tree, which will finally used for the calculation. This implies that certain rules have to be followed. In particular:

- The diagram must be formed by *nodes* and *directed arcs*.
- A node is the *head* of the diagram if no arc goes into it.
- A diagram must have one and only one head.
- The diagram may not have cycles (but it may have closed loops and bifurcations).

Figure II.13 illustrates the practical implication of following the above listed rules.

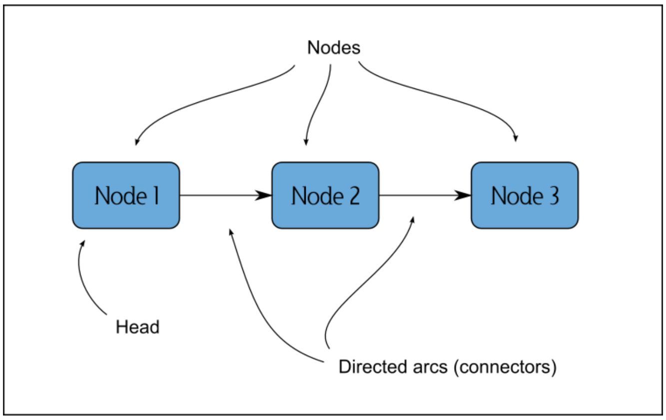


Figure II.13 Basic rules in building an influence diagram

Following the principles explained above, a group working session was fully devoted to build the complete architecture of Hällby Risk Model, that had to integrate the outcomes of Potential Failure Mode Identification and the Gate Performance fault tree on one hand with the loading conditions for normal and hydrologic scenarios (typically treated as one continuous scenario) and, on the other hand, with consequences of failure.

Starting with the proper integration of Failure Modes, each mechanism of the 8 identified failure modes was evaluated in terms of dependency of other variables, thus affecting the likelihood of such mechanism.

Results of such discussion were graphically captured as shown in Figure II.14. (where one additional row to the 8 failure modes has been added to capture the case of "non-failure")

Figure II.14. "System response part" of the overall risk model

Where:

MaxWL:	Maximum water (pool) level.
QSp:	Discharge through the main spillway
TOv:	Time (persistence) of overtopping
QRouted:	Total discharge
X Symbol:	The mechanism is absolutely necessary for the failure mode to progress

According to the logics of the risk model, the "left hand" (loading conditions) influence diagram should incorporate all variables identified in the immediate "right hand" (system response), namely maximum water (pool) level, discharge through the main spillway, time (persistence) of overtopping and total discharge.

This left hand part of the overall risk model is graphically presented in Figure II.15 where it is important to recall that the fault tree develop to characterize the reliability of the spillway gates would be linked to the node "SpAv".

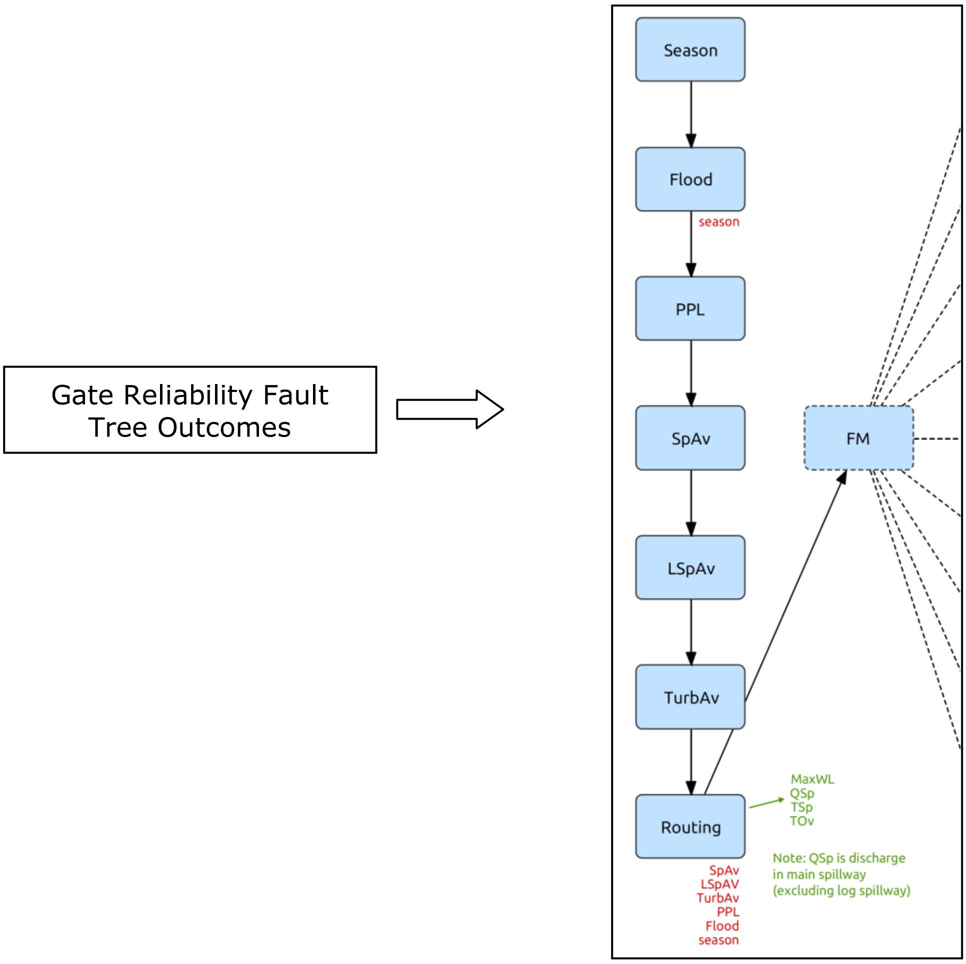


Figure II.15 "Loading condition" part of the overall risk model

Where:

