Risk management governance by Dutch regional water authorities in infrastructural projects.

Identifying improvement areas

Figure 1: Dike strengthening by installing sheet wall.

Master Thesis

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Preface

Dear reader,

The underlying thesis is the result of my graduation research which, combined with my defence presentation, is the last and final step in order to graduate for the master program Construction Management & Engineering at Delft University of Technology. It is a moment I have looked forward to after a long educational journey.

I started my education at the MTS Infratechnology, after which I continued at the HTS Civil Engineering where I graduated in the area of Hydraulic Engineering. I worked for an engineering company for two years and then I decided to go for my master degree because I wanted to increase the breadth of my knowledge. This master program was at times a struggle but it also represented fun, excitement, and challenge.

Writing this thesis was at times challenging but fortunately, I was surrounded by people who truly helped me. And these people I would like to thank: first of all, I would like to thank the chair of my graduation committee Marcel Hertogh for his guidance and knowledge. Erik Mostert, Rob Schoenmaker, Paul Visser, dhr. Hensbergen, Jules Verlaan, thank you for giving me guidance, investing time and sharing your knowledge with me. And last, but definitely not least, Erfan Hoseini thank you for your input, the many conversations we had, your feedback and for the opportunity you gave me to graduate as part of your research team.

At the hoogheemraadschap van Schieland en de Krimpenerwaard I would like to thank Laura Koedoot for investing time in me and for supporting and motivating me. And a big 'thank you' also to the all interviewees, without whom I could not have conducted my research.

And of course I would like to thank my family who supported, motivated and believed in me.

Although it wasn't always easy, I do look back at a successful period and I am equally looking forward to the future.

Enjoy reading,

Thomas van Haren
Den Haag, November 2017

Summary

The main question which this thesis research answers is:

"How do Dutch regional water authorities (WS) perform project risk management practices in infrastructural projects and which areas for improvement can be identified?"

The initial hypothesis prior to this thesis research was that risk management is almost non-existent and/or should be completely developed within the water authority. This hypothesis was based on the findings of previous researches, which concluded that risk management is either non-existing (Scholten 2007) or has to be completely developed as part of project steering and control (Taskforce 2010).

The overriding conclusion in this thesis is that risk management is currently part of integral project management at the WS. The history and the resulting culture results in a risk aware organisation in which the necessity and importance of performing risk management in projects is naturally understood. In all projects analyzed, elements of risk management were identified. Risks were assessed from different perspectives, control measures were selected and performed and time and cost contingency for risk control were in place. Experts recognize that also other WS have (started to) professionalize(d) their entire project management practices. Especially those WS that participated in large projects for the program 'Ruimte voor de rivier' have already professionalized and also WS that are now conducting large projects in the High Water Protection Program (HWBP) are in the process of professionalizing their project management practices including includes risk management.

To assess the validity of the initial hypothesis both literature research, interviews, case study evaluation and model matching (Hoseini) in three different projects at the Water Board (WS) were conducted. In order to assess the current practices of risk management performance the first step was to conduct a literature study in order to create a framework or an 'ideal' way of performing risk management.

The literature review assessed four well-known risk management standards and standards related to the relation between risk management and project management. These were ISO31000 risk management standard, the RISMAN Method, ATOM project risk management method, and Nicholas and Steyn project management handbook.

Based on the conducted literature review it was found that in order for risk management to be effective, two areas must be addressed being "Organization aspects" and "Process & application aspects". The organizational aspects that ensure that risk management is supported within the organisation are 1) management commitment towards risk management, (2) the strategy and policies of the organisation or project team in applying risk management, (3) Culture and (4)

personnel knowledge. The "risk management process and application" is the factual backbone of risk management, anchored in a cyclic process that consists of coordinated activities which ensure that: a) risks and/or opportunities are made explicit (identified) are analysed and evaluated, b) appropriate control measures are coupled to the risks / opportunities, c) control measures are planned and implemented, d) control measures are monitored and evaluated on a regular basis and e) the process is repeated regularly.

The second step was to gain in-depth knowledge in how risk management is currently performed within projects of the WS organisation. This knowledge was acquired by investigating the risk management practices in three infrastructural projects executed by the WS. By using semi-structured interviews, process observations and with help of the risk maturity model of Hoseini (2017) in-depth insights were gained. The general results were presented to experts in the field of risk management and in WS in order to see if they were valid also for other WS.

As mentioned before, the results do not show a lack of risk management on project level (process & application). Especially large projects like HWBP project receive full attention for risk management. Risks are identified and assessed, control measures are selected, performed, regularly monitored and time and cost contingency for risk control are in place in planning and estimates. The thesis research found that it is especially in the area of "Organization" where steps towards an even more effective risk management process can be made. These areas are:

Top management commitment
Within the WS there is no direct steering involved nor are there clear instruction by top management on how to perform risk management within projects. There is no control mechanism in place to assess if risk management is performed or not. It is for a large part up to the project team to decide on whether and how to set up risk management. Another point mentioned by the respondents is that based on the reported risk status in the progress reports, a real conversation between the internal client and the project leader about the project risks rarely takes place. However, also the top management finds it an important aspect of project management. Conclusion: top management can provide a more facilitating context and support for the effective use of risk management (see section 6.2).

Uncertainty on how large to set up risk management
It was discovered that there is uncertainty on how large to set up risk management in relation to the size of the project and that there is no clear guidance how or if to perform it. In the current situation higher-level managers provide no steering as to the way in which the risk management process is set up. It is up to the project leader or project team to decide whether and how to perform risk management (see section 6.3).

Sharing knowledge across projects

It was found that within the HWBP project, knowledge from other HWBP projects was included in the organisation of the project, but also that quite some time had passed since knowledge was shared with other project teams in HWBP. Furthermore, it was found that there is a risk register on department level in which all risks across projects can be collected and shared. The interviewees stated that after each project there should be a review in which the knowledge and learning is captured in a 'lessons learned' report. This shows that the organization has recognized the importance of cross-project learning. However, they also indicate that this register is not being used. According to the interviewees it is just not workable because risks are described on a level that it not usable in their own projects, it is not updated and therefore, they simply do not use it. The interviewees also state that capturing lessons learned, especially for the average internal project, is not always performed (see section 6.4).

The HWBP financial regulations and its effect on risk-, reservation and management

It was found that in the financial regulations of the HWBP an incentive is in place, which 'can' and probably does influence the performance of risk management in the projects executed within the new HWBP. The direct consequence of the new financial regulations (HWBP) is that it is in the direct interest of the WS to enlarge the risk reservation as it acts as an extra financial reserve. With the current system being based on a bonus-malus system, unspent money remains at the WS. The consequence of this could be a more expensive program, less km of dike renovation, an overall longer duration and a more expensive programme overall (see section 6.5).

Based on these findings the following recommendations were made:

1. **Provide leadership from top management (top-down):**
   A. Put in place a guiding framework that allows matching the project size with the set-up of risk management (see section 6.3 for an initial proposal);
   B. Implement control measures to assure risk management is performed, (only allow a project to shift from phases if a risk analyses is performed).
   C. Assure that communication /interaction between project leader and internal client is integrated in the risk management process as this will motivate the project team;
   D. Explicitly define how risk management on project level can be made "fit-for purpose" during the project kick-off session.

2. **Assure Sharing knowledge across projects:**

   A. Continue sharing information and knowledge within and across projects (especially for big cyclic HWBP projects). Earlier mentioned (section 6.4) specific recommendations on how to do this on project level are:

- Regular meetings with other project teams to exchange (risk) learning points;
- Invite people with execution knowledge - other than only from the engineering company - into the risk sessions;
- Include external risk experts to assess the risk register prior to important project phase transfers and decisions;
- Carefully weigh costs of potential benefits of the reduced risks vs costs of control measures and select a strategy (reduce, avoid, accept, transfer);
- Increase involvement/reviews from other (internal) project leaders in risk sessions;

   B. Assure that the general risk register is brought to the attention and only list those risks that have actually fired in previous projects. Link them to the 'lessons learned' report. Learning points formulated should make a split between specific content-related learning points and process, - and/or organizational learning points; the latter may have a longer 'shelf life'; Make capturing 'lessons learned' the responsibility of the project leader (maak & haalverplichting) (section 6.4).

3. **Reconsider the HWBP financial regulations**

Keep the 10% own contribution by WS in place as an incentive to assure effective use of financial resources; at the same time, remove the incentive to enlarge the risk reservation by taking WS out as risk owner and by allowing post-project calculation (see section 6.5).

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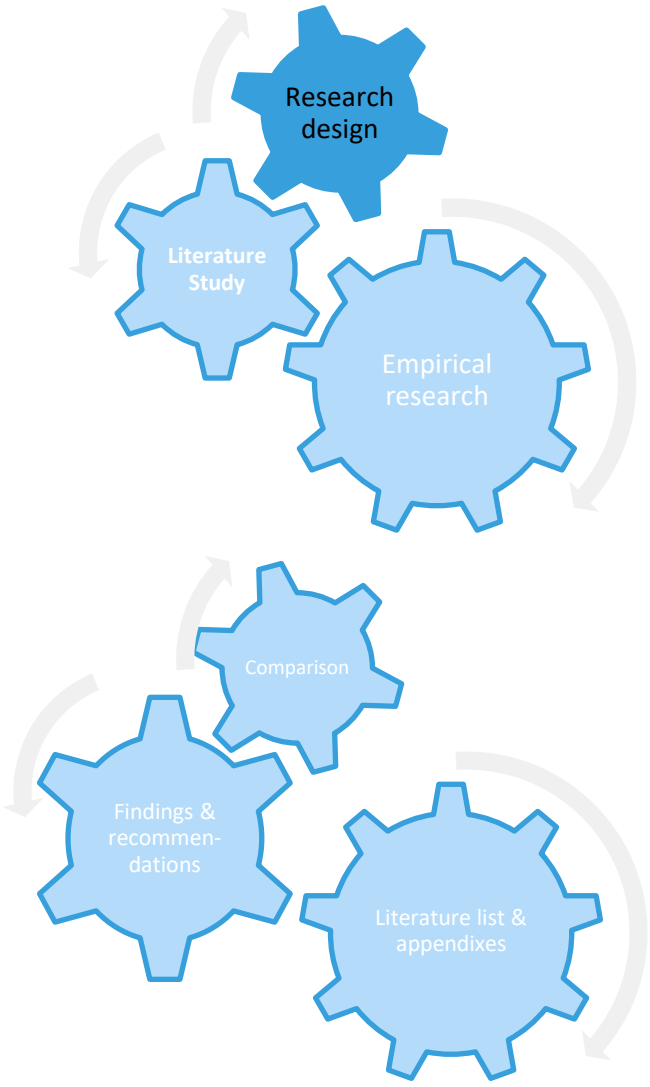
Research design



1 Introduction

The Netherlands is renowned for its interdependency with water due to its geographic location as a delta area, its partial relative low surface level compared to water levels in rivers and seas and its way of managing these interdependencies. The continuous set of activities regarding the management of these interdependencies, with records going back to the 10th century and beyond, is relevant now and will continue to be so in the future. The country's rich history has resulted in the current policy of water management. Watersystem-management is a governmental responsibility, divided among several Governmental authorities. Rijkswaterstaat (RWS) is the executing authority for the Ministry of Infrastructure & Environment (I&M) and is responsible for the "Rijkswateren", which are the main waterways, lake waters and coastal protection systems. The Dutch regional water authorities (waterschappen or hoogheemraadschappen (WS)) are responsible for the regional waters, dikes and waste water treatment (Mostert 2016).

An important program of projects is currently under construction, called the High Water Protection Program or the Hoogwaterbeschermingsprogramma (HWBP), which is part of the Delta program. In this program WS and RWS take measures to ensure safety for the inhabitants and assets of the Netherlands against flooding and unwanted water problems in a continuous set of activities. The purpose of the program is to comply with flood safety standards by strengthening the water infrastructure system until the entire system is up to standards. This will take until the year 2050. Initially, it was expected that the program of strengthening the infrastructure against flooding to the defined norms could be accomplished with relatively limited time and resources. But in reality this expectation will not be met: partly because the scope is bigger than expected (the strength of the current system was over-estimated), and partly because projects that have started require more time and resources than previously estimated (the cost estimation made in 2008 was 1,8 bln; an estimation of costs made in 2010 brought that amount 2,7 bln) (Taskforce 2010, Hoogwaterbeschermingsprogramma 2014).

The problems with regard to the control (budget, scope, time) of infrastructure projects are not unique. A study conducted by Cantarelli, Flyvberg et al. (2012) states that large infrastructural projects have the tendency to go over budget and time.
The study, based on the analysis of 77 projects, concludes that the total average cost underestimation is 14.6%. Some of the projects in the Netherlands that follow(ed) this path are:

- the Storm Surge Barrier in the Eastern Scheldt in the Netherlands, executed from 1976 until 1986, with an initial cost of € 3,0 bln ended up in a cost overrun of 16 % and a time overrun of 10%; protection duration (quality) has not been met;
- the Ekofisk Protective Barrier in the North Sea (1988-1989, initial cost € 700 mln, cost overrun about 30%, no time overrun);
- the Storm Surge Barrier Rotterdam (1990-1996, total initial cost € 400 mln, cost overrun 15%, time overrun 15%)(Ridder 2016).

The picture sketched out of this should be nuanced since these were high innovative, never performed scale projects.

In 2010 the minister of V&W (processor of I&M) announced an investigation into the problems of control aspects of the HWBP (scope, time, money and risks). The taskforce Ten Heuvelhof, that investigated the problems, formulated several issues and recommendations for the program to ensure a more effective management. Recommendations have to a large extent been implemented. Amongst the recommendations featured the idea to introduce an incentive structure in which both WS and RWS were to pay 50 % of the costs. The taskforce also advised that risk management, performed by WS, should be completely developed and integrated as part of project steering and control (Taskforce 2010).

Literature agrees with the recommendation that risk management can help projects to stay the course. The following allegations on risk management are common in literature:

- Risk management is a vital part of project management and must not been seen as optional. It is a continuous process that, when implemented holistically, delivers benefits like increased likelihood of and a better effectiveness and efficiency in achieving organisational or project objectives. It helps preventing underperformance of projects (BSI 2000, Hillson and Simon 2007, ISO 2009, COSO 2013, PMI 2013);
- All projects contain some level of uncertainty. There are always unforeseen obstacles or risks that can cause missed deadlines, cost overruns, safety problems and poor project performance. But opportunities, which can increase project success can also occur. Management must try to anticipate to these problems and opportunities, plan for them, adjust activities and shift resources in such way that risks are mitigated or opportunities exploited. This is the field of project risk management (Hillson and Simon 2007, NASA 2007, Nicholas and Steyn 2012, PMI 2013);
- Risk management is an important influential factor of project success, from which (novel) infrastructural projects can benefit (Cooke-Davies 2002, Chapman and Ward 2004, Hillson and Simon 2007, Hopkinson 2012, Schwindt and Zimmermann 2015, Hoseini 2016).

However, implementing risk management never goes without hurdles and is clearly a learning process. It is not a 'one-size-fits-all' activity but rather a 'fit-for-purpose' process. Both the organisation and the project team should think about at what point risk management is fit for purpose, how it adds value, how it can be made most effective and how procedures can best be tailored to the organization and the individual project needs (Hillson and Simon 2007, ISO 2009). Implementing risk management, reviewing the process and adjusting it to organisation or project needs is a continuous process. RISMAN argues that the implementation of risk management should be customised for every project, depending on its size, organisation, phase of the project, knowledge of the employees, culture of the organization, etc. (Hillson and Simon 2007, Well-Stam, Lindenaar et al. 2007, ISO 2009).

The above is in line with the findings of the Head of Department of Integral Plans and Projects (IPP) of the Dutch regional water authority of Schieland and the Krimpenerwaard. Having held this position for the past 15 years, he is responsible for the introduction of risk management at the Dutch regional water authority of Schieland and the Krimpenerwaard. According to him the introduction of risk management in this particular regional water authority started after the inability to control two specific projects in terms of costs and time and also because the WS were professionalising the entire project management process. Since then, progress in implementing risk management within the department of IPP has been made.

1.1 Problem statement

Despite the uniform consensus about the added value of risk management and its positive influence on project success and achieving organisations objectives, risk management does not score high on the list of project management techniques with regard to effective deployment and use. Suggesting that even though most organisations recognize its' value, effective implementation of risk management into organizations and projects is not (yet) common (Bosler 2002, Hillson and Simon 2007, Purdy 2010).

Recent research conducted at WS authorities confirms this finding. Scholten (2007) concluded that risk management was almost non-existent within the WS. The commission "Taskforce HWBP" under supervision of Prof.mr.dr. E.F. ten Heuvelhof examined the problems in the HWBP in 2010 and advised that risk management performed by water board authorities should be completely developed as part of project steering & control (Taskforce 2010). Das (2011) concluded that WS were *currently in the process of* implementing or making plans to implement risk management into their organisations/projects.

It seems valid that WS can benefit from risk management. These authorities manage serious amounts of infrastructural assets (Dikes, pumps, waterways, sluices etc.) and are continuously involved in planning and executing new (capital intensive) infrastructural projects, which are notorious for exceeding budget and time.

Based on the above, the following problem statement has been formulated:

Despite research findings pinpointing risk management as an important influential factor of project success (Cooke-Davies 1998, Hillson and Simon 2007), literature says that it is not always performed efficiently in infrastructural projects (Bosler 2002, Hillson and Simon 2007, Purdy 2010). Previous researches (Scholten 2007, Taskforce 2010, Das 2011) have concluded that Dutch regional water authorities form no exception to this. The research question is how these authorities currently perform with regard to project risk management governance in infrastructural projects and whether there is room for improvement.

1.1.1 Research objective

Verschuren and Doorewaard (2015) point out that a research objective should meet the following criteria:

- Useful (what is the benefit of your research to the problem/solution?);
- Realistic (contribute to the solution of the problem);
- Feasible (within time scheduled and within your capabilities & resources);
- Clear (be precise in what your project's contribution to the problem/solution is);
- Informative (rough idea of knowledge generated towards a solution).

Based on the above the following research objective has been defined:
The research objective is to contribute to the professionalization of project risk management practices performed by WS in infrastructural projects by providing insight into current policies and practices and by giving recommendations for improvements.

1.1.2 Research scope

This research focuses on project risk management within infrastructural projects performed by Dutch regional water authorities (WS) and assesses whether the recommendation to develop risk management as part of project steering and control has been followed up. The research was performed at the Dutch regional water authority of Schieland and the Krimpenerwaard, which is one of the 22 Dutch regional water authorities. The research tries to give an in-depth understanding of the current situation on project risk management. Profound research on one WS was the preferred option both from a time and quality of information point of view.

1.1.3 Research questions

The following research question is answered in this thesis:

"How do Dutch regional water authorities perform project risk management practices in infrastructural projects and which areas for improvement can be identified?"

This research question is answered by answering the sub-questions stated below.

1 *How should risk management in projects ideally be governed according to literature?*

The first sub-question was answered by performing a literature review on risk management in projects and by selecting appropriate assessment criteria. The answer to this research sub-question provided an ideal approach to performing project risk management and formed the basis for the preparations of the interviews to answer sub-question 2.

2 *How do Dutch regional water authorities perform risk management in project in practice?*

The second sub-question was answered by analysing three infrastructure projects performed by Dutch regional water authorities. Results were obtained by a process of observation, reading documents, conducting semi-structured interviews and comparing the outcome to the risk maturity model of Hoseini (2017).

3 *Which improvement areas for project risk management can be identified in real-life infrastructural projects performed by Dutch regional water authorities?*

The third sub-question was answered by comparing the results from the literature study (model results and knowledge gained during the empirical study) with results from the empirical study. The improvement areas identified make it possible to answer the last part of the main research question. Recommendations can be used to improve risk management in practice and therefore, this research contributes to the professionalization of risk management within WS.

1.2 Research methodology

According to McQueen and Knussen (2002) "research is carried out in order to describe, understand, explain, and predict a progressively sophisticated function" (p.4). In other words: research aims to describe a situation/phenomenon/process that is not yet completely understood. Conform Crotty (1998) there are four major steps in developing a research study. The broadest level addresses the issues of philosophical assumptions such as epistemology and how knowledge is gained. These philosophical assumptions influence the theoretical perceptive of the researcher in the study which then influence the methodological approach and, consequently, the method of data collection. According to Tashakkori and Teddlie (1998) there are four major social science paradigms/worldviews in order to create foundation for social science studies. In Table 1 the three most important paradigms are compared.

Table 1: Comparison paradigms used in social sciences. (Tashakkori and Teddlie 1998)

Paradigm [-]	Methods	Logic	Epistomology	Axiology	Ontology
Positivism	Quantitatative	Deductive	Objective	Inguiry value free	Naïve realism
Constructivism	Qualitative	Inductive	Subjective	Inguiry value bound	Relativism
Pragmatism	Qualitative + Quantatative	Inductive + deductive	Objective + subjective	Values play a large role in interpreting results	Accept external reality. Choose explanations that best produce desired outcomes

The positivist paradigm underlies the so-called quantitative methods and the constructivist paradigm the qualitative methods. "The quantitative method emphasizes objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires and surveys; it focuses on gathering numerical data and generalizes them across groups of people to explain a particular phenomenon. 'Qualitative' implies an emphasis on the qualities of entities, processes and meanings that are not experimentally examined or measured in terms of quantity, amount, intensity, or frequency. Qualitative researchers stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry" (Denzin and Lincoln 2000).

Verschuren and Doorewaard (2015) points out that for a starting researcher a case study research has the benefit of providing useful results even without too much knowledge on methodology. Case study research is a methodology that allows gaining an in-depth understanding of a typical situation, process, event program or activity. Cases are bound by time and activity, and researchers collect detailed information using a variety of data collection procedures over a period of time (Creswell 2013). Since this study aims to explore, clarify and understand the current situation of risk management within the WS, largely driven by complex interactions between humans and organisation, a qualitative case research method is the most appropriate way of investigating (Kumar 2011).

In order to define the improvement areas for risk management in practice, the ideal situation was compared with risk management applied in practice. The first step was to define ideal risk management related to infrastructural projects. A literature study forms the basis for the definition of this ideal situation and for the preparation of the interviews.

In order to build an accurate and profound view on current risk management governance in practice, semi-structured interviews with employees of the Dutch regional water authority of Schieland and the Krimpenerwaard were held. Qualitative content analysis was used to extract information from the interviews. The coding of the transcripts was performed based on the main aspects discussed in the literature study and additional aspects identified during the interviews. On top of that project documents were analysed and the risk maturity model of Hoseini (2017) was applied (data triangulation). The choice to focus this study on risk management within one regional water authority was made in negotiation with graduation commission. The strength of focusing this study is that it allows for gaining in-depth knowledge rather than broad knowledge (internal validness). The weakness of this method is that the external validity of the results can be questioned (Verschuren and Doorewaard 2016). In order to mitigate external weakness, the results of the study were validated with two external risk management experts that are familiar with the WS organisation. This methodology can be seen as qualitative research (Tashakkori and Teddlie 1998, Creswell and Plano Cloark 2011). The previous mentioned data triangulation allows for and pursues enrichment and validity in data and findings (Creswell 2013).

The next step is to compare the results from the literature study with results from the empirical study. The differences identified between the ideal situation and risk management in practice make it possible to answer the main research question and to provide recommendations, which can be used to improve risk management in practice. The research approach is summarized in Figure 2.

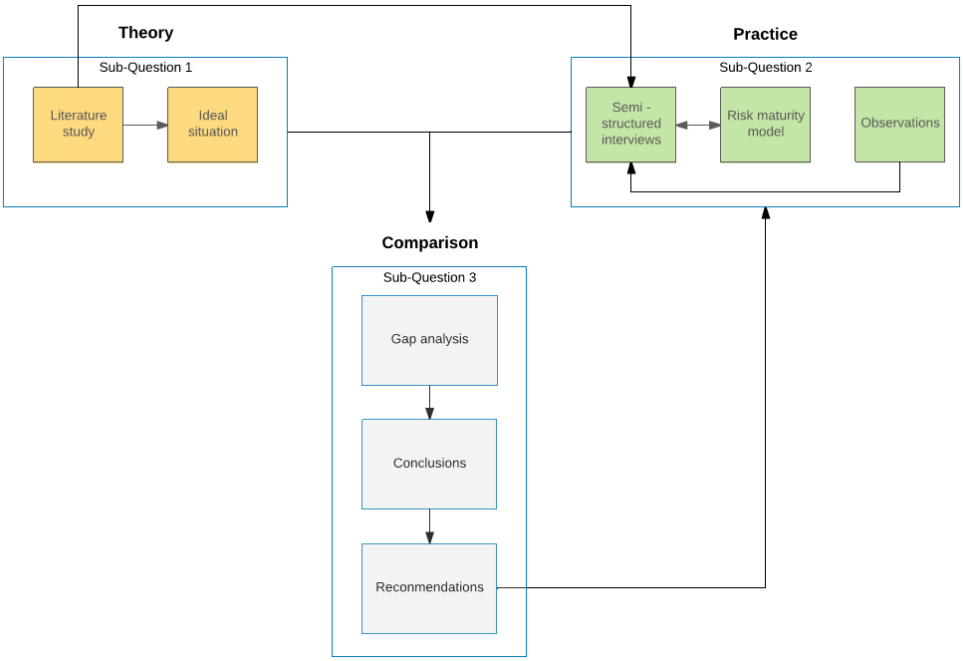


Figure 2: Research approach

1.3 Interview methodology

Interview is a method of in-depth data collection suited for complex situations and - in combination with documents and process observations - enables the researcher to gain an integral in-depth knowledge of an particular complex situation (Verschuren and Doorewaard 2016). Interviewing allows for retrieving rich qualitative data but their quality depends on the experience of the interviewer (Kumar 2011). In this case study semi- structured interviews were conducted in order to collect insights on the governance of operational project risk management performed by the Dutch regional water authority. Semi-structured implies that the topics and questions are largely predetermined by an interview protocol. They are largely open ended and are based on a literature study to ensure that relevant topics are discussed. Another advantage of semi-structured interviews is that they give room to ask extra questions depending on the context of the conversation with the interviewee. This allows for further probing. The interview preparations and protocol are further described in appendix C.

1.3.1 Selecting interviewees

Employee selection criteria were the following:

- Experience with project management in the water authority;
- Position in the firm and in the projects;
- Willingness and availability to be interviewed;

1.3.2 Interviewed persons

In total nine persons were interviewed, six of them project members and three of them top managers in the firm (director, head of department IPP and internal client). The project team members were questioned on how risk management was adapted in their project, how they see risk management in the organization and which improvement areas they see. Top managers (head of department and director of the organization) were asked how risk management was integrated within the organization and if they acknowledged (some of) the findings of the respondents. This in order to validate the respondent findings.

1.3.3 Performing the interviews and transcribing them

With permission from the employees, interviews were recorded and recordings were used for transcribing. The goal of transcribing is to stay as close to the reality of the respondents as possible. The duration of the interviews, varied between 40 and 120 minutes. The final results were sent to interviewees to ensure they agreed with the findings. The transcription of all interviews conducted can be found in the Appendices.

1.3.4 Qualitative content analysis

The data of the interviews were analyzed using qualitative content analysis. Since questions asked during the interview were mostly open ended, retrieving insights could be difficult (Kumar 2011). The transcripts were categorized based on the main aspects described in the literature study and those brought up during the content analysis. This method helped to compare the data of the interviews. The preparation and the results of the qualitative content analysis can be found in the appendices.(Kumar 2011)

1.3.5 Categorization and coding

In the literature study two main subjects have been described: (1) Organizational aspects and (2) risk management application and process aspects. The qualitative content analyses also revealed subjects that were used for coding the transcripts. Coding allows for comparing information by main category across different interviews.

1.4 Assisting risk maturity model

Hoseini's general risk maturity model (GRMM) is based upon 13 risk maturity models, 12 risk management processes and five lessons learned in applying risk management. Based on these, Hoseini divided risk management into two main categories, respectively: 'organizational aspects', 'application and processes', with 'organizational aspects' being further subdivided into top management commitment, culture, policy and strategy and personnel. 'Application and processes' is subdivided into risk analysis and evaluation (assessment), risk treatment and monitor and review. Figure 3 shows a schematic overview of the GRMM:

The risk maturity model of Hoseini (2017) is a tool that allows for determining a score for the risk management aspects or dimensions; `Strategy & policy', `Top management commitment', `Culture and personnel knowledge', `Risk assessment', `Risk treatment' and `Monitor and review'. These aspects are elaborated in the literature review chapter. The benefit of the model is that it gives a quick insight into the opinion of the respondents about the different aspects. Prior to the semi-structured interviews, the risk maturity model of Hoseini (2017) was filled in by the project managers. The results of the model formed input for discussion during the semi-structured interviews. The limitation of the model is that it had not been used before and was tested for the first time in this research.

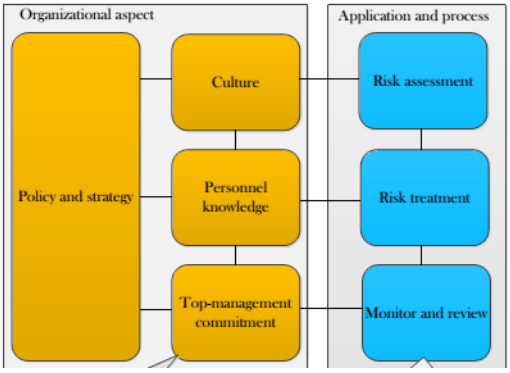


Figure 3 GRMM (general risk maturity model) (Hoseini 2017)

Based on his theoretical framework in combination with expert assessments he extracted several statements for each of the sub-aspects. The model has been built as an interactive Excel document in which the user can range from A ('totally applied') to D ('not applied'). B signifies 'applied to a large extent' and C stands for 'applied on a limited scale'. Figure 4 shows an overview of the GRMM for the aspect 'Monitor and review' An extensive list of all statements related to those aspects can be found in the appendix.

ID	Monitor and review	Score	Value	Importance in the project
1	Status of the control measures are updated (in progress, applied, not applied yet)	B	7	10
2	Status of risks are updated in the risk register (active, managed, occured)	B	7	10
3	New risks are added to the risk register and the previous steps are repeated for the new risks	A	10	10
4	Cost/schedule documents are updated based on the status of risks	C	3	3
5	Probability and consequences of active risks are updated based on the risk matrix of the organization	B	7	7
6	Lessons learned (occurred risks, performing risk management, etc.) are recorded	B	7	10
7	The entire monitor and review process is based on the project risk management process	B	7	7
8	The outcome of monitor and review process is documented and communicated to internal and (if needed) external stakeholders	B	7	7

Figure 4: overview of the GRMM

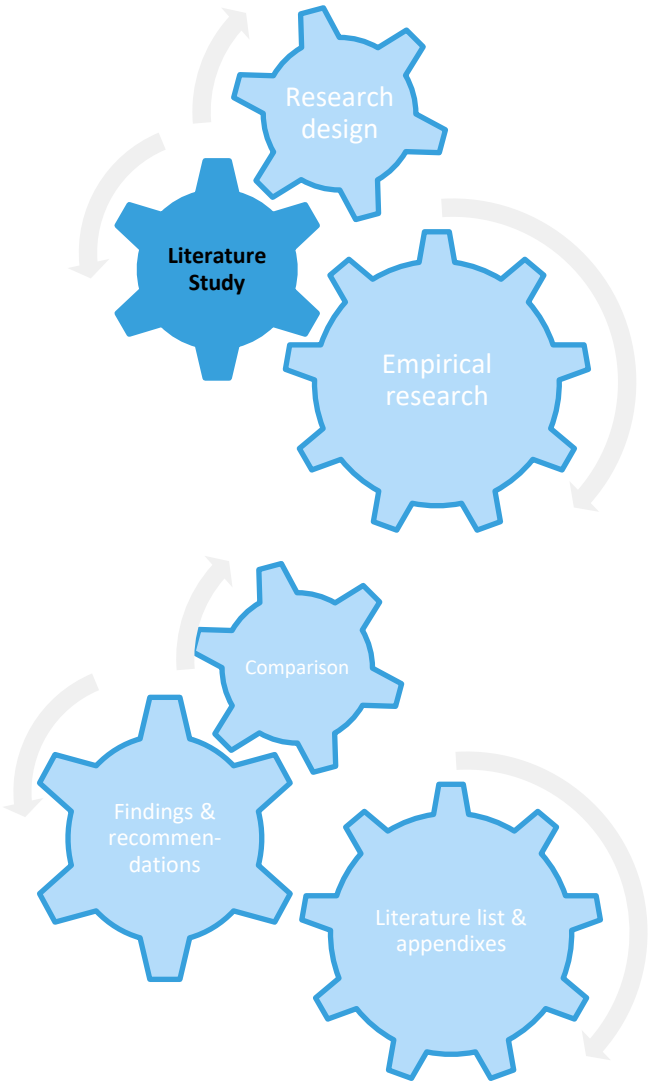
1.5 Validation of results

The results of the interviews were reviewed by the project management team itself and by two external risk management experts familiar with the working method of the WS organization. In this validation step the experts were asked if the results were representative for other water authorities.