Season: season of the year
Flood: characteristics of the flood (including the Annual Probability of Exceedence)
PPL: water (pool) level immediately previous to the flood arrival
SpAv: reliability/availability of main spillway gates
LSpAv: reliability/availability of log spillway gates
TurbAv: reliability/availability of turbines in terms of water discharge capacity
Routing: parametric routing study in terms of different combinations of "Flood", "PPL", "SpAv", "LSpAv", "TurbAv" to provide the needed variables for the right hand calculations ("MaxWL", "QSp", "TOv" and "QRouted")

Finally, the "consequence" part of the overall risk model needed to be properly linked to the different failure mechanisms in which every of the eight failure modes result. Figure II.16 shows the architecture built and such links to the different failure mechanisms.

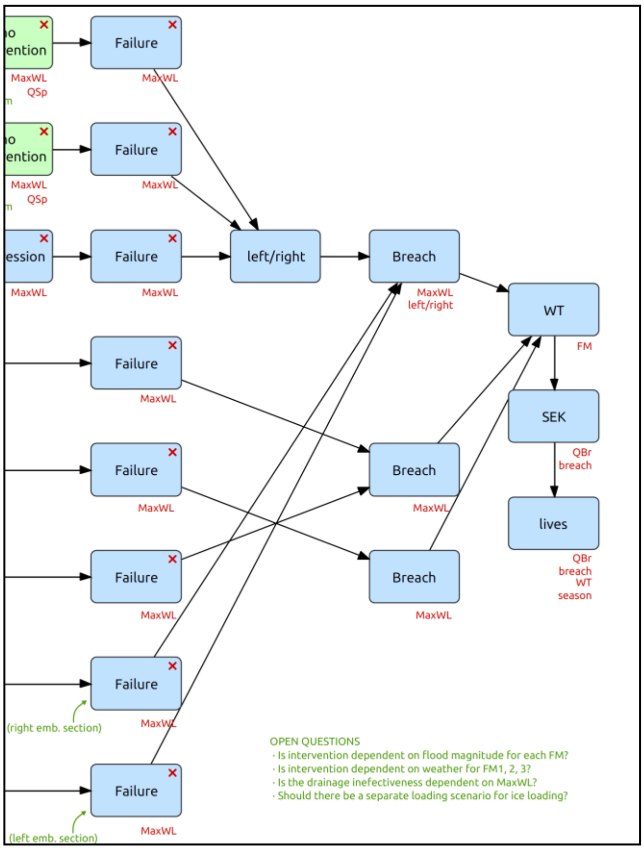


Figure II.16 "Consequence part" of the overall risk model

Where:
WT: Warning Time
SEK: economic consequences
LIVES: societal consequences
Left/Right: left or right embankment of the embankment section
FM: failure mode
QBr: breach peak discharge
Breach: breach characteristics

Figure II.17 shows the working session were the full architecture (See appendix A4, under DELIVERABLE 3) was developed.

Figure II.17 Building the full architecture (working session)

7 FURTHER STEPS AND RESEARCH POTENTIAL FOR PHASE II

Processes involved in building Dam Safety Risk Models rely on sound engineering activities such as Potential Failure Modes Identification to develop the architecture of the model itself. This task has been successfully finished on Phase I of the Project, as explained in points 1 to 6 of this document.

Phase II will require to elaborate the input data that will result later in risk calculation and evaluation, as well as it should allow to study the impact on risk reduction of any mitigation measure.

Figure A.5.1 shows the scope of Phase II within the overall processes of risk analysis:

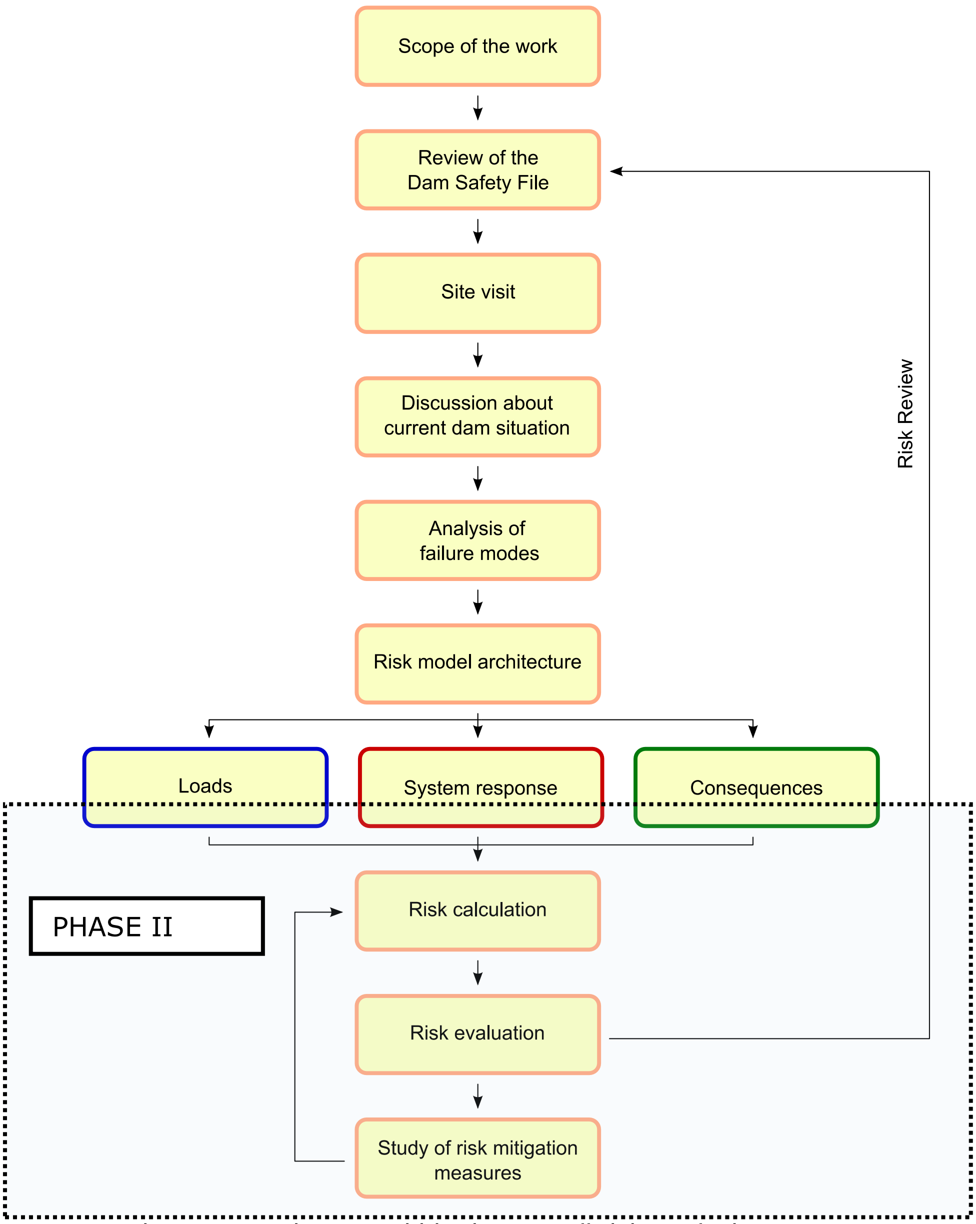


Figure II.16 Phase II within the overall risk analysis processes

According to the previous scheme, tasks to be undertaken under Phase II are:

- Assessment of subjective probability estimates for Hällby.
- Performance of "current" risk calculation and definition of structural and non structural risk mitigation measures to be evaluated.
- Evaluation of different risk mitigation measures and management options.
- Evaluation of the impact of practical developments and research within the Project as well as addressing best practices to extend practical application and further research.

With regard both to best practices in today´s practical application as well as potential for research, it is worth to remark that many of the main issues for both topics, and the diffuse frontier sometimes existing between both, have been identified and structured during the III International Forum on Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management held in Valencia in October of 2011, organized by the Universidad Politécnica de Valencia (UPV, Spain) and the Department of Homeland Security (DHS, United States).

In order to better illustrate the potential for research, Tables II.5, II.6 and II.7 have been specifically prepared and show the different degree of complexity when elaborating the inputs required for the risk model, as well as some issues linked to evaluation and management of risk within the risk model.

MODEL COMPONENT	COMPLEXITY LEVEL 1	COMPLEXITY LEVEL 2	COMPLEXITY LEVEL 3
FLOODS	Existing anual hydrographs and interpolation/extrapolation if needed	Uncertainty analisys over existing hydrology	Seasonal hydrology incorporating uncertainty analysis
PREVIOUS POOL LEVEL	Maximum Operating Pool Level	Historical records adjustment	Inflows and water demands simulation
GATED SPILLWAYS AND OUTLET WORKS RELIABILITY	Standard recommended values	Simplified fault trees plus probability estimates	Complete fault trees plus probability estimates
FLOOD ROUTING	Inflow equals Outflow untill maximum discharge capacity	Operating Rules procedures or clear existing rules for flood routing	Consideration of a full and potentially complex system of water resources

Table II.5 Inputs and degree of complexity for "load" components of the risk model

MODEL COMPONENT	**COMPLEXITY LEVEL 1**	**COMPLEXITY LEVEL 2**	**COMPLEXITY LEVEL 3**
FAILURE MODES	Overtopping	Overtopping Internal Erosion (Emb. D.) Sliding (Concr. D)	All failure modes from expert judgement working sessions
CONDITIONAL FAILURE PROBAILITY	Published general curves	Expert judgment	Numerical modelling and Montecarlo simulations
DAM BREACH AND HYDROGRAPHS	Those included in Emergency Action Plan	Expert judment and distinguishing for each failure mode	Numerical modeling and Montecarlo simulations

Table II.6 Inputs and degree of complexity for "system response" components of the risk model

MODEL COMPONENT	*SIMPLIFIED LEVEL*	*INTERMEDIATE LEVEL*	*ADVANCE LEVEL*
CONSEQUENCES	Empirical methods for damage plus interpolation from Emergency Action Plans	Empirical methods for damage plus hydraulic simulation of downstream response	Simulation methods for damage plus hydraulic simulation of downstream response
CORRECTIVE MEASURES	Standard actions (many published in scientific literature)	Detailed particular solutions plus approximate budget	Detailed to construction project level
OVERALL UNCERTAINTY	Only sensitivity analysis	Uncertinty over most relevant variables	Complete uncertainty analysis over natural and epistemic components

Table II.7 Inputs and degree of complexity for "consequence" components of the risk model, impact of corrective measures and uncertainty

It is finally worth to remark that, after the last working session with the Steering Committee, held in December 1, 2011 it was agreed that developing the proper consequence indicators, from the perspective of economical consequences of different types of failures, as linked to the overall hydropower business, may be one of the research priorities for Phase II.