1.6 Report outline

The underlying report is divided into six parts: (1) introduction, problem statement and research design (chapter 1), (2) literature study on risk management (chapter 2 until and including chapter 4), (3) empirical study which consists of; research results and discussion, and (5) conclusions and recommendations and (6) literature list, feedback model and appendices.

Literature study



2 Project risk management

In order to create a common understanding on the terms risk and risk management and on the extent to which these can be useful for Dutch Water Authorities, risk and risk management will first be defined. Risk management is broader than project risk management. In order to form an integral picture, both must be understood. Since the Dutch Water authorities are exposed to more than only project risks, the areas where risk management is applicable will also shortly be described in this chapter.

2.1 Project Risk management definitions

Literature often uses the terms "Risk", "Uncertainty", "Risk management" and "Project Risk Management". But what exactly do these terms stand for? To be able to get a good understanding of these terms they will be defined in this paragraph. Thereafter, the term "Project Risk management" will be defined. Table 2 lists several definitions of 'Risk':

Table 2: Definitions of Risk

Source [-]	**Definition of 'Risk"** [-]
(ISO 2009)	Effect of uncertainty on objectives
(Well-Stam, Lindenaar et al. 2007) (RISMAN)	An event that has a possibility to result in: Higher project costs, project delay ornot meeting project quality, information and organisation demands/standards Risk = Probability * Consequence
(Hillson and Simon 2007)	Any uncertainty that, if it occurs, would have a positive or negative effect on the achievement of one or more objectives
(NASA 2007)	A measure of the inability to achieve overall program objectives within defied cost, schedule, and technical constraints and has two components: (1) the probability of failing to achieve a particular outcome and (2) the consequences/impacts of failing to achieve that outcome. Both the probability and consequences may have associated uncertainties
(Nicholas and Steyn 2012)	The notion of project risk involves two concepts: -The likelihood that some problematic event will occur; -The impact of the event if it occurs Risk is a joint function Risk=f(Likelihood, impact) Risk can also mean opportunities – e.g., the potential for additional rewards, savings or benefits"
(Kaplan and Garrick 1981)	Risk can be seen as an answer on the questions: What can go wrong? How likely is it to go wrong? If it does go wrong, what are the consequences? Therefore risk is a combination of hazard and likelihood. It is a triple < si , pi , xi > where:
(Miller and Lessard 2001)	"Risk is the possibility that events, their resulting impacts and dynamic interactions may turn out differently than anticipated. While risk is often viewed as something that can be described in statistical terms, uncertainty applies to situations in which potential out-comes and causal forces are not fully understood: we refer to both as risks."

Table 3: Definitions of (Project) risk management

Source [-]	Definition of 'Project risk management" [-]
(ISO 2009)	Coordinated activities to direct and control an organisation with regard to risk
(NASA 2007)	Technical risk management is an organized, systematic risk-informed decision making discipline that proactively identifies, analyses, plans, tracks, controls, communicates, documents, and manages risk to increase the likelihood of achieving project goals
(Well-Stam, Lindenaar et al. 2007)	Risk management is an instrument, within project based working approach, that can support better control over the project"
(PMI 2013)	"The objectives of project Risk Management are to increase the likelihood and impact of positive events, and to decrease the likelihood and impact of negative events in the project"

Based on the definitions mentioned in table 2 **risk is defined as**:
"A risk is an uncertain, future event, that if it occurs has a negative or positive impact on project promises. Risk is a function of likelihood and" (Own definition).

Based on the definitions mentioned in table 3, **project risk management** is defined as:

A process of coordinated activities to guide, control and assist an organisation and/or a project team in increasing the likelihood of achieving or outperforming project objectives, by reducing the likelihood and/or impact of negative occurrences and enlarging the likelihood and/or impact of positive occurrences (future uncertainties) on project objectives " (Own definition)

Most definitions use the term "Uncertainty". But what does "**Uncertainty**" mean? An attempt to define uncertainty is listed below.

- In every project there is a certain amount of uncertainty. Project risks originate / find roots in this uncertainty (Perminova, Gustafsson et al. 2008).
- In a practical, scientific and engineering context, certainty is achieved through observations, and uncertainty is what is removed by observation. Hence in this contexts uncertainty is concerned with the result of possible observations." (Bedford and Cooke 2003)

Relation between uncertainty and project risks

Of all literature sources reviewed, the Standaard Systematiek voor Kostenramingen (SSK-2010) best clarifies the relation between uncertainty and risk. SSK-2010 acknowledges three types of uncertainties; knowledge-, realisation- (future) and decision uncertainties. **Knowledge uncertainty** is: the lack of information to describe the plan, situation, scenario, the system and the variables. These are known to be uncertain (100% chance of happening) but the financial consequences are unknown. These normal uncertainties are within the project scope (endogenous) and are arising from uncertainties in the actual prices and quantities of the project objects and materials. These are the **normal uncertainties** and are known to fluctuate. **Realisation (future) uncertainties** refer to special events which can occur during the project and which can have an influence on the project objectives. The chance of happening (<50%) and the consequences are largely unknown. These are the actual '**risks**' which a risk analyses focuses on / tries to determine. These uncertainties are within the project scope (endogenous). It is well understood that not all risks can be determined by a risk analysis. Unknown risks are a given and for this an extra financial reservation can be made. Such reservation varies between 5% and 10% of the direct foreseen building costs. **Decision uncertainties** arise from the decision making of the client on different solutions. These uncertainties are outside the project scope (exogenous) (CROW 2010). The types of uncertainties are listed in Table 4.

Table 4: Definitions of (Project) risk management

[-]	[Chance]	[Type of uncertainty]	[scope]
Normal uncertainties	100%	Knowledge uncertainty	endogenous
Special events	<50%	Realisation (future) uncertainties / Risks	
		Decision uncertainties	exogenous

2.2 Risk management application areas

Risk management can be used in a variety of areas such as financial risk management, risk based maintenance, project risk management, safety risk management, crisis management, IT risk management, corresponding investment decisions and many more.

Within every environment, the objectives of projects, programmes and/or organisations in terms of money, time, quality and image are threatened by risks. Risk management enhances the probability of achieving the defined objectives, by identifying and making risks explicit, by preparing and connecting control measures to these risks and by implementing these measures within the (project)-management.

According to Twynstra-Gudde (2017) a distinction can be made according to on which level risk management can be applied. These are respectively: Organisation-, Programme- and Project-level as illustrated in Figure 5. In this thesis the focus is on risk management at project level.

Organisation level:
Risk management at organisational level is about making those risks explicit that can have an effect on organisational objectives in which the focus is on strategic and tactic risk management. It addresses top risks which stem from the different functional businesses and which can potentially threaten the survival of the organization.

Program level:
Risk management at programme level is about making risks and control measures explicit at the level of a 'portfolio of projects' and should allow for understanding and controlling the effects in terms of time, feasibility, efficiency, flexibility and goal achievement at such level.

Project level:
Risk management at project level is about making explicit and controlling the risks which can have an effect on project objectives (time, money, quality, information, organisation).

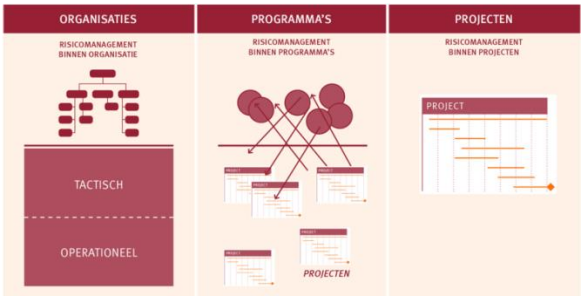


Figure 5: Risk management area's (Twynstra-Gudde 2017)

2.3 Project success and project risk management

Projects in the infrastructural construction sector are often classified as 'successful' or 'unsuccessful' with regard to cost overruns and delays. A well-known definition of project success includes time, costs, scope and quality (Atkinson 1999). This definition is illustrated by Figure 6: The Iron triangle.

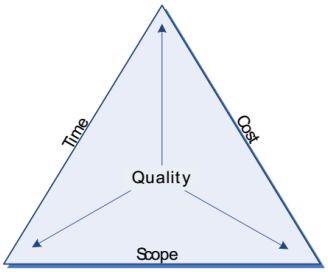


Figure 6: The Iron triangle

However, this is not the complete picture. Project success depends on the perception of the stakeholders, which is likely to be diverse. In reality it can occur that a project is unsuccessful in terms of meeting the iron triangle criteria but that end users still perceive it to be a great succes. A good example is the Sydney opera house: its construction was far over budget and time; it took three times longer than planned to build and the costs were almost five times higher than estimated. However, the Sydney opera house became Australia's land mark. This cannot be expressed in terms of money and therefore, the project is perceived as a great success. The example demonstrates that besides time, cost and quality there are other success criteria such as the appreciation by the client's project personnel, users, contracting parties and stakeholders.

Project success in this thesis will be defined as;
"Project success is the extent to which involved actors are satisfied with the project result " (Aken 1996)

'Actors involved' include clients, project manager, project team, project contractors, users, management and direct, indirect and social interest groups. Criteria for satisfaction are budget, cost, delivery time, process satisfaction, usability, hindrance, etc.

Risk influences project performance. The task of project risk management is to control projects and to identify and mitigate those occurrences that can influence objectives. (Hillson and Simon 2007). Within this study, risk management aims at controlling risks and opportunities that could influence the project objectives and based upon the definition of project success.

2.4 Project risk management to increase project success

Project success is measured in terms of how well a project meets requirements in terms of budget, schedule and performance (Nicholas and Steyn 2012). Project management is an important contributor to the successful realisation of the project and project risk management is an important part of project management (Hillson and Simon 2007, Nicholas and Steyn 2012). Identifying risks and selecting and applying appropriate control measures allows for better reactions and, therefore, a higher chance of success.

Risk management is a tool that on the one hand helps to reserve enough financial room in the project for coping with possible uncertainties and on the other hand tries to reduce the usage of this reserve by implementing control measures and strategies.

A system for risk management ensures that project risks are structurally identified which reduces the possibility for missing important risks and therefore contributes to project success (Hillson and Simon 2007, Nicholas and Steyn 2012, PMI 2013). All projects contain some level of uncertainty. There are always unforeseen obstacles or risks that can cause missed deadlines, cost overruns, safety problems and poor project performance or, on the other hand, opportunities. Management must try to anticipate to these problems, plan for them, and adjust activities and shift resources to mitigate or overcome them and try to exploit the opportunities. This is the field of project risk management (Hillson and Simon 2007, NASA 2007, Nicholas and Steyn 2012, PMI 2013).

2.5 Relation between project control and risk management

Risk management is not a goal on its own, but is part of project management. Risk management can only be effective when it is part of the integral way in which a project is controlled. This section describes the relation between risk management, cost estimation (2.5.1), estimates in project phase (2.5.2), Risk events and estimates (2.5.3), risks and planning (2.5.4) and contract (2.5.5).

What should be noted is that the information out of the risk management process is input for the other disciplines, and visa versa, but it is not to the risk manager to make an estimate for the project. The information of risk management should be input for the cost estimator, planner and also for tendering, etc.

2.5.1 Risk reservation and cost estimation

In order to build an accurate estimate of the project costs, the SSK2010 takes into account the following uncertainties and risks:

- "To be determined";
- Knowledge uncertainties / normal uncertainties
- Realisation uncertainties (risks);
- Future uncertainties;
- Uncertainty reserve.

The risk reservation consists of knowledge, realisation and future uncertainties. It also includes an uncertainty reserve depending on the accepted exceedance probability of the estimate (probabilistic). The risk management application and process (risk analyses) partly focuses on making the realisation uncertainties (risks) explicit in order to reserve a budget for them and partly to mitigate the usage of the budget by adapting control measures. Risks have a discrete distribution, either they happen or they do not. However, in the estimation the average chance is multiplied with the estimated cost of the consequences after control measures. The sum of these risks forms the realisation uncertainty. In the estimation a spread in monetary value of the risks can be used. Since not all risks can be determined a fixed percentage for unforeseen risks (future uncertainties) of 5%-10% is mostly used. (CROW 2010, ProRail 2011). This is illustrated in Figure 7 and Figure 8. Scope changes can also contribute to budget exceedance; however scope changes are the result of deliberate political and/or administrative choices and should not be confused with the risk reservation. The two main types of available estimations are deterministic and probabilistic estimations, respectively.

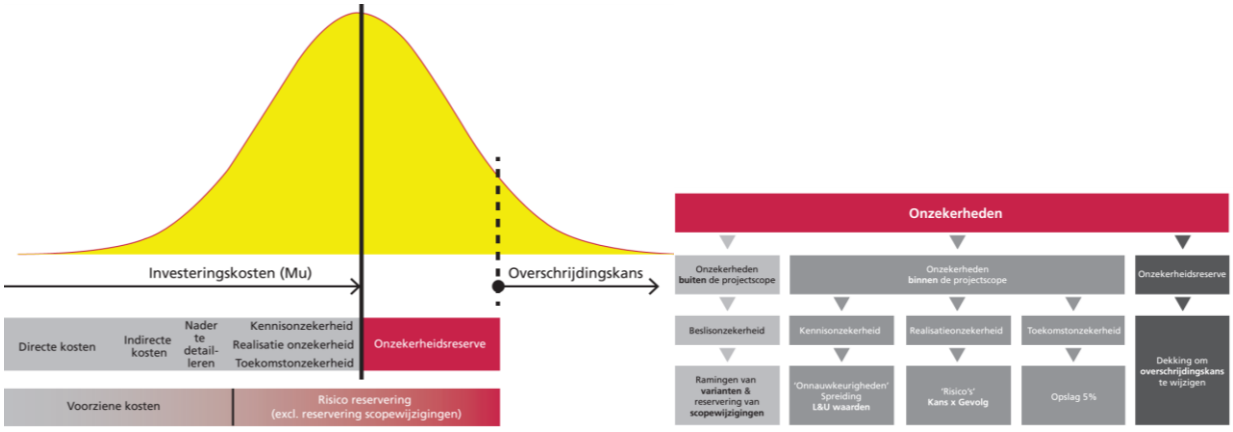


Figure 7: uncertainties in cost estimations (ProRail 2011)

For probabilistic estimations, knowledge uncertainties or normal uncertainties are included in the direct costs by inserting a 'low', 'high' and 'most likely' estimate for each of the objects. On top of the knowledge or normal uncertainty also the risks (special events / future uncertainties) can be included. By using a statistical Monte Carlo simulation, the sum of the uncertainties and the estimation budget can be determined. Knowledge about the variance and elements that are most likely to contribute can be determined. If dependencies exist it is important to include them. For example: the uncertainty about the amount of excavation depends on the amount of backfill after excavation. For each part (activity) of the estimation the dependence should be understood. The part 'special events or future uncertainties' comprises those risks that are determined in the risk analysis sessions.