8 OVERALL CONCLUSIONS

The context and conditions under which risk analysis techniques have been applied by ELFORSK rely in the fact that Hällby Dam, as a practical case study, becomes the driving force for knowledge transfer and a common fire place where experiences could be exchanged.

It was also acknowledged that processes involved in building dam safety risk models have to be based on sound engineering activities such as failure mode identification, which has required the proper consistency and diversity of expertise within the working team.

To cope with such requirements, the authors of this report (management team of the project) have developed the works together with the "working group" and "invited expertise for consultancies and universities", and have periodically reported to ELFORSK steering committee.

It can be concluded, on one hand, that the challenge of building capacities and knowledge transferring, has been very satisfactory achieved through a quite positive group dynamic, that allowed to integrate the expertise of all participants in the project results.

As a matter of fact, the results of "Quantitative risk analysis for Hällby – a case study. Phase I", show how the objective of building a complete risk model architecture for Hällby, based on sound engineering and incorporating the logics that would later allow to compute, analyze and evaluate risks, has been successfully addressed.

In summary, Phase I completeness and robustness enables to undertake Phase II, which aims to quantify current risk as well as to inform the impact on risk reduction of any mitigation measure.

As another main pillar of the overall project, during Phase I, a wide field for research and development has been preliminary identified, and Phase II will allow to narrow the spectrum of such field and indeed develop some original approaches (i.e. developing the proper consequence indicators, from the perspective of economical consequences of different types of failures, as linked to the overall hydropower business, may be one of the research priorities for Phase II)

It is finally worth to remark that the growing application of risk analysis has in the recent years created a paradigm shift that has fostered progress in assessing and managing not only the impacts associated with flooding but also other events and incidents that may affect the public, environment, and economic development. Examples of this paradigm shift are represented through the establishment of European Directive 2007/60/EC on the assessment and management of flood risks, and European Directive 2008/114/EC on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.

These directives, and other equivalent international legislation, recognize and explicitly require risk analysis to be utilized as the primary tool for infrastructure management, addressing all aspects of the process to include improving our understanding of natural hazards, implementing more effective operation and maintenance approaches, and developing best practices to minimize impacts to the public and environment.

PART III: APPENDIXES

A.1 TERMS OF REFERENCE

Addenda/Update to Terms of Reference (March 2011) for ”Quantitative risk analysis for Hällby – a case study”

On the initiative of Elforsks R & D program on dam safety and in cooperation with Swedish HydroPower Centre the project ”Quantitative risk analysis for Hällby – a case study” will be undertaken with Prof. Dr. Ignacio Escuder-Bueno, Universidad Politecnica Valencia as a project manager.

The project is divided in two phases. The first phase will be started in May 2011 and the optional second phase will preliminary be undertaken in 2012.

The first phase will comprise an initial elaboration of the scope of work, presentation and analysis of the perquisites and current dam situation, identification of load scenarios, failure modes and consequences and establishment of a risk model for Hällby dam. The second phase is suggested to comprise risk calculations, risk evaluation and studies of risk mitigation measures in Hällby dam.

The project purpose is to

- Provide common experience of a quantitative method for risk informed dam safety decisions (quantitative analysis of “risk reduction efficiency”).
- Suggest further initiatives to develop practical applicable risk based methods in dam safety management.
- Identify needs and initiate research and development concerning risk analysis, uncertainties, failure modes and probabilities of failure of relevance for dams and dam safety.

The idea is that Hällby as a practical case study should be the driving force for knowledge transfer and a common fire place where experiences could be exchanged. Knowledge transfer and identification and initiation of research and development in the field shall also be stimulated through involvement of expertise and active researchers within Swedish HydroPower Center in the project.

Preliminary Terms of Reference (December 2010)

Background

Following the discussion April 28th 2010 a working group has been established through Elforsks dam safety R&D group. The working group is to define the stake holders expectations on a dam and dam safety risk analysis pilot project and develop a project description.

Through E.ON and Carl-Oscar Nilsson, Hällby dam has been identified as a suitable and possible pilot.

Through Elforsks dam safety R&D program resources has been allocated to be able to involve international support in the pilot project development 2010 and as a project facilitator/manager in the implementation phase 2011-.

The ambition is also to involve Swedish universities through Swedish Hydro Power Centre (SVC) in the implementation phase, preliminary in more detailed studies of loads and system response and concerning educational matters. Resources for this is available through SVC.

Prerequisites for a pilot project on quantitative risk analysis of Hällby

- FDU 2000 (Eng)
- Impact analysis 2007 (Eng)
- Risk analysis 2008 (Eng)
- Special Auditing 2008 (Eng)
- Reliability analysis spill ways 2009 (Swe)
- Action programme following Special Auditing 2009 (Swe)
- Dam measuring program, tentative (Swe)
- Ongoing investigation (WSP) regarding remarks from Special Auditing (Swe)
- Operating statistics.