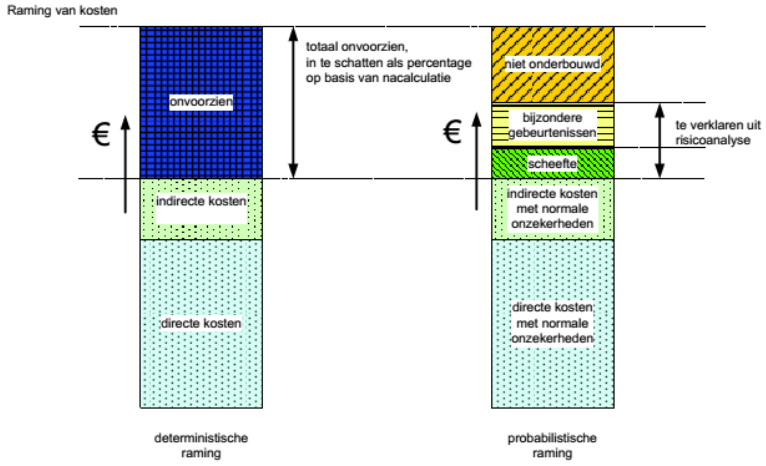


Figure 8: deterministic vs probabilistic estimation

2.5.2 Uncertainty in estimates

The accuracy of the estimation is dependent on the phase of the project. In the initial phases of the project high uncertainty of quantities, prices and scope is in the estimate and towards maturing of the project there is an increasing accuracy of estimate because of lower levels of WBS are available. This is illustrated in Figure 9

	Bouwfase	Soort kostendrager en prijs	Benaming kostenopzet	Risico-reservering*	Band-breedte
1	Initiatief / voorstudie	Functionaliteit x kengetal	Prognose	40%	40%
2	Definitie / planstudie	Element x elementprijs	Kostenindicatie	30%	30%
3	Voorontwerp	Hoeveelheid x richtprijs	Kostenraming	20%	20%
4	Def. ontwerp	Hoeveelheid x eenheidsprijs	Conceptbegroting	10%	10%
5	Bestek	Hoeveelheid x eenheidsprijs	Besteksbegroting	5-10%	5%
6	Realisatie	Hoeveelheid x eenheidsprijs	Besteksbegroting	5-10%	0-5%

** Percentage over de investeringskosten bedoeld als in het samenvattingblad van het rekenmodel SSK 2010*

Figure 9: Uncertainty in estimate (HHSK)

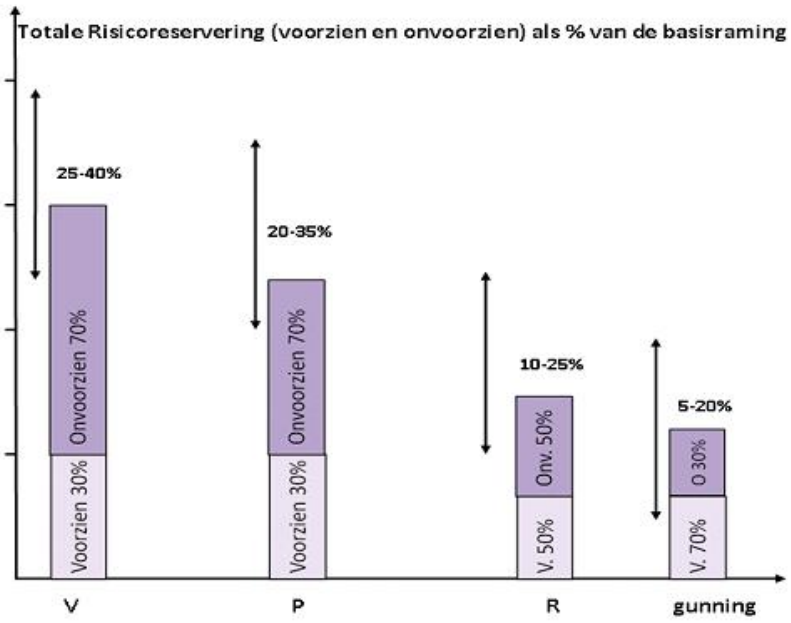
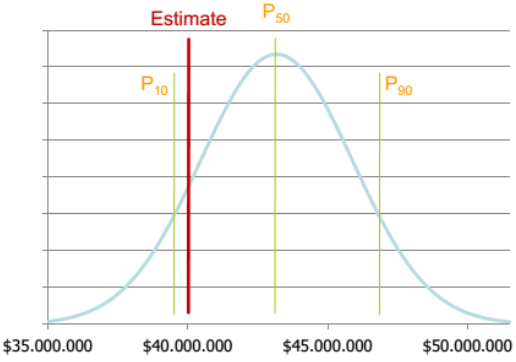


Figure 10: risk reservation boundaries HWBP

2.5.3 Risk Events and the Range Estimates

Risk events in relation to and range estimated can be best explained by an example, consider the following example illustrated in Figure 11 , note that P50≥'most likely'.



P_{10}	$ 39,689,642
Estimate	$ 40,000,000
P_{50}	$ 43,166,667
P_{90}	$ 46,643,691

Detailed Scope List		Variability			Probability	
Item	Estimate	a	m	b	μ	σ
Big Scope 1	$ 10,000,000	$ 8,000,000	$ 10,000,000	$ 16,000,000	$ 10,666,667	$ 1,333,333
Big Scope 2	$ 8,000,000	$ 8,000,000	$ 8,000,000	$ 12,000,000	$ 8,666,667	$ 666,667
Big Scope 3	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ -
Big Scope 4	$ 5,000,000	$ 4,000,000	$ 5,000,000	$ 12,000,000	$ 6,000,000	$ 1,333,333
Labor	$ 12,000,000	$ 9,000,000	$ 12,000,000	$ 20,000,000	$ 12,833,333	$ 1,833,333
Allowances	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ -
	$ 40,000,000					

Figure 11: Example of range estimate: source: (Verbraeck 2015)

what will risk events do to our estimate?

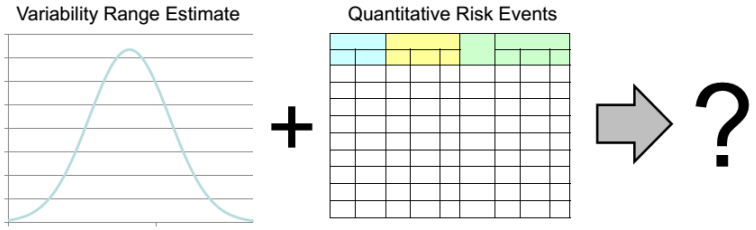


Figure 12: estimate + risk register (Verbraeck 2015)

Risk events 'distort' the symmetry of the range estimate; 1).Promise faces either no consequence or full consequence; 2).Moderately affects the P_{50} through expected value but, 3) significantly affects the P_{90} by almost its full consequence as ca n be clearly seen in Figure 13.

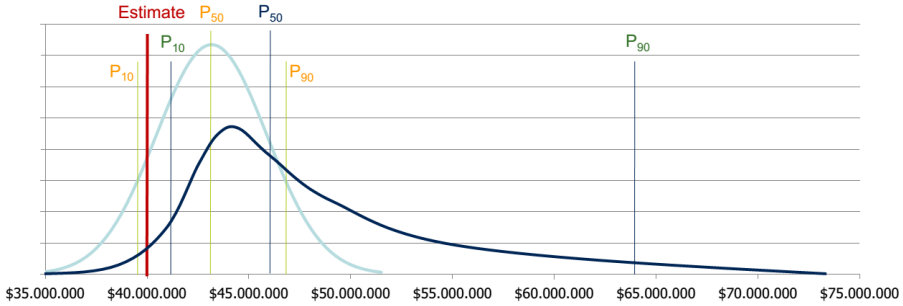


Figure 13: consequences of risk events on estimate (Verbraeck 2015)

2.5.4 Risks and planning

The residual risks (risks after control measures) listed during the risk analysis application and process session, can and ideally should be used in the deterministic or probabilistic planning. However, inserting risk as a spread into the deterministic planning reduces the traceability of the risks. Therefore, it is advised to link the risk with the activity, but to keep the separation visible by not putting the risk as a spread in the planning. For the probabilistic estimation the risks, including their chance of happening, should be included and a relation with other activities should be built, as illustrated in the figure below. One should always realise that a risk is a function of chance and consequence. This implies that important risks with a high consequence but a low chance of happening can be misleading, because if the risk occurs (fires) the consequences are high and the entire reservation and more can easily be spent. Such risks should be dealt with on a higher level (organisational level).

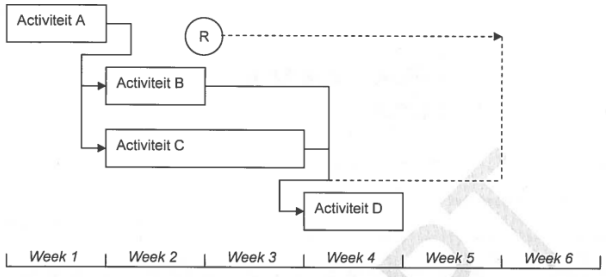


Figure 14: risks in planning

2.5.5 Risk management and the relation with tendering, contract and contract control

In the project contract the division of risk between contractor and client is documented. The risks identified and assessed in the preparation phase ideally form an important input for the tendering specification and selection criteria. The way in which the most important risks are controlled represents a set of qualitative criteria useful for contractor selection. In the tendering phase new input from the contractors may result in an updated risk register. The risk register after tendering is then the basis for the risk management of the contract. This is illustrated in Figure 15

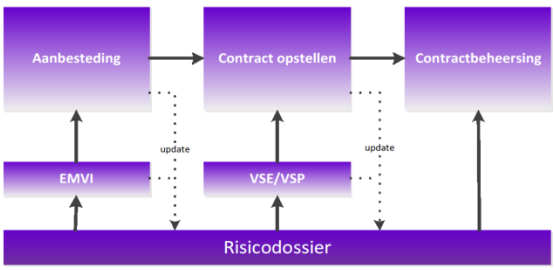


Figure 15: relation between risk analysis and contract

3 Risk management methods

In this chapter, four well-known theoretical methods for performing risk management in infrastructural projects are analysed. It should be mentioned that there are many more methods available today. After consulting both the HHSK and the graduation committee it was decided that in order to build a comprehensive view on how literature advices to perform project risk management, the following standards will be analysed: ISO, RISMAN, ATOM and Nicholas & Steyn Project management handbook. Each method is briefly discussed in the sections below. The understanding of the different methods is used to decide which information is relevant. There will be a further elaboration on how literature advises to perform risk management to form an "Ideal" or "Right" way of performing risk management in infrastructural projects (first sub question).

3.1 ISO's Risk management directives

The International Organization for Standardization, better known as ISO, is a non-governmental international network of national standardization organisations. It consists of institutions of 162 countries, including the Dutch normalisation institute (NEN). ISO was founded in 1947 with the objective of answering one fundamental question: "what's the best way of setting internationally recognized standards?" (ISO 2009).

ISO has three directives for Risk management:

- NEN-ISO 31000 (Risk management - Principles and guidelines);
- ISO/IEC Guide 73 (Risk management – Vocabulary);
- NEN-ISO/IEC 31010 (Risk management - Risk assessment techniques).

NEN-ISO 31000 forms the ISO risk management basis; the ISO guide 73 and ISO/IEC 31010 are complementary and make the standard more complete.

3.1.1 ISO/IEC Guide 73 (Risk management vocabulary)

The ISO Guide 73 provides vocabulary in order to create a common language for risk management concepts and understanding. The guide describes the main terms used in risk management to encompass the general field of risk management (ISO 2009).

3.1.2 NEN-ISO/IEC 31010 (Risk management - Risk assessment techniques).

The NEN-ISO/IEC 31010 provides a detailed description of clause 5 of the ISO 31000 risk management standard. This clause, the risk management process, is the actual part of the standard that is practically orientated to adapting or performing a risk management session. The annex of the directive provides a comparison of the available risk assessment techniques.

3.1.3 NEN-ISO 31000 (Risk management - Principles and guidelines)

The ISO 31000 standard consists of five clauses/chapters, being: (1) scope, (2) terms & definitions, (3) principles, (4) framework and (5) process. Each clause is made up of several components. Figure 16 gives an overview of the relations between risk management principles, framework and process. According to ISO the standard can be applied to any type of risk, regardless of whether it has positive or negative consequences (scope). Clause 2; terms and definitions, goes without saying (ISO 2009).

Effective risk management starts with an organisation acknowledging the principles listed in clause 3 (Principles). These principles form the basis for creating mandate and commitment and are also the starting point for creating a framework. As can be seen in clause 4 (Framework), designing, implementing, reviewing and improving the framework is an iterative process. Implementing risk management, meaning the actual process of performing the risk management process according to the framework, for enhancing the organisations objectives is described in clause 5 (Process). Notice that there is a loop between implementing the framework (clause 4) and the process (clause 5). This means that the framework needs feedback from the actual process in order to learn, grow and tailor itself to organisational demands and vice versa. The framework ensures that information about risks is reported and that there is the basis for decision making. Following these steps ensures continual improvement of risk management and its alignment with organizational needs.

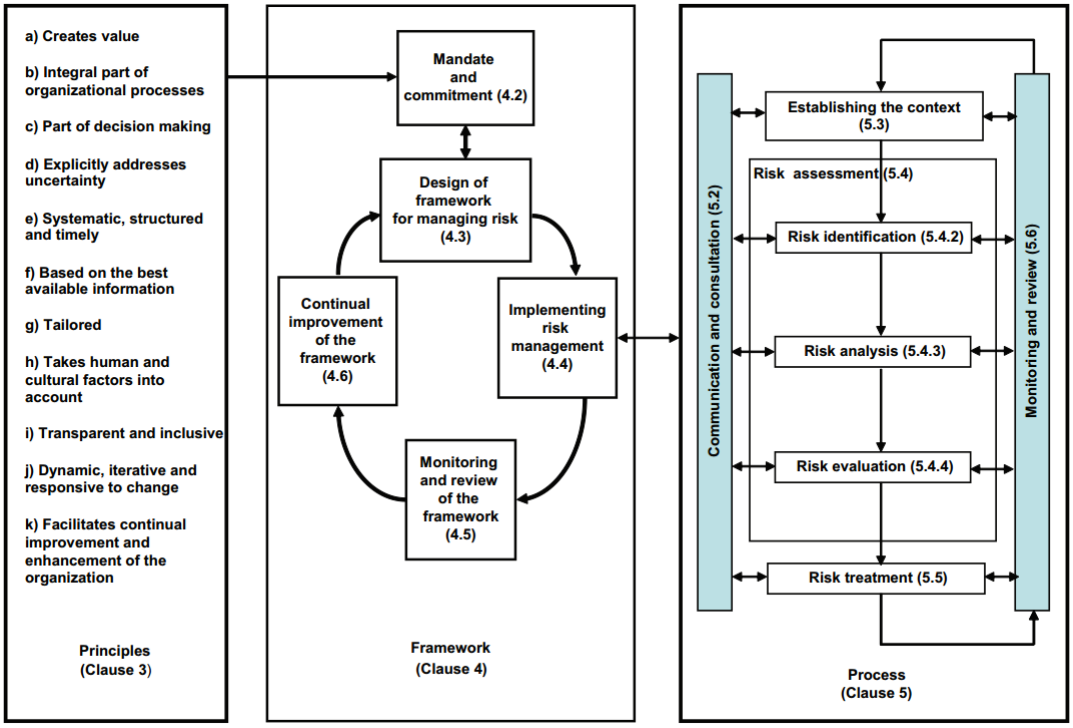


Figure 16: Relationships between the risk management principles, framework and process (ISO 2009)

The actual risk management process consists of the following parts:

1. establishment the context;
2. risk identification
3. risk analysis;
4. risk evaluation
5. risk treatment,
6. monitor and review.

The combination of activities 2, 3, and 4 is also called risk assessment.

As can be seen in Figure 17, the process of establishing the context, the risk assessment and treatments, continuously involves communication, consultation, monitoring and reviewing. Clear is that it is not a static but rather a living and organic process that is adaptable in order to reach the required objectives efficiently.