Stake holder expectations on a dam and dam safety risk analysis pilot project

The above mentioned working group (representing the the stakeholders) has defined the following expectations on a dam and dam safety risk analysis pilot project:

- Overall, the goal is to in a pilot project (Hällby) undertake a full quantitative risk analysis of a dam to gain experience of a "verified" tool and concept of quantitative risk analysis and of international safety criteria.
- The Project Steering Group (see preliminary organization below) are to summarize the experiences and lessons learned from the pilot project and propose further initiatives to develop practical application of risk analysis in dam safety work.
- E.ON has also expectations with regard to the basis for priority dam safety
- measures actions in Hällby.

The project will aim to:

- Overcome barriers (skepticism, uncertainty faced with uncertainties, design oriented educations) by means of practical experience.
- Create a concrete indicative example.

- Gain experience of international criteria for tolerable risks (life, economy, environment).
- Identify and analyze uncertainties.
- Gain experience of quantitative methods for optimization, and prioritization of potential dam safety measures.
- Identification of research needs relating to uncertainties, failure modes and failure probabilities (in order to balance the risk analysis).
- Gain experience of integration of traditional methods and risk assessment methodology.
- Involve —SVC universities and researchers for analyses.

Project manager
Prof. Ignacio Escuder, Universidad Politecnica Valencia with extensive international experience of risk analysis applied on dams. He was also part of the Special Audit of Hällby. Role: Lead and delegate work tasks in dialog with the steering group and the chair of the steering group. Responsible for the risk analysis tools.

Steering group
Stakeholder/dam owner representatives, preliminary Carl-Oscar Nilsson, E.ON (Chairman), Lars Hammar, Vattenfall, Stefan Berntsson, Vattenfall, Ylva Helmfrid, Fortum, Martin Hansson, Statkraft, Maria Bartsch, Svenska Kraftnät. Role: Decides on changes in relation to the project plan, workgroup manning, etc. Involved in the implementation of the risk analysis, i.e. identification of loads, failure modes, consequences and probabilities and analysis of potential measures, etc. The Steering Group will also summarize the experiences and lessons learned from the pilot project and propose further initiatives to develop practical application of risk analysis in dam safety work.

Working group/ expertise efforts based on the needs regarding loads, identified failure modes and measures
E.ON is responsible for the compilation of existing information and data. Jointly funded (via Elforsks dam safety R&D program and Swedish Hydro Power Center (SVC)) expert input based on the needs regarding loads, identified failure modes and measures.

A.2 DELIVERABLE 1

Sweden, 2011/05/10 to 2011/05/10

Note
This document is accompanied with a zip file with all the presentations and documents which were used during the sessions plus the pictures that were taken. People are referred to in this document and in the accompanying files by their initials. The initials used are:

- CN: Carl-Oscar Nilsson
- ME: Mats Eriksson
- HR: Hans Rönnqvist
- AN: Åke Nilsson
- IEB: Ignacio Escuder Bueno
- ASL: Armando Serrano Lombillo

Day 1 (Stockholm, 2011/05/10)

Day 1 was devoted to introductory matters and to define the scope of the work. It was divided into a morning session and an afternoon session.

Morning session (8:00 – 11:30)

- [CN] Introduction
- [IEB] Introduction
  - file `01 [IEB] Introduction.pdf`
- [IEB] Principles, procedures and tools of Risk Analysis
  - file `02 [IEB] Flood Risk Tolerability Criteria.pdf`
  - file `03 [IEB] Safety RA.pdf`
  - file `04 [IEB] Security RA.pdf`

Afternoon session (12:30 – 16:00)

- [IEB] Experiences from previous case studies
  - file `05 [IEB] Overall Examples.pdf`
- [CN] Current dam situation
  - file `06 [CN] Hällby Dam, Design and Construction.pdf`
- [IEB] Preliminary scope of the work

  - file 07 [IEB] Preliminar Scope.pdf
  -

Day 2 (Site visit, 2011/05/11)

Day 2 consisted in a visit to Hällby dam and downstream area. The notes and the pictures of this day can be found in the accompanying files.

Day 3 (Stockholm, 2011/05/12)

Day 3 was a group working day. After an introduction, three main topics were covered: review of information, current dam situation and training on failure mode identification. Several information requirements were identified (see next section in this document). Also, a group discussion was carried out about the current state of the dam, which is summarized in the 08 [group] Engineering assessment ratings.pdf file.

Finally, for the failure mode identification, three documents were provided as tools we will be using next session.

- [IEB] Introduction
  - file 01 [IEB] Introduccion.pdf
  - file 02 [IEB] Introduccion.pdf
- [ASL] Review of information (with presentations by ME, HR and AN)
  - file 03 [ASL] Hällby dam, review of information.pdf
  - file 04 [ME] Reliabilty analysis discharge equipment.pdf
  - file 05 [HR] Internal erosion.pdf
  - file 06 [AN] Internal erosion.pdf
- [ASL] Discussion about current dam situation
  - file 07 [ASL] Hällby dam, discussion about current dam situation.pdf
  - file 08 [group] Engineering assessment ratings.pdf
- [ASL] Training on failure mode identification
  - file 09 [ASL] Hällby dam, preliminary identification of failure modes.pdf
  - file 10 Procedure for FMI.doc
  - file 11 Aids for embankment dams.xls
  - file 12 Aids for concrete dams.xls

Information requirements

For next session

- Range of maximum reservoir levels / depth of overtopping that can be expected in Hällby dam.

- Order of magnitude of ice loads.

- Completion of "Procedure for FMI" booklet (file `10 Procedure for FMI.doc` in "Day 3" folder) up to and including point 4 by participants in next session.

For the risk model

- Historical records of reservoir levels.

- Hydrologic study (numerical values of hydrographs).

- Reservoir physical properties (volume-elevation curve).

- Spillway and outlet works properties (discharge curves).

- Routing procedures.

- Ice loads characterization.

- Computer files for the "Dam-break Flood Simulation and Consequence Analysis for Hällby Dam Facilities".

Other missing information

- Mats Erikson's presentation on "Reliabilty analysis of discharge equipment".

- Appendix of the "Reliabilty analysis of discharge equipment" report with the fault trees.

- Computer version of "Dam-break Flood Simulation and Consequence Analysis for Hällby Dam Facilities" (only a paper version was provided).

A.3 DELIVERABLE 2

Sweden, 2011/09/13 to 2011/09/15

Note

This document is accompanied with a zip file with all the presentations and documents which were used during the sessions plus the pictures that were taken. People are referred to in this document and in the accompanying files by their initials. The initials used are:

- CA: Cristian Andersson
- IEB: Ignacio Escuder Bueno
- LAG: Luis Altarejos García

Day 1 (Stockholm, 2011/09/13)

Day 1 was devoted to the review of new information followed by the working session on geotechnical failure mode identification, which was divided into a morning session and an afternoon session.

Morning session (9:00 – 11:30)

- [CA] Introduction
- [IEB] Review of new information
  - file `01 [IEB] Hällby dam, Overall introduction and review of information.pdf`

Afternoon session (12:30 – 16:00)

- [LAG] Working session on failure mode identification for geotechnical failure modes
  - file `02 [LAG] Hällby dam, IFM Introduction.pdf`
  - file `03 [LAG] Hällby dam, IFM Geotechnical.pdf`

Day 2 (Stockholm, 2011/09/14)

Day 2 was devoted to the working sessions on structural, hydraulic and overtopping failure modes. All failure modes were considered and several failure modes were either discarded or grouped together with other similar failure modes. After this, the working group discussed the conceptual structure of the chain of events in relation to gate failure at Hällby, and a failure tree was proposed by the group. The detailed description of all failure modes proposed, together with the fault tree for gate failure to be reviewed by the working group, and the pictures of days 1 and 2 can be found in the accompanying files.

Morning session (8:30 – 11:30)

- [LAG] Working session on failure mode identification for structural failure modes
  - file `04 [LAG] Hällby dam, IFM Structural.pdf`

Afternoon session (12:30 – 16:00)

- [LAG] Working session on failure mode identification for hydraulic and overtopping failure modes
  - file `05 [LAG] Hällby dam, IFM Hydraulic.pdf`

  - file `06 [LAG] Hällby dam, IFM Overtopping.pdf`

- [LAG] Summary of failure modes for group review
  - file `07 [LAG] Hällby dam, Failure modes.xls`

- [LAG] Working session on fault tree analysis of gate failure
  - file `08 [LAG] Hällby dam, Gate failure FTA.pdf`

Pictures taken during DAY 1 and 2 are in folders `09 and 10`

Day 3 (Stockholm, 2011/09/15)

Day 3 was devoted to the meeting with the steering committee.

NEXT STEPS: Overall requirements

Work to be performed before next working session (Nov 29-Dec1)

- Review, update and/or validation of the failure modes in the attached excel file (file `07`).
  WORKING GROUP MEMBERS. DUE BY NOVEMBER 17
  Please add your comments on the empty boxes prepared for each node of each failure mode

- Review, update and/or validation of the fault tree in the attached pdf file (file `08`).
  WORKING GROUP MEMBERS. DUE BY NOVEMBER 17
  Please add your comments in a separate document if needed

Information updates for the future risk model

- Historical records of reservoir levels. Extended to at least 20 years

- Numerical values of hydrographs up to 10000 years

- Spillway and outlet works discharge curves.

- Routing procedures (in pdf format)

- Computer files for the "Dam-break Flood Simulation and Consequence Analysis for Hällby Dam Facilities".

Miscellaneous information

- Appendix of the “Reliabilty analysis of discharge equipment” report with the fault trees.
- Computer version of “Dam-break Flood Simulation and Consequence Analysis for Hällby Dam Facilities” (only a paper version was provided).
- Existing information on results of performance of scale models of the spillway and stilling basin for several inflows from lab tests.

A.4 DELIVERABLE 3

Sweden, 2011/11/29 to 2011/12/01

Note

This document is accompanied with a zip file with all the presentations and documents which were used during the sessions plus the pictures that were taken. People are referred to in this document and in the accompanying files by their initials. The initials used are:

- CA: Cristian Andersson
- AN: Åke Nilsson
- IEB: Ignacio Escuder Bueno
- ASL: Armando Serrano Lombillo

Day 1 (Stockholm, 2011/11/29, Working group)

Day 1 was devoted to reviewing new information and its impact, and to incorporating comments from the group to the failure modes and gate reliability fault tree.

- [CA] Introduction
- [IEB] Introduction
    - file `01 [IEB] Introduction.pdf`
- [AN] Results from onsite investigations
    - file `02 [AN] Onsite investigation results.pdf`
- Discussion on FM7 (spillway toe erosion)
- Discussion on FM8 (overtopping)
- Discussion on gate reliability fault tree
- Discussion on internal erosion fault trees
- Discussion on more or less likely factors

As a conclusion of these discussions, two new documents have been generated, one collecting all the final comments and changes made to the failure modes and another one with the final gate reliability fault tree. These documents are:

- file `03 Failure modes.pdf`
- file `04 Fault tree.pdf`

Day 2 (Stockholm, 2011/11/30, Working group)

Day 2 was devoted mainly to the risk model architecture, including training on risk modeling, building together the architecture for Hällby dam, discussing the dependencies between variables and identifying the inputs to the model. Also, a presentation was given on research opportunities.