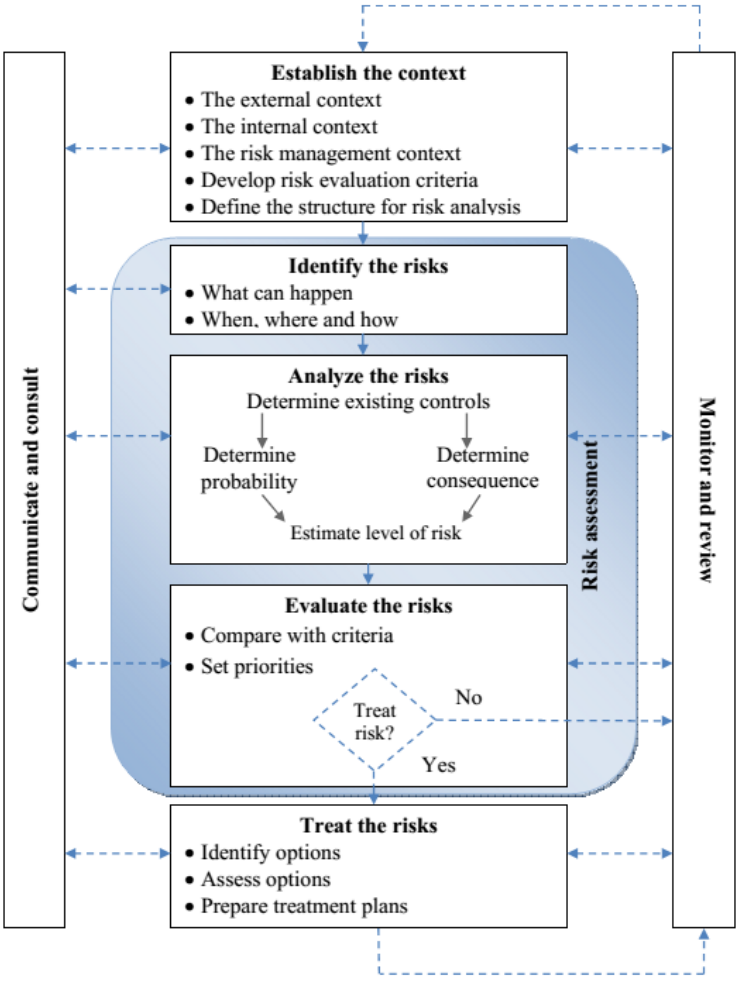


Figure 17: Risk management Process (ISO)

3.2 Hillson & Simon's Practical Project Risk Management ATOM methodology

The ATOM methodology was developed by Hillson & Simon and includes both threats and opportunities. The aim of Active Threat Opportunity Management or (ATOM) is to ensure a comprehensive, practical description on how to manage risk properly, efficiently and effectively. The book does not give an academic theory or generic principles but gives very practical guidance. The methodology presents a simple stepwise process, with limited ambiguity about what actually should be done with regard to project risk management. It aims to meet the need for a simple scalable risk management process that is be applicable to all projects (Hillson and Simon 2007).

ATOM gives four critical success factors for effective risk management, respectively: (1) Supportive organisation, (2) Competent people, (3) Appropriate methods tools and techniques, (4) Simple, scalable process.

The full ATOM process is illustrated in
Figure 18 and is composed of the following eight activities (steps) which are shortly explained:

- Initiation;
- Identification;
- Assessment;
- Response planning;
- Reporting;
- Implementation;
- Review;
- Post-project review.

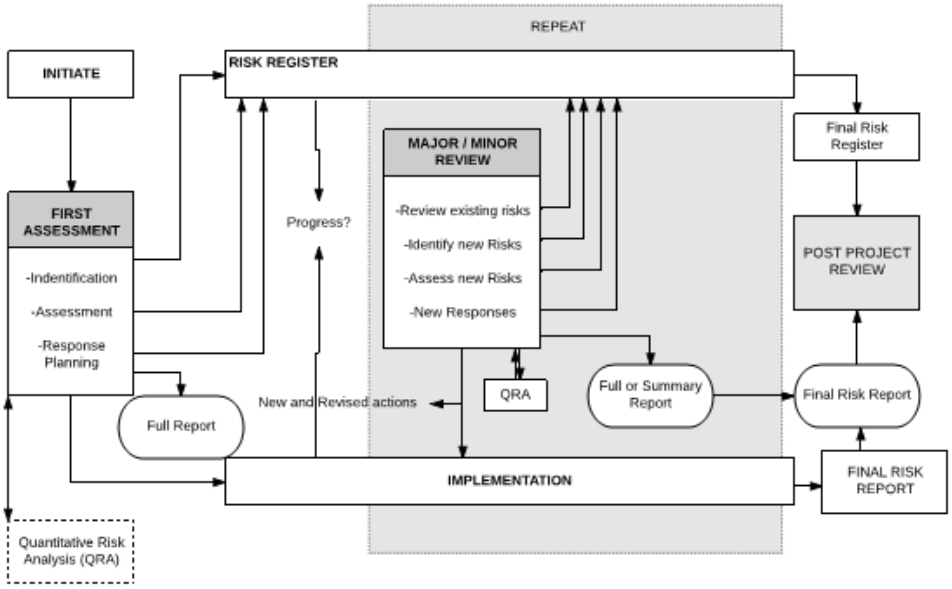


Figure 18: Full ATOM process overview (Hillson and Simon 2007)

3.3 RISMAN Method

The RISMAN method was developed by the consortium of organizations consisting of the municipality of Rotterdam, NS Railinfrabeheer, RWS Bouwdienst, RWS directive Zuid-Holland, TU Delft and Twijnstra Gudde. It aims at continuously making risks explicit and controlling them pro-actively instead of reactively, in order to consciously manage and handle their corresponding control measures.

The RISMAN method provides a systematic method to assess and govern uncertainties (risks) and their effect on cost and time estimations in projects. The method acknowledges that performing risk analysis depends on project size, complexity and organisation and that the risk analysis should be specific on one aspect per time (time, cost, quality, information and organization or other aspect).

The RISMAN method essentially consists of two main parts; the first part is the risk analysis which gives an overview of the most important risks and possible control measures. The identification of risks should be performed systematically and from different angels in order to pursue integral risk identification. Such angels can be technical, organisational, spacial, political, juridical, financial, and social. The risk analysis says:

- Determine the risk analysis objectives;
- Identify the risks;
- Determine the most important risks;
- Identify control measures;

The second part, the risk management starts with updating the input from part one, choosing between control measures, implementing control measures, evaluating control measures). In the risk management phase (part 2) control measures should be chosen and specified until it is a (set) of specific activities part of operational project management. The effect of the control measures should be monitored regularly, to see if it is in line with expectations. After the evaluation of the chosen control measures, the risk analysis should be updated. The RISMAN method points out that after each project phase (initiation, definition, realisation phase) a risk analysis and update of the previous register should be performed. The RISMAN method is illustrated in Figure 19.

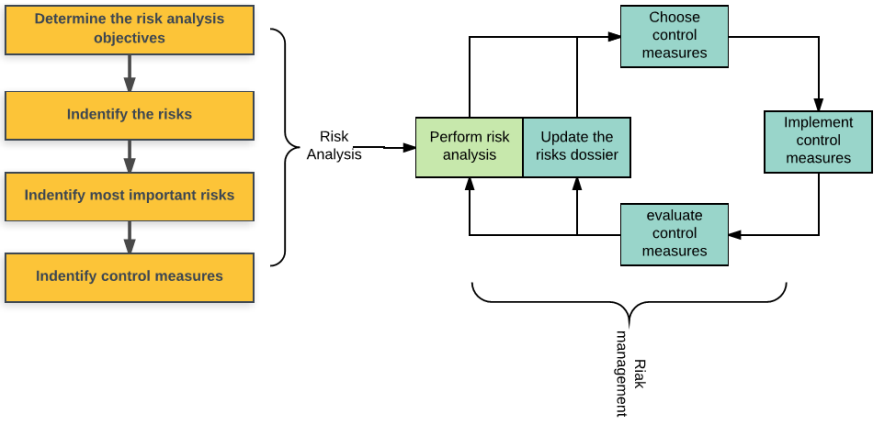


Figure 19: Risk analysis → risk management (Well-Stam, Lindenaar et al. 2007)

3.4 Nicholas & Steyn - Managing risk in projects

This method places risk management among other parts of project management practices such as requirements and work definition, planning, budgeting, configurations management, change control and performance tracking and control. According to the handbook risk identification, assessment and response planning should be treated as a formal part of project planning. The method acknowledges that not all projects need a comprehensive risk management procedure. For small projects a well-educated and motivated project leader can usually overcome difficulties with associated risks. (Nicholas and Steyn 2012)

The handbook describes some general principles that should be followed to ensure that risk management is performed:

- Create a risk management plan;
- Create a risk profile;
- Appoint a risk officer;
- Include a risk reserve;
- Establish communication channels;
- Specify procedures to ensure accurate and comprehensive documentation.

The risk management process described by Nicholas & Steyn is illustrated in Figure 20, and consists of the following steps: identification, assessment, plan risk responses and track and control risks.

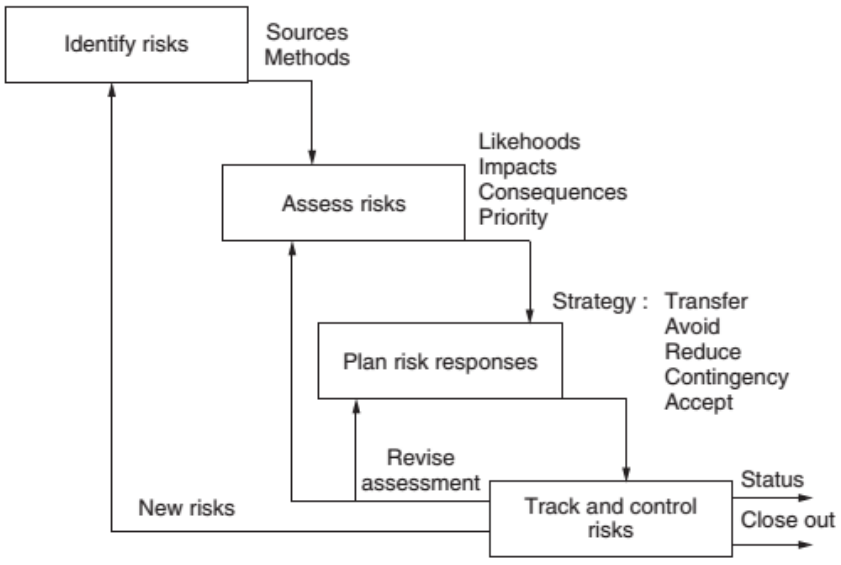


Figure 20: Risk management elements and process (Nicholas and Steyn 2012)

3.5 Insights and comparing the risk management methods

3.5.1 Personal findings of the methods

The analysis of the four different risk management methods, briefly summarized in the previous paragraphs, results in insights for project risk management. ISO31000 is one of the most complete methods in describing all aspects / facets of risk management. It highlights the need for designing a framework and adapting it to organizational needs by means of an iterative learning process. ISO is complete, rather ambiguous and the ISO31000 standard is not a thick book. This is both the strength and weakness of this method. The way in which it is written allows for self-interpretation and gives freedom to organisations to tailor the method to their needs, something which ISO advocates. The weakness is that it is not always entirely clear what actually is expected from applying risk management in practice. As a consequence, ISO31000 can be perceived as vague and unclear. An organization could see this as a hurdle and quit the process.

The ATOM method is the opposite of ambiguous: it is practical and simple and focuses on a scalable and simple process. The risk management process is in line with the process of ISO31000. The book gives a good idea on what is meant with project risk management. It reduces the hurdle to actually start using risk management in projects by supplying standard tables and lists and by accurately describing what should be done.

The RISMAN method highlights that it is important to be aware of and to include stakeholders' different perspectives (political, environment, social, technological, legal and environment) in the risk identification. It is about continuously making risks explicit, controlling them pro-actively and making them negotiable. It is focussed on projects and especially suitable for Dutch infrastructural projects.

The Nicholas & Steyn method is the least comprehensive of the four methods analysed. It is in line with the other methods and does not contain any aspects not described by the other methods.

After performing the literature review, the overriding conclusion is that the different methods have more similarities than differences.

The first part includes the organisational aspects of risk management. Each method recognizes that top management commitment is important and that risk management should be tailored to meeting the needs of the organization and/or project. All methods agree that implementation is a learning process and that it is up to the organization or project team to define how risk management should be implemented in order to meet the objectives. Recommended is to align risk management and organizational or projects goals and to fit risk management to the work structure. According to RISMAN the implementation of risk management in any organisation can be seen as a project. ISO sees the same activity as a process and ATOM gives a 'just do it' recommendation. All methods agree that the implementation and use of risk management should be monitored and adjusted in order to improve it and tailor it to the required standards.

The second part is applying the risk management process in projects.
All methods point out the need for a scalable process based on the objectives, size and complexity of a project. They acknowledge that there is no uniform scale of performing risk management.
Each of the four methods describes a similar risk management application process:

- Determine the risk analysis objectives;
- Identify risks;
- Analyse risks;
- Plan and implement control measures;
- Monitor and review control measures.
- Report lessons learned

3.6 Risk management main areas

The previous paragraph gives insight into the similarities of the analysed risk management methods. Based upon these insights risk management can assessed along the lines of two main aspects, namely:

- Organizational aspects;
- Application and process

The division between aspects is not discrete but rather fluid. There is a certain overlap between the features in the area where the different aspects meet and are part of each other. Each aspect requires communication and information, as illustrated in Figure 21.

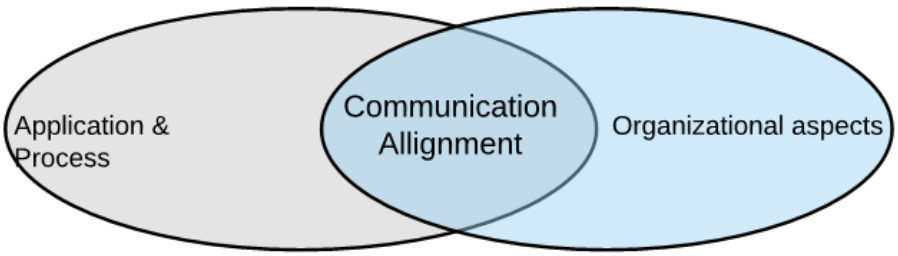


Figure 21: Main aspects of risk management

The division of risk management into two main aspects is in line with the findings of the research performed by (Hoseini 2017). In his research, based upon several risk management best practices, risk maturity models and lessons learned, he establishes the following division of risk management aspects: (1) Organizational aspects and (2) Application and Process.

The first sub-question aims at evaluating how risk management is promoted and described in literature. The two main components stated above will act as the main structure for further elaborating on the ideal way of performing project risk management. Each of the main aspects will be further discussed in the next chapter.

4 Ideal Risk management conform literature

In this chapter the earlier described main parts of risk management are described in more detail in order to answer the first sub-question of this research "*How is risk management ideally governed within projects?"* The organizational aspects are first described, followed by a description of the application and process aspects. The last step will be to answer to the first research question.

4.1 Organizational aspects

Organizational aspects are those aspects that ensure that risk management can be performed effectively in the organization and in the project. In consists of sub-aspects such as commitment and attitude of both top management and personnel towards risk management, the availability of resources, training, etc. Based on literature review, the following categories for 'organizational aspects' have been defined: (1) management commitment towards risk management, (2) the strategy and policies followed by the organisation or project team in applying risk management, (3) Culture and (4) personnel knowledge.

4.1.1 Top management commitment towards risk management

Zwikael (2008) argues that top management support is considered to be among the Critical Success Factors for project management. Commitment and support from top management and personnel is very important in influencing the success in almost any initiative within an organization (Hasanali 2002).

Top management support in risk management includes generating awareness on the risk management purpose and strategy as well as on providing the necessary resources. In order to lead and to encourage the continuous effort to support risk management, top management can appoint a risk sponsor / manager. This role requires the authority to define and implement the necessary changes and the ability to engage staff to cooperate with the protocol. But top management commitment does not end with appointing a risk sponsor within the organisation; management can also support the training of staff; it can promote learning and growing in risk management by hiring consultancies to help with the implementation or improvement of risk management; and – as a starting point for creating a risk management framework - it can ensure the explicit formulation of the policy and strategy towards risk. Communication between top management and personnel about risk management goals and strategies and the alignment with practice is vital. Management will need to create an enabling context for risk management and support effective use in order to meet the objectives and to ensure that risk management does not become a paper tiger. Top management should take risk-based decisions. It should feel responsible for the effectiveness of risk management and its being 'fit-for-purpose' (Hillson and Simon 2007, Well-Stam, Lindenaar et al. 2007, ISO 2009).

4.1.2 Strategy and policies

Organizational structure in the form of strategy, procedures and policies defines the lines of authority and communication and enables to allocate tasks and resources whilst providing a means of coordination. It predetermines the way employees work. Structure and processes of an organization are most effective when their design functions match their environment and when they have a positive impact on the organization's strategies (Hunter 2002).

Strategies and policies with regard to risk management are described in the framework. An explicitly formulated framework, setting clear objectives and guidelines, enables the organisation to internally and externally communicate, coordinate tasks and responsibilities which enhances effective risk management (Crawford 2001, Bosler 2002). In order to decide on the appropriate level of risk management applied in projects, it is important to integrate a formulated risk management sizing tool into the framework (MacGillivray, Sharp et al. 2007).

An organisation does good by tailoring the risk management strategies and policies to fit the existing working structure and by taking into account the culture of the organisation (Hillson and Simon 2007, ISO 2009).

Since the internal and external environments are dynamic and risk management is most effective when its design function matches the environment in which it operates, the frequency of analysis, monitoring, reviewing and reporting should be in line to ensure that organisations or project objectives with regard to risk management are met. Therefore, the strategies and policies should be audited on a regular basis (Chapman and Ward 2003, Zou 2010, Hopkinson 2012).

Strategy and policy involves clarifying which party should take the responsibility of risk, which steps should be taken in a project's risk management process or by the organization and which tools and techniques to use. They should also include the strategy with regard to the project reserve for risks, the risk appetite of the organisation and the lines of communication (Hoseini 2017).

4.1.3 Culture

According to Hofstede (2001) culture is defined as: "*the collective programming of mind that distinguishes the members of one group or category of people from another".*
Hofstede says that culture consists of shared values, ideas, thoughts and feelings and is transmitted by symbols and behaviour. Consequences of beliefs, attitudes and skills influence thoughts, emotions and actions. Culture with regard to risk management addresses the attitude of project personnel towards it. This involves the extent to which risk events are openly communicated within the organization, the attitude of personnel towards risk management, the current way of working etc. Knowledge transfer requires individuals to openly interact, exchange ideas and share knowledge. An open culture is an important enhancer for effective risk management (Loosemore 2000, Yeo and Ren 2009).

4.1.4 Personnel knowledge

Effective risk management largely depends on the employees responsible for it. The presence of experts to support and teach others and the availability of training in the organization are important facilitators for it. Important questions to address are whether people involved in risk assessment truly understand it, whether they are able to describe risks according to risk management Meta language and whether and how experienced they are in performing similar projects. Ideally all of these questions should be answered with 'yes' (Hillson 1997, Öngel 2009, Hoseini 2017).

4.2 Application process aspects

As mentioned in the previous chapter, the risk management process is a structured, cyclic process. It actively integrates a learning effect and communication and interaction are essential. The methods reviewed describe a similar risk management application process:

1. Determine the risk analysis objectives / set up risk management;
2. Risk assessment
3. Risk treatment
4. Monitor and review
5. Tools and techniques

In the next sections each of the steps will be described in more detail.

4.2.1 Determine the risk analysis objectives and boundaries

In order for risk management to be effective, its objectives in relation to the project should be defined, agreed upon and documented in a risk management plan.
Since there is not a "one size fits all" application of risk management and because the depth of risk management depends on the project, it is advised to decide on an appropriate level of applying risk management, for example with the help of a project sizing tool. In the risk management plan several points should be discussed, some of which some are listed below:

- The responsibilities (risk manager is process,- and discipline-responsible and project leaders are content-responsible);
- The risk register (dynamic document, integral register of risks)
- Risk categories (geographic, discipline, project phase);
- Risk scoring classes (scoring classes for semi-quantification, project specific based on % of construction, maintenance, time, costs);
- Risk threshold / appetite level (which risk levels are acceptable)
- Periods between risk analysis and updating of risk register;
- Risk reservation (cost/time contingency).

4.2.2 Risk assessment

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation (ISO 2009). In this subsection these steps will be further explained.

Risk identification

Risk identification is the process of finding, recognizing and recording risks.
The purpose here is to identify and describe all known risks and opportunities that might affect the achievement of the project's or organization's objectives (Hillson and Simon 2007, ISO 2009, Nicholas and Steyn 2012). Risk identification is not only the identification of the risk itself but also the identification of its causes and potential consequences (ISO, 2009). There are several techniques that can help in improving the accuracy and completeness of risk identification. These are: brainstorming, assumption and constrain analysis, interviews with stakeholders, use of risk checklists, scenario analysis etc. IEC/ISO31010 describes some 30 techniques.

RISMAN highlights the importance to identify risk and opportunities from different perspectives. These different perspectives comprise: technical, organizational, zoning, political/administrative, legal/ legislative, financial/ economic and social/ community connected-based. Other categories are:

- PESTLE (Political, Economic, Social, Technological, Legal, Environment)
- PESTLIED (Political, Economic, Social, Technological, Legal, International, Environmental, Demographic)
- TECOP (Technical, Environmental, Commercial, Operational, Political).

The involvement of important stakeholders allows for a broader perspective.

In order to perform risk identification effectively, the following input is required: the risk management plan, project objectives and the scope of risk management, a work breakdown structure, planning, cost estimations, risk checklist, etc.

Attention should be paid to the clear formulation of risks in order to avoid confusions between cause, effect and risk. The ATOM methodology gives a practical and normative risk meta-language, that consists of a three part structured description of a risk. The use of this meta-language, which separates cause, effect and risk, avoids confusing these three parts.

According to ATOM a risk should be described as follows: "As a result of <definite cause>, <uncertain event/risk> may occur, which could lead to <effect/impact on objectives>". (Hillson and Simon 2007). This format allows to clearly distinguish between cause, risk and effect and this improves the allocation of control measures.

Risk analysis and evaluation

ISO mentions that there is a certain overlap between identification, analysis and evaluation and, therefore, calls these steps together the risk assessment. In the analysis step the identified risks are separated by cause, effect, consequence and probability in order to develop an understanding of the risk so that each can be prioritized and control measures can be determined. The risk analysis results in:

- Understanding of the causes, consequences and probabilities;
- Prioritized and categorized (initial) risk list. This involves risk quantification based on the organization's risk matrix.

In the risk analysis, quantification is essential for prioritization and as input for probabilistic calculations. There are three approaches, which can be used to quantify risks:

- Qualitative;
- Semi-quantitative;
- Full Quantitative.

A good tool for qualitative risk analysis is the BOWTIE tool. Figure 22 shows that this tool allows for a good representation and understanding of what the risks actually comprise. The 'bow-tie' diagram provides a pictorial representation of the relationship between risks, initiating events, controls and consequences. Visually separating the initiating events /causes from the risk itself and its consequences improves the understanding of the actual risks and allows for easier communication by management, engineers, and other personnel. The key here is to break down a risk event to a level on which the initiating events became clear; the same applies for the consequences. One of the most frequently made errors is not breaking the risk down far enough. The ATOM risk management meta-language in combination with the bowtie method contributes to a good risk analysis.

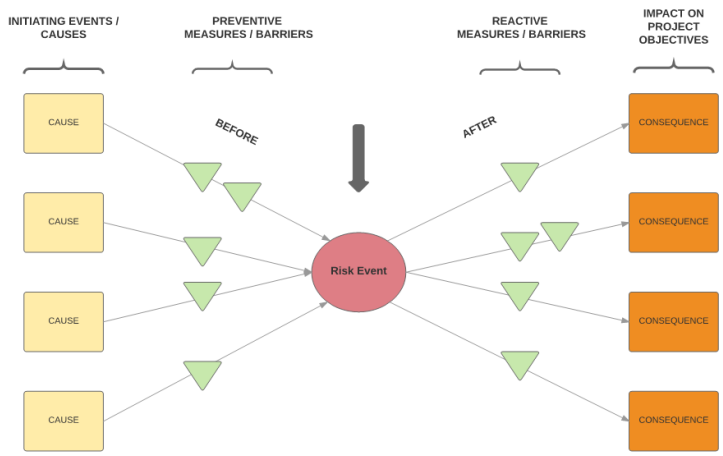


Figure 22: BOWTIE Method

A full-quantitative analysis - the goal of which is to calculate the total project risk - can be performed for the control aspects 'time' and 'costs' with. In doing so values have to be determined for:

- Probability, set %
- Direct costs, estimation of €
- Time, estimation of working days
- Estimate of probability distributions

Risk analysis leads to the understanding of risk events, their initiating causes and their consequences on project objective, and opportunities. Doing a risk analysis always requires having a clear understanding of the project objectives. After risks have been analysed, resources to the most important ones can be allocated.

4.2.3 Risk treatment and mitigation (Plan and implement control measures)

Once the risks and opportunities that can harm or benefit project objectives have been identified, analysed and prioritized, preventive, detective or reactive measures can be determined, planned and implemented. The reason for this is to reduce the probability of the risk occurrence, to reduce the consequences of the risk event when it materializes or to select detective measures for better control (Hillson and Simon 2007, ISO 2009).

Building a bowtie allows to understand a risk and to come to a better selection of tailored control measures. The construction of a bow tie starts with the main risk event. In order to understand the causes of the risk event, the question 'but why' should be asked until either the answer is "it just is", or "it is out of the project influence". Only then have the causes of the risk event been reached. The process of assessing the impacts follows a similar pattern (Tattem 2013).

The methods are in line with that it is important to allocate an owner to each risk, which will largely improve the risk control process. Not appointing an individual owner but leaving the risk under the responsibility of a group instead may well lead to a situation where nobody feels responsible.

Selecting the most appropriate risk treatment option involves balancing costs and efforts of implementation against benefits of the control measure. The ratio has to be favourable. The resulting costs and time have to be adapted in the overall project budget and planning (ISO 2009).

Even when control measures have been defined, there will most likely be residual or secondary risks resulting from the response. These should be considered and quantified as well and, if needed, controlled. Other response strategies to threats and opportunities are presented in Figure 23.

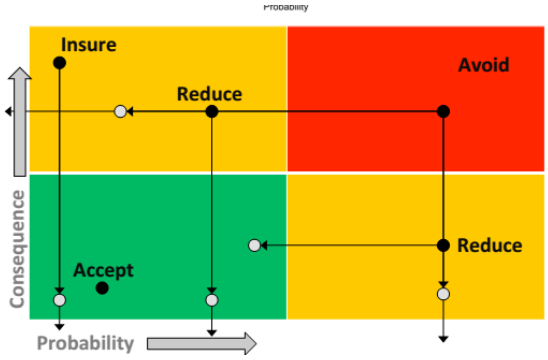


Figure 23: response strategies

4.2.4 Monitor and review

Although this step is the last one, the risk management process is a continuous process and this step can thus be seen as the starting point for yet another cycle (ISO 2009). To be able to respond to risks and thereby controlling them, indicators for earlier identified and possible new risks should be tracked (Nicholas and Steyn 2012).

The goal of monitoring and reviewing is to ensure that control measures are effective and efficient in both design and operation and to identify new risks or delete closed risks. Regularly monitoring and reviewing the implemented risk management strategies, allows to derive learning points, near misses, changes, successes and failures from actual events, (ISO 2009).

Nickolas & Steyn advice that risks once identified should be added to a risk register. After ranking, the most important risks should be tracked for indicators throughout the project. Someone has to be given the responsibility to track and monitor the risk.

According to ATOM, conducting this process one-off will not ensure that risks are effectively managed throughout the project life. ATOM claim that it is essential to maintain momentum throughout the whole project life cycle. This can be achieved by a series of activities, such as: reviewing all current risks and determining their status, identifying, describing and assessing new risks, selecting owners and responses, updating the risk register and project plan with the account of risks and drafting and distributing a risk report for project reporting.

Post project review and report

Post-project reviews are important and offer a structured mechanism for capturing lessons from previous projects that can be applied to new ones. However, it is also observed that post-project reviews are one of the least well-performed parts of the project life cycle (Hillson and Simon 2007).

4.2.5 Tools & techniques

In this section different tools and techniques that can be used to support performing risk management in practice are described. Note that the list of possible tools is much longer than the ones described here. The tools and techniques described in this section are based on the reviewed methods, respectively ISO 31010 (2009), Nicholas & Steyn (2012), Hillson and Simon (2007), and RISMAN (2007). The list is provided in the Appendix.

ISO (2009) suggests to use scenario analysis in the early phases of the project in order to identify risks by considering possible future developments and exploring their implications. Scenario analysis can assist in making policy decisions and planning future strategies.

Hillson & Simon (2007) recommend using a structured brainstorm session, analysis of assumptions and constraints, and a risk checklist in a workshop to identify the first risks. The checklist allows identifying the most common risks that were identified in previous projects. A structured brainstorm session helps to find new risks and opportunities that could occur. Another tool is the assumption analysis. With assumptions being uncertain, these need to be analysed as well. Hillson & Simon (2007) advise to assess the risks in a qualitative way, prioritize them, and, if required, do a quantitative analysis.

A consequence/probability matrix combining qualitative and quantitative data in order to produce a level of risk or risk rating is advised for all sizes of projects. The format of the matrix, including definitions used and should be in line with the context in which it is applied. The strengths of this technique are that it easy to use and that it provides a rapid ranking of risks according to different significance levels. However, there are also limitations to this technique: the matrix does not allow to tailor it to the context (project size), it is difficult to define unambiguous scales and the use is very subjective, leading to a significant variation between raters (ISO 2009).

For larger and more complex projects probabilistic estimations based upon a Monte Carlo simulation can be performed.

In monitoring and reviewing the control it is important to identify changes related to the project and to track and review risks, effects and control measures on their effectiveness. Hillson & Simon (2007) advise to do this by means of regular meetings.

Also here the term ‘fit-for-purpose’ is applicable. Only tools that are usable and add value should be used, and therefore a trade-off should be made between the usability of the outcome and the input required. The information from the tools and techniques (output) is only valuable if it’s accurate, timely and truthful.

4.2.6 Communication and systems

Communication is an essential part of risk management. Lack of information and communication between stakeholders is a barrier for its effectiveness. Without communication and sharing information, risk management cannot be fit-for-purpose. Communication is important both for the quality of the process and for the improvement of the risk management framework (ISO 2009). The process should be communicated to internal and external stakeholders timely, with the right amount of documentation and quality to assist these stakeholders in their decision making process.

Evaluating and improving the risk management process on a regular basis is vital and involves communication and process information. It is recommended to put a well-documented information system for the entire risk management process in place so that risk and control measures are traceable over time. Communication of results should be understandable for everyone.

As it can be seen in Figure 21, communication and information is required at all times and among all disciplines. The documents created for the framework and as part of the process should be made fit-for-purpose and add value to the organisation or project.

Serpella (2014) argues that the way in which knowledge and information is used, is often a failure factor to achieve effective risk management.

4.2.1 Relation between ideal risk management based upon literature and the risk maturity model

The division of the main aspects in this research largely overlap with the findings of Hosseini. This allowed the maturity model of Hosseini to provide extra guidance during the empirical analysis (interviews and document investigations) on the practices performed by Dutch regional water authorities. Since the model has not been used before, and in this thesis will be used for the first time, also feedback will be given on the model in order to make the model better. The relation between the ideal risk management described in the previous chapter and the maturity model is summarized in Table 5

Table 5: relation between ideal risk management conform literature study and the risk maturity model.

Main aspects	**Ideal risk management based on literature study [aspects]**	**Maturity model [aspects]**
Organisational aspects	Top management commitment	Top management commitment
	Culture	Culture
	Personnel knowledge	Personnel knowledge
	Policy and strategy	Policy and strategy -
Application & process	Determine the risk analysis objectives / set up risk management	
	Risk assessment	Risk assessment
	Risk treatment	Risk treatment
	Monitor & review	Monitor & review
	Post project review	

4.3 Conclusion on ideal risk management

The previous chapters have captured the essence of project risk management by analysing the different methods described in literature. Hence, based on this information the first sub-question can be answered.

1 *How should risk management within projects ideally governed according to literature?*

General

Ideally, risk management should be made fit –for-purpose to the organization and/or project in a systematic continuous process. Risk management strategies and policies should be tailored to fit to the existing working structure and should take into account the culture of the organisation. The support of risk management by top management is considered to be among its Critical Success Factors. Management facilitates effective risk management by creating motivation and awareness, providing the necessary resources including training, appointing responsibilities, forming procedures and policies and ensuring continuous learning within the organization. As the effectiveness of risk management largely depends on the experience and motivation of personnel towards performing it, positive stimulation by top management is key.

The risk management application process consists of several iterative steps: 1. determining the risk analysis objectives and set up risk management plan; 2. identifying and analyzing risks; 3. planning and implementing control measures; 4. monitoring and reviewing control measures, post project review. It is important to analyze and update risks during the different phases of the project. For this, several tools and technique are available. The output of the risk application process should be used as input for cost estimation, planning and contract and tender strategy. This process, too, should be made fit-for-purpose and tailored to the existing work structure in order to be effective and add value. Information and communication of risks created within the process should be shared in order to ensure effective controlling of risks and decision making. It is advised to add ways of communication to the risk management plan. It is also recommended to use a risk register - that is updated after each step of the process - and to hold post-project reviews in order to learn from the process and project.