- [ASL] Training on risk model architectures
  - file `01 [ASL] Risk model architectures.pdf`

- Architecture for Hällby dam

- [IEB] Research opportunities
  - file `02 [IEB] Research opportunities.pdf`

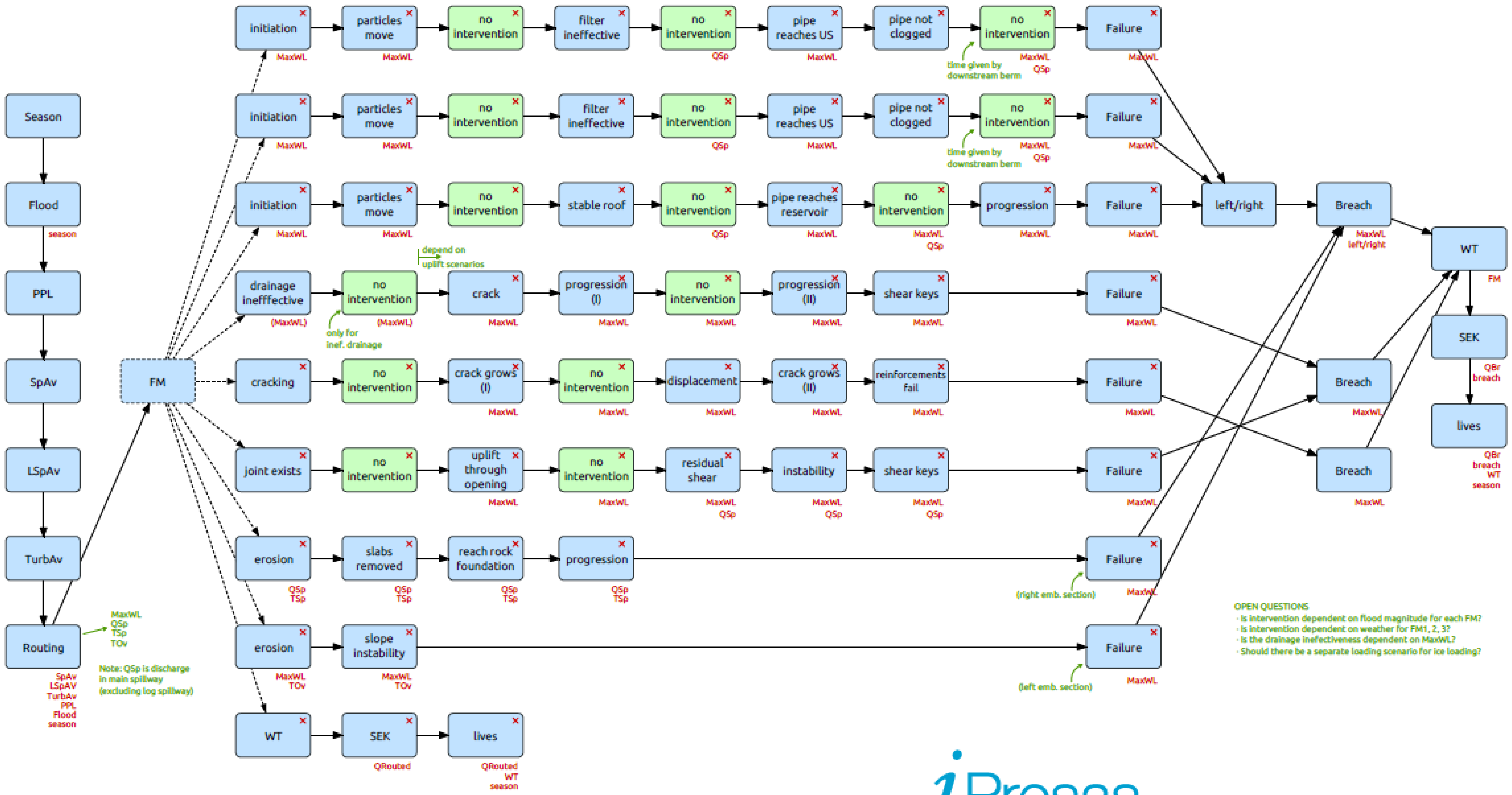
As a conclusion of these discussions, a risk model architecture was identified, which is included in the following file:

  - file `03 Hällby risk model architecture.pdf`

Day 3 (Stockholm, 2011/05/12)

Day 3 was devoted to the meeting with the steering committee.

Due to its importance as "final product" of Phase I, the overall architecture of Hällby Risk Model is given in next page of this appendix (taken from `03 Hällby risk model architecture.pdf)`



Note 1: A complete definition of the boxes, variables and symbols within the given scheme can be found on Part II of this document.

Note 2: The complete architecture, as shown in Part II of this document, includes a complete Fault Tree for the event of "not being able to open a gate of the main spillway when intended"

A.5 PROPOSAL FOR PHASE II

Processes involved in building Dam Safety Risk Models rely on sound engineering activities such as Potential Failure Modes Identification to develop the architecture of the model itself. This task has been successfully finished on Phase I of the Project.

Phase II will require and elaborate the input data that will result later in risk calculation and evaluation, as well as it should allow to study the impact on risk reduction of any proposed mitigation measures.