A commonly made error resides in faulty description of risks, causing events and consequences. These are often mixed up and consequently not fully understood, which in turn results in ineffective risk management. The BOWTIE tool helps to overcome this shortcoming and allows for the clear representation of a risk's event, it's root causes and its consequences and controls. This improves clear communication.

Communication is important and is required in all steps of risk management, in order to make risk management fit for purpose until communicating about the results of risk management. Since risk management is not a one-size-fits-all but rather fit-for-purpose, the organisation should think about at what point risk management is fit-for-purpose, how it adds value, how it can be made most effective and how to tailor management procedures to organizational needs. An open communication is vital in order to make risk management fit-for-purpose.

Risk management is divided into two main aspects, which are in turn divided into sub-aspects. This breakdown of risk management improves understanding and is the starting point for analysing the risk management adaption by Dutch regional water authorities in practice. Also this will be done along the lines of three main aspects.

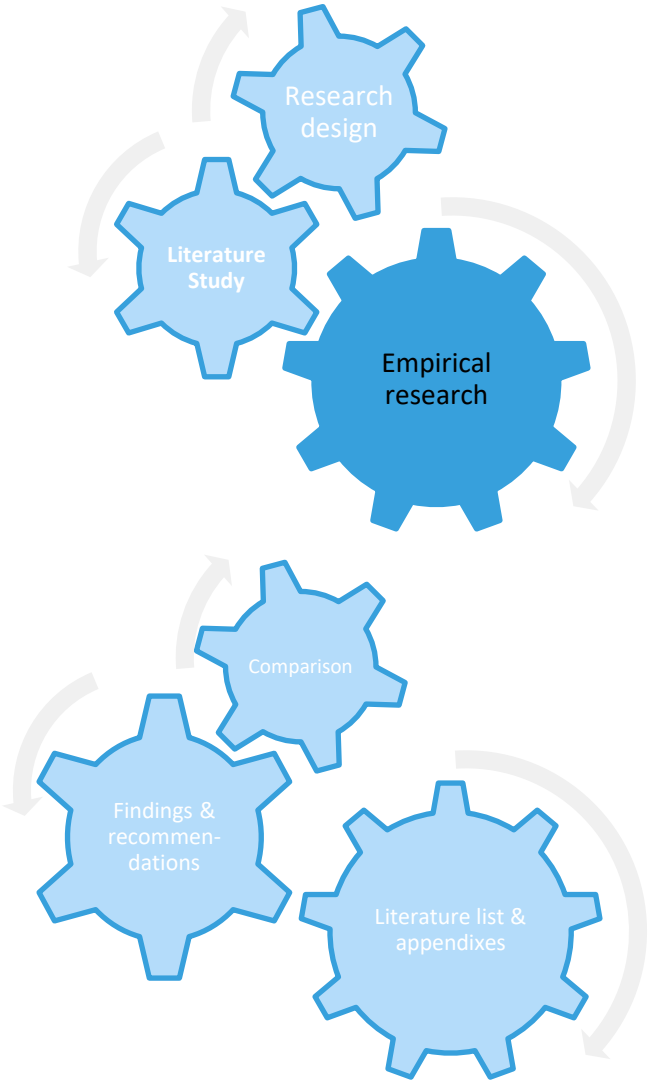
Organizational aspects:

- management commitment towards risk management;
- the strategy and policies that the organisation or project team follow in applying risk management;
- Culture;
- Personnel knowledge

Application and process aspects:

- Determine the risk analysis objectives / set up risk management;
- Identify / update risks;
- Analyse and evaluation of risks;
- Plan and implement control measures;
- Monitor and review of control measures;
- Post project review and report findings.

Empirical study



5 Risk management in practice

In order to gain an integral in-depth understanding of the current situation, both semi-structured interviews and document analysed in combination with the risk maturity model of Hoseini (2017) were used. This chapter elaborates on risk management in each of the projects. The full results of the model can be found in appendix B, the full interviews can be found in appendix C.

5.1 Analysed projects

The insights on current practices was obtained by analyzing three different infrastructural project executed by the Regional water authority. One of the three projects analysed is executed within the (HWBP), the other two are in house (HHSK) projects. The two types of projects differ because projects under the HWBP are partly financed by the HWBP, whereas the in house projects are entirely funded by HHSK. The projects vary in size, complexity and assets involved. Projects analysed, documents and team members are summarized in Table 6. Each project is shortly described in the subsection of this section. The selection of projects was based on the following criteria:

- Willingness and availability of the project personnel to talk openly
- Way of financing (internal vs external);
- Project size and complexity;
- Project organisation.

Table 6: Overview of analysed projects, documents and interviewed project members of HHSK

[-]	**Analysed documents** [-]	**Interviewees** [-]
Project A	Input dashboard risk management, Risk dossier, Activiteitenplan (AP) Opstellen en beheren risicomanagement Deelplan projectbeheersing	Risk manager (7) Project manager (6) Manager project control (5)
Project B	Project start up (project contract), Voortgangrapportages; Risk dossier, SSK raming. Kostenrapport watersystemen	Project manager (2)
Project C	-Voortgangraportages wegen & wegbruggen -Risico dossier project wegen & wegbruggen	Project manager (3) Manager project control (4)
General	-Projectmanagement 2011 -Reader kosten ramingen; -Bijlage B, Inhoudelijke eisen voor het opstellen van (SSK) ramingen, behorend bij PvE; -Programma van eisen voor (SSK) ramingen voor het HH; -Risico database -memo uitgavenpatroon en risicoreservering; -Boekje projectmatig werken; -Leidraad Projectplannen waterwet; Financieringsregeling	Head of department IPP (1) (Ex) project manager (8) Managing director (9)
validation	-	Expert 1 Expert 2

5.1.1 Project A

This project is part of the HWBP in which, based on new safety norms against flooding, part of the Hollandse Ijssel dike 'Dijkring 15 ', between Gouderak and Krimpen and den Ijssel (10km) needs renovation. The project is complex because of dwellings alongside the dike and because the dike is also an important infrastructural link between Gouderak and Krimpen an den Ijssel.

The project is divided into three phases; exploration phase, detailing phase and realization phase. The current phase of the project is the exploration phases (2015-2018) in which different alternatives are analyzed. The result of this phase is an 'Voorkeursalternatief', which will be further detailed in the next project phases. The costs of this phase are estimated at +/- 18 million euros, whilst total project costs are estimated at around 200 million euro. 90 % of project costs if funded by the HWBP. The water board receives the subsidy based on an SSK (p50) cost estimation. Next to this a risk reservation can also be requested. The subsidy is being paid per phase as a lump sum, meaning that the water board is risk owner. However, procurement risks and risks for regulation changes are for the HWBP.

The project team consists of a full IPM team including and own risk manager.

Figure 24: overview of the dike project

5.1.2 Project B

The second project consists of constructing a new water pumping structure. Based on new norms and climate scenarios, and in order to prevent water problems with high peak intensity rainfall, the water system of the 'Zuidplaspolder' was updated on several points. One of the structures that helps preventing water problems in this location is the new water pumping station. The project is executed between 2013 and 2016.

The project is a typical water authority project and stems from the department water systems and was executed by project department IPP. The project is low in technical and environmental complexity. Project cost are around 2,2 million euro. The project team consists of one project leader that procures the different aspects of the project (design, estimation etc.). The responsibility for the risk management process is for the project manager.

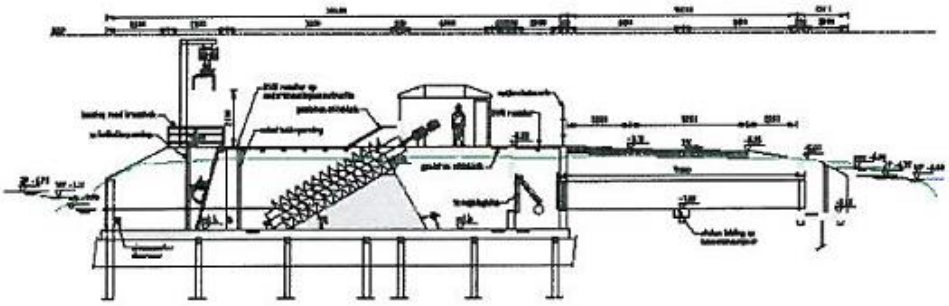


Figure 25: Pumping station

5.1.3 Project C

Programma Reconstructie Polderwegen 2017 consists of two road reconstructions and of life extending maintenance on two other roads. The duration of the project is estimated at 2 years, including preparation. These measures require and investment of 1.73 million euros. The project is a low on complexity and planned for execution next year. The project team consists of an IPM light team with one project manager and one manager project control. The manager project control is responsible for the risk management process.

Figure 26: Programma reconstructie polderwegen

5.2 Project risk management organization at HHSK

In order to comply with responsibilities of water system- and water chain management, the water authority formulates long-term visions and goals (meerjarenplannen). Infrastructural water systems have to be maintained and updated periodically, resulting in a request for adjustment, replacement or renovation of a typical infrastructural structure. It is out of these responsibilities, vision and goals out of which projects originate (HHSK 2011). The project initiation usually comes from the departments Water Systems, Wastewater Treatment and Water Retaining Structures and roads (problem owner). After the initiation phase the project assignment is passed on to a project leader of the department "Integrale Plannen en Projecten" (IPP). The problem owner formulates the problem, objectives and requirements. Ideally, one of the project leaders of the IPP-department should be involved already in this phase.

Within HHSK, IPP is an internal project management department, which focuses specifically on project management. Projects are executed on behalf of the various primary departments of WS. The departmental head of the respective department often fulfills the role of project assignor. At the start of a project, at project acceptance by the project leader, the boundary conditions are defined in consultation with the assignor.
Project leaders – who execute projects as a discipline - form a project team consisting of WS-personnel and external parties with different disciplines/knowledge types (technical, juridical, financial etc.). External knowledge brought in mainly relates to the areas of design, cost estimation, contracts and contract supervision.

Conducting risk management within projects is part of the overall project approach and, thereby, one of the responsibilities of the project leader. Within IPP no strict rules or guidelines are in place as to *how* risk management should be done. There is, however, an agreement in place that it *should* be done and reported back via internal progress reports to both the project assignor and the board. In reality, the way in which risk management is applied shows large variations.

The projects within the WS differ in size, complexity and way of financing (subsidized vs internally financed projects) and so does the setup of risk management. Large (HWBP) projects have an integral project management (IPM) team, which consists of a project manager, manager project control, stakeholder manager, technical manager, contract manager and also an own risk manager. Within this project team set up risk management and its process is the responsibility of the risk manager and the manager project control. Smaller projects are either fully led by the project manager or in some cases an IPM-light (where the five roles are divided among less people) is applied. This implies that in such smaller projects the responsibility for all facets of the project, including risk management, is allocated to one or two roles. However, the execution of risk management process is the responsibility of the entire team.

HWBP financial regulations also influence risk management usage. HWBP regulations create a supportive environment for risk management as integral part of project management. The HWBP regulate that WS are allowed to request a risk reservation based on a substantiated risk dossier. This creates an extra motivation to build up and maintain the risk register. Within the in-house financed projects, the risk reservation in not always based on a substantiated risk register but either on a fixed percentage or no risk reservation at all. This is because before a project can start, credit has to be requested at the general board of control. Usually, for internal projects this is done by the assignor. Credit for the execution of a project is requested based on preliminary project information. After approval of the daily board of control the credit is allocated to the project and the project can start. This means that the reserved money is predetermined, and it happens that no room for risks is accounted, which creates a different setting for the project leader and risk management.

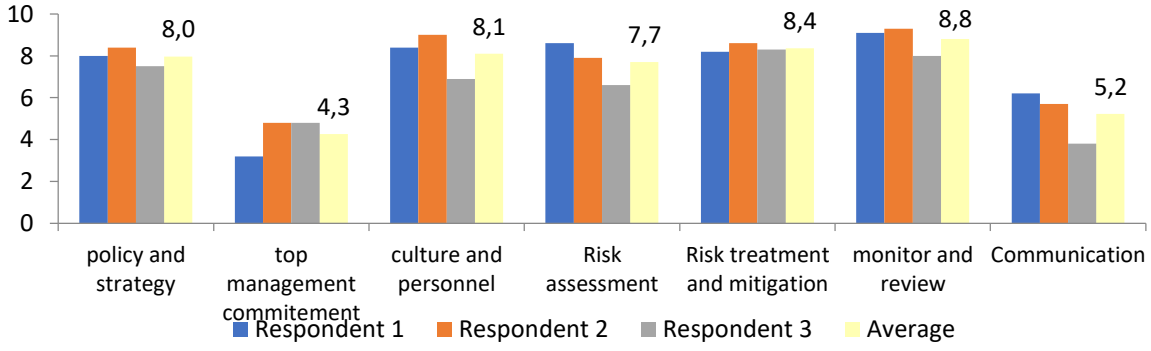
In the current set up it is seen as unwanted to allow a large risk reservation for the in-house financed projects. This is because it is found unwanted to hold a risk reservation on each project because this brings higher costs if it remains unspent. The focus is more on giving just enough money to execute the project. This means that the estimated project costs do not always include a risk reservation based on a substantiated risk dossier and that in this respect risk management differs from the HWBP projects. The alignment between projects and risk reservation can be improved by an early involvement of the IPP department in the calculations of future projects, ideally with requesting money at the board (before the initiation phase).

5.3 Risk management in Project A

The risk management practices for project A are in this section described based on the findings of the model in combination with the knowledge gained during the interviews and observations.

5.3.1 Summary results model project A

As can be seen in Figure 27 the respondent scores of the GRMM model were overall high for most aspects, except for top management commitment. The high scores of the respondents for the aspect **strategy and policy** indicate that personnel, time and energy are dedicated to performing risk management in the project. The results indicate that risk management is integrated in the project management approach and that the objectives of risk management are well understood and documented, indicating that the project has a risk management plan on how to execute risk management. The respondent results indicate that procedures to report on risk management to internal and external stakeholders are determined and that there is a formal procedure to determine the risk reservation for the project. Results indicate that **top management commitment** can be improved. Within the project team the necessity of risk management is understood and there is an experienced person responsible for it (**culture & knowledge).** The results of the model show that the overall **risk assessment** aspect is on a high level of professionality. Risks are described by cause, type, consequence, status and owner. They are quantified in time/money based on the risk matrix for the project and are stored in the risk register (**treatment and mitigation).** Control measures for the risks are based on the 'reduce' strategy. Cost and time of the control measures are considered in the project budget/schedule, residual risks are quantified and together form the risk reservation of the project. In the project there is focus on applying control measures. The **monitoring and review** aspect is also scored high by the respondents, indicating that the status of risks, control measures and all related information is updated regularly. The results show an average score on the **communication** aspect. The full results can be found in the appendix (model results).



σ(std)	0,37	0,75	0,88	0,83	0,3	0,57	1,03

Figure 27: Risk management scoring overview project A

5.3.2 Discussion model results and interview/observation findings

The results of the model show a good score on almost all aspects. The high score for policy and strategy indicates that risk management is integrated into project management approach, the high score on culture and personnel knowledge indicates that the project team is risk aware and stands positively towards performing risk management, the high score for risk assessment indicates that risk assessment has taken place and that time and effort have been put into treatment and mitigation of risks and monitoring and reviewing. Based on the average results shown in Figure 27 of section 5.3.1 it looks like project risk management is overall well performed in this project.

Interview and observations confirm these results. At the start of the project, the project team really thought about how to make risk management an integral part of project management and how to deal with it. The team agreed on fixed risk session intervals and responsibilities for the risk management process. They thought about how to keep track of control measure implementation, how to let risk management be part of project control and they documented this. Besides managing risks, opportunity sessions are also performed.

In the project regular updates are held and integral sessions are performed. The risk manager performs reviews with individual role keepers on a monthly base and discusses the status of the control measures (e.g. how they currently see the world, whether there are new risks and if risks have materialized). Based on this information all cost/schedule documents are reviewed and updated. Next to the monthly meetings, the entire team meets twice a year with important project phase shifts.
The risk register has a well-defined structure and addresses almost all aspects that are mentioned in literature. For each risk identified the following is mentioned: date of the identification, risk ID, WBS element nr, risk owner, description of initial risk, causes and consequences, allocation of the risks (client/contractor), quantification (in terms of time, money, quality) of initial risk, the control measures, their status and who is responsible for the them, the residual risk after control measure in terms of estimated time delay and estimated cost reservation. There is also a section which lists the fired risks and the resulting costs, which makes it clear which risks have happened

The risk register forms the basis for the construction of the PPI (Project Planning Infrastructure) and the SSK cost estimation. Financial risks are included in the cost estimation and time is included in the planning. By doing this the consequences in time and money are largely controlled. Although the risk itself is not being controlled, there is a clear ownership of the control measures. Control measure activity is integrated into the daily work 'activiteitenplan' of the risk owner and this - in combination with the monthly feedback loop – leads to a situation where risks are well controlled.