Figure A.5.1 shows the scope of Phase II within the overall processes of risk analysis:

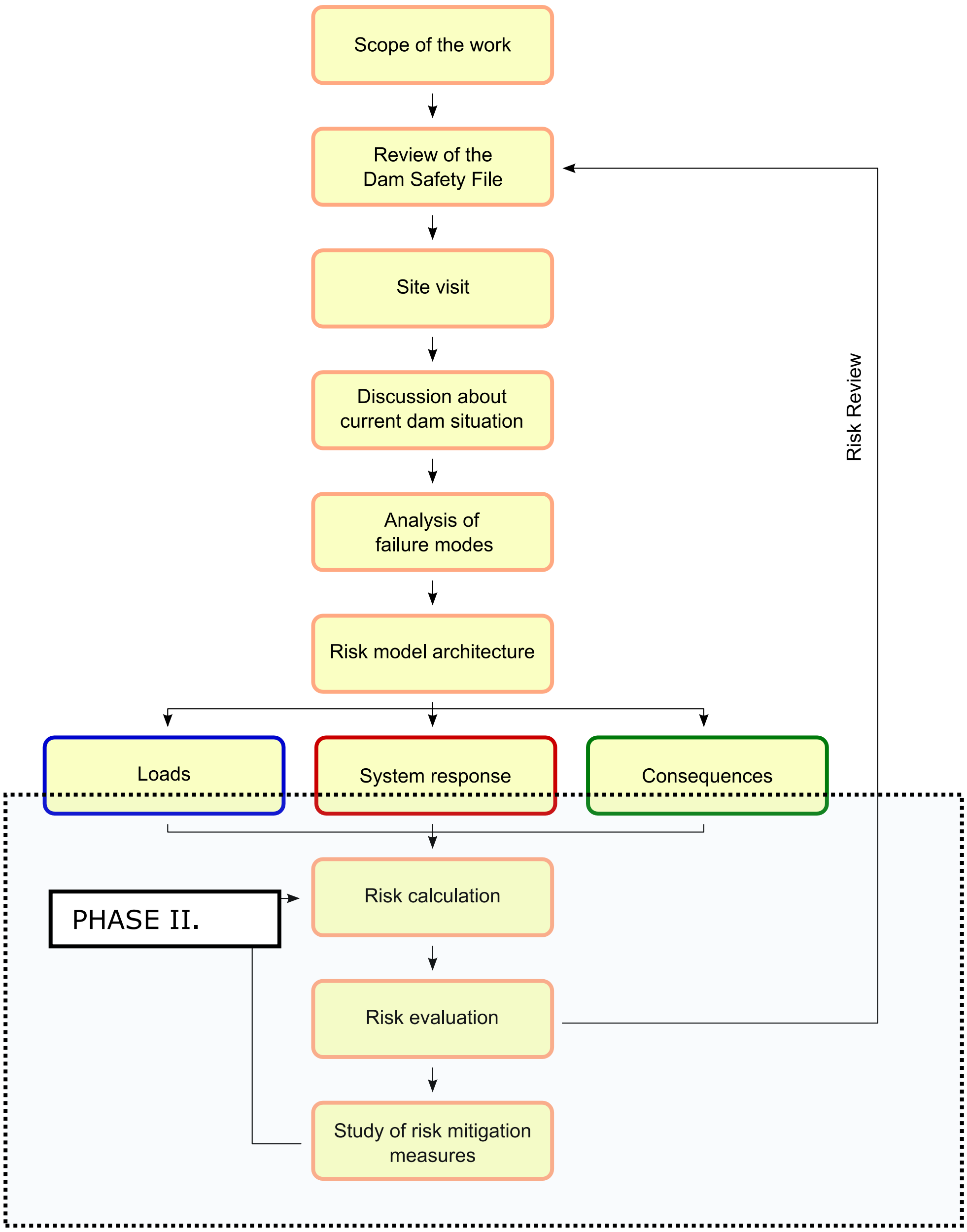


Figure A.5.1. Phase II within the overall risk analysis processes

The sequence of working sessions proposed for the second Phase (Table A.5.2) has been developed consistently with the process described in Figure A.5.1.

DATE	AGENDA
March 2012 (3 Days)	Training on different type of probability estimates and techniques. Assessment of subjective probability estimates for Hällby. Assigning tasks/commitments for the next working session.
June 2012 (3 days)	Training on risk computation. Performance of "current" risk calculation. Definition of structural and non structural measures. Assigning tasks/commitments for the next working session.
October 2012 (3 days)	Training on management options (sequence of corrective measures, efficiency, equity, etc.). Discussion on results with regard to the impact of different alternatives.
December 2012 (1 day)	Presentation and discussion on the overall results with focus on how to address further research and practical application.

Table 2. Sequence of working sessions

Each working session of three days will result in a DELIVERABLE (4, 5 and 6, following DELIVERABLES 1, 2 and 3 of Phase I), and there will be and Overall Project Report to be presented in the last one day working session,

Professor Ignacio Escuder-Bueno will serve as project Manager, closely supported by Dr. Armando Serrano-Lombillo and Dr. Luis Altarejos-García. Other members of the working team are Eng. Adrián Morales-Castillo, Eng. Javier Fluixa-Sanmartín and Eng. Jessica Castillo-Rodriguez.

The budget follows exactly the same parameters as in Phase I, thus equally resulting in the same budget as PHASE I.

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