Project updates are held on a regular basis and also integral sessions are performed. The risk manager performs reviews with individual role keepers on a monthly basis. He discusses with them the status of the control measures, their current view on the world, new and fired risks. Based on this information all cost/schedule documents are reviewed and updated. Besides the monthly meetings with all role keepers the entire team meets twice a year with important project phase shifts.

According to the risk manager of the project, lessons learned from other projects within the HWBP are integrated by negotiation with project leaders of previous executed projects. The lessons learned resulted in the current way of organizing the project. The lessons learned from previous project were integrated at the start op project A only.

5.3.3 Deviations between model and interview/observations project A

Overall the model results matches with findings during interviews and observations. However, the following results did not match the interview and observation findings:

Secondary risk

Although the statement about secondary risks received respondent high scores, they are in reality not considered in the project. Secondary risks are defined as risks that arise from implementation of an agreed response strategy to the basic risk (Hillson and Simon 2007). The respondents thought the statement was about the risk after control measures.

Cost/time of residual risk is considered as cost/time contingency

The statements received low/average scores in the model, however in reality one of the main goals of the entire risk analyses (next to mitigation by control measures) of this project under HWBP, is to determine a cost and time contingency (risk reservation). Therefore, in reality this score should have been 'completely applied'. The respondents did not understand the term contingency.

Cost/time contingency for unforeseen risks based on the complexity of the project.

The statements received low/average scores in the model. However, part of the SSK estimation, in accordance with the HWBP financial regulation, 5% to 10% of the direct costs is maintained for risk reservation in relation to the complexity of the project. Therefore, high scores should have been given. The respondents did not understand the term contingency.

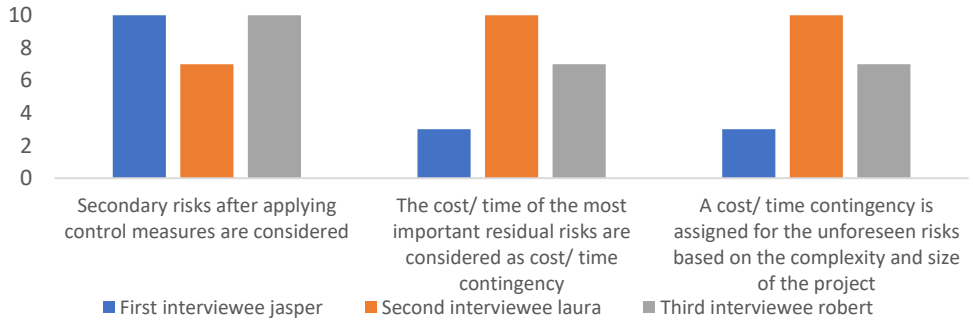


Figure 28:Deviating scores

5.3.4 Summary and areas for improvement project A

There is a clear strategy towards risk management. The project team created a plan because they felt it was needed with so many people working on it. Project risk management is integral part of project management. Risk management information is used in the planning, in determining the scope, in financial estimations, in environment management. There is a good focus on implementation of control measures and updating the risk file. The team is risk aware and finds it important. There are regular risk sessions. The project forecasts are updated on a monthly basis, the internal client 'opdrachtgever' is informed and involved on a monthly basis; if needed, important risks are escalated. Lessons learned from other projects are implemented into important project decisions. The overall importance for risk management is understood and supported by the organisation.

Although lessons learned from other projects are integrated at the start of the project, during the observation period no other project teams or project leaders were invited to talk about their problems, how they solved it in their projects, and which things this project should look out for. Also the model results show low scores on this aspect.

However, inter-project learning is vital for a cyclic program as the HWBP in which similar projects are executed, because it is important to learn from other projects in the HWBP (kruisbestuiving). Working on a project for several years with a fixed group of people can result in several group phenomena that can create unwanted side effects like tunnel vision and groupthink (Newell, Robertson et al. 2009).

"Thinking about risks is a discipline on its own, you have to take distance and be able to look from a broad perception, think in different scenario's, through different project phases. Sometime you realise that you set out a line with the team and that lots of information has been explained away You develop a tunnel vision with your project team, and it might be good to ask different project leader or an experienced consultant for a review, but this does not happen. – Respondent 2

Improvement areas

Based on the GRMM low results (risk maturity model) summarized in Table 7 , interviews and observations several detailed improvement / attention areas can be pointed out. The following improvement areas are identified:

- Include more Key externals (besides the key internal stakeholders) in the process;
- Continue involvement and reviews from other (internal) project leaders in risk sessions;
- Continue to meet with other project teams in the HWBP, invite other project teams, ask other teams for lessons learned (create learning points from other projects in the HWBP program). Looking at only end results of other projects is not learning;
- Start with inviting execution knowledge into the risk analyses (do not only look through the eyes of an engineering company);
- Let an external risk expert critically assess the project risks before important project

phase shifts and decisions are due (look for 'missed angles');

- Weigh the potential benefits vs the cost of the control measures, and select a strategy. It might be overall more beneficial to accept certain risks.
- Decide per risk a control measure based on different strategies (reduce, avoid, transfer, and accept);
- Take in account a risk threshold level;
- List the cost of control measures;
- Assess if the benefit of control measures outweigh the cost of them;
- Identify & asses secondary risks.

Table 7: Overview of the lower scored statements by project members on policy and strategy

Aspect	Statement	Respondent & score			
[-]	[-]	1	2	3	Avrg
Policy & Strategy	The risk appetite of the project is defined and documented	3,0	3,0	0,0	**2,0**
	The risk appetite document of the project is internally communicated and available	3,0	3,0	0,0	**2,0**
	The procedure for deciding risk reservation is based on the defined risk appetite of the project	3,0	3,0	0,0	**2,0**
Top management commitment	Management communicates goals and strategies of risk management within the project	0,0	0,0	3,0	**1,0**
	Management uses risk management reports to make decisions	0,0	3,0	3,0	**2,0**
	Management defines roles (with authority and accountability) to perform risk management process within the project	0,0	3,0	3,0	**2,0**
Risk assessment	Key external stakeholders (besides the key internal stakeholders) participate in risk identification	3,0	3,0	3,0	**3,0**
	Important risks for treatment and mitigation are identified based on the risk appetite of the project	7,0	3,0	3,0	**4,3**
treatment & mitigation	Per risk a control measure based on different strategies (reduce, avoid, transfer, and accept) is defined	3,0	3,0	3,0	**3,0**

5.4 Risk management in Project B

The risk management practices for project B are in this section described based on the findings of the model in combination with the knowledge gained during the interviews and observations.

5.4.1 Summary results model project B

For this project respondent scores were lower than for other projects. As can be seen in Figure 29, the **policy and strategy** aspects scored below six, indicating that limited effort and resources (personnel, time and energy) are committed to performing risk management and that the project has a limited risk management plan. Also in this project **top management commitment** received low scores, indicating that top management commitment can be improved. The necessity of risk management was understood, an experienced person was responsible for it and there was openness and trust in reporting risks (**culture & knowledge).** The overall **risk assessment** is performed on a satisfactory level, indicating that risks are identified and described by cause, type and consequence and that they are quantified on the risk matrix. However, lower scores for the risk **treatment and mitigation** indicates that the treatment and mitigation of risks is underperformed. Also, low scores for the **monitor and review** aspect indicate that the status of risks, control measures and other related information is not updated regularly. The **communication** aspect received a lower score from respondents, indicating that the communication of risk management related information can be improved. The full results can be found in the appendix B.3.

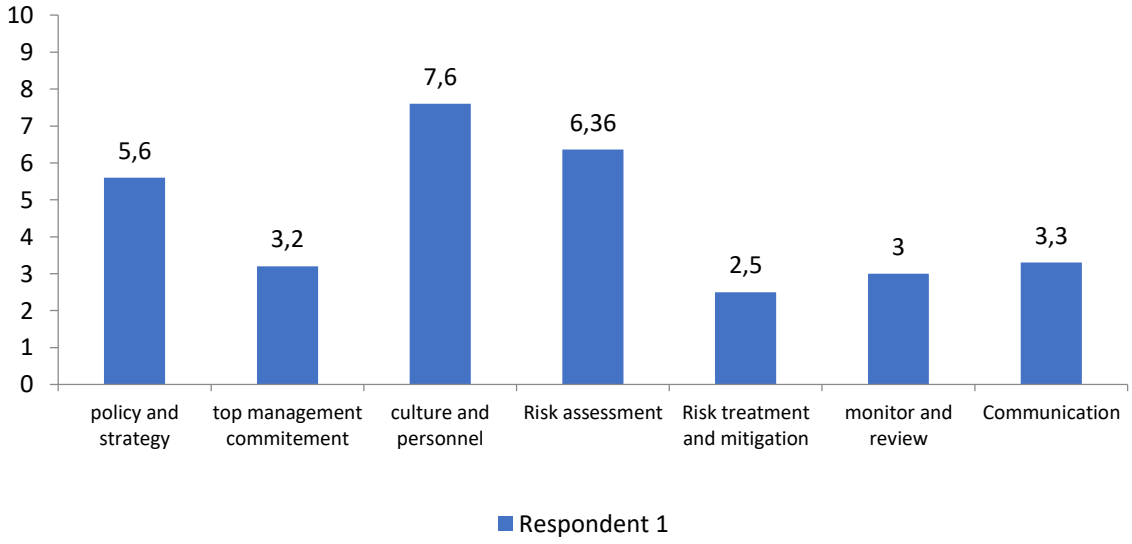


Figure 29: Risk management scoring overview Project B.

5.4.2 Discussion model results and interview/observation findings

As can be seen in Figure 29, risk management aspects that score particularly low are: risk treatment and mitigation (score 2,5) and monitoring and review (score 3,3). Also strategy and policy does not score high (5,6), nor do Communication and top management commitments. The latter will be discussed in section 6.2 since these are more related to organization than to project. Only risk assessment and cultural and personnel knowledge scored well, respectively 6,4 and 7,6. According to the model, risk management underperforms in this project. The strategy and policy part scored low because respondents gave low scores for statements related to risk appetite, procedures to report to external and internal stakeholders, having a documented risk management plan / process and not having procedures for deciding on risk reservation. The risk treatment & mitigation scored low because of not considering the costs/time of control measures and the residual risks and reserving a cost/time contingency for them. The score for applying control measures was also low. The monitoring and review aspect scored low because of low scores for not updating the status of control measures and risks in the risk register, not adding new risks and not updating the probability and consequence of active risks in the risk register. (See full scorings in appendix B).

Based on observations of the risk register and discussion with the project leader it is acknowledged that the above did indeed not take place. According to the project leader, it concerns an average-size, not too complex project within the water board. Right from the start it is very clear what the top-10 risks are and how to mitigate them. The project leader already implicitly integrates the mitigation measures within the work of the project and therefore, it is less important to quantify the residual risks and other elements of the model. He recognizes the importance of a risk assessment at the start of the project and acknowledges that it is important to look at the project from different perspectives, to have a good consensus with the internal client about what should be done and what is important and if it is realistic in term of time/costs. He also mentioned that risk management in projects of this size resides entirely with the project leader himself and therefore, updating the risk register sometimes not happen because of priority setting. He also mentioned that risk management should not become a paper tiger.

> *"The biggest risk in my opinion is that the assignment is not clear. And that we are start working on it. I have seen projects in the past of which it was not clear what the scope was and if the given time and money was realistic. But people said 'oke we are going to do it' and then you saw that these project run out on all sides. As a project leader you do good by really investigating the assignment and see if it all fits within the given time and money and to understand what is important for the client. – Respndent 2*

5.4.3 Deviations between model and interview/observations

Within project B some deviations are noticed between the model results and what has been discussed during the interviews/document observations. These are discussed below.

Risk management objectives are defined and documented

The model results indicate that the risk management objectives are defined and documented. However, no formal risk management plan or strategy towards the adaptation is created for the project. The project leader implicitly knows the objectives of risk management and also performs in this way.

Per risk a control measure is based on a strategy (reduce, avoid, transfer, accept) is defined.

The score of the model indicates that strategies were explicitly chosen, however document observation revealed that in the risk register no explicit formulation of strategies is noted.

Lessons learned are recorded:

The scores indicate that a project review has been performed. However the project leader explicitly stated during the interview that such review has not been carried out.

Risk are communicated to the relevant contractor

The model score indicates that the risks identified have not been communicated to the contractor. However, during the interview and within the risk register, it is explicitly mentioned that as a control measure some risks were communicated. Therefore, this score should actually be higher.

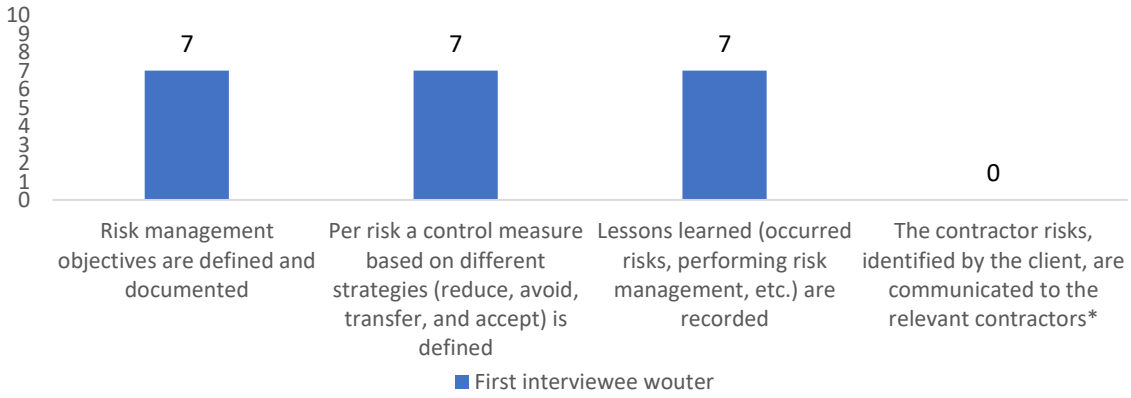


Figure 30: deviating scores project B

5.4.4 Summary and areas for improvement project B

Based on the model results and observations it is found that risk management in this project is somewhere in between being implicitly and explicitly used. At the start of the project there was an integral risk session and the risks are summed in the risk register, however a clear strategy towards risk management is missing. Based on literature it is advised to create a risk management plan at the start of the project (Hillson and Simon 2007).

It can be questioned if it is wise to make a risk management plan if the project team is the project leader. This would increase the paper work and workload (paper tiger). However, the risks should be put in the risk register and updated regularly. The reason for this is of a pure practical nature: what if the project leader decides to leave the project and a new project leader comes in? He will not know what the risks are or how they are being controlled? Risk management literature says that project risk management should be fit for purpose and should not be a paper tiger (Hillson and Simon 2007) (Well-Stam, Lindenaar et al. 2007).

There should be some general framework on how large to set up risk management within these average size projects and when to update it, but this should be dealt with at department level and will be further discussed in section 6.2. Conclusion: 1) it is a low complexity project, 2) an integral risk session at the start resulted in a situation where the project leader had an clear view on the risks in the project, 3) housekeeping of the process after risk assessment is performed less efficiently and 4) The project leader understands the necessity of risk management and finds it important.

Based on the GRMM low scores summarized in Table 8 (risk maturity model) and interviews and observations several improvement areas were pointed out. These are:

- Establish the context / Decide if it is needed to make a plan how to set up risk management at start project;
- Determine and consider the cost/time of the control measures and the residual risks in project cost/time (treatment & mitigation);
- Allocation of risk ownership and applying control measures, connect individual persons to the risks and control measures to assure effective response to the risks (see section 4.2.3 of ideal risk management);
- Perform regular minor reviews and update the risk management information on a more regular basis (risk status, status of control measures) (monitor & review);
- Make sure that VGR and risk registers match;
- Discus the project risks during the progress meetings with internal clients;
- Include knowledge of key externals;
- Share lessons learned with other project leaders.

Table 8: Overview of the lower scored statements by project members on different aspects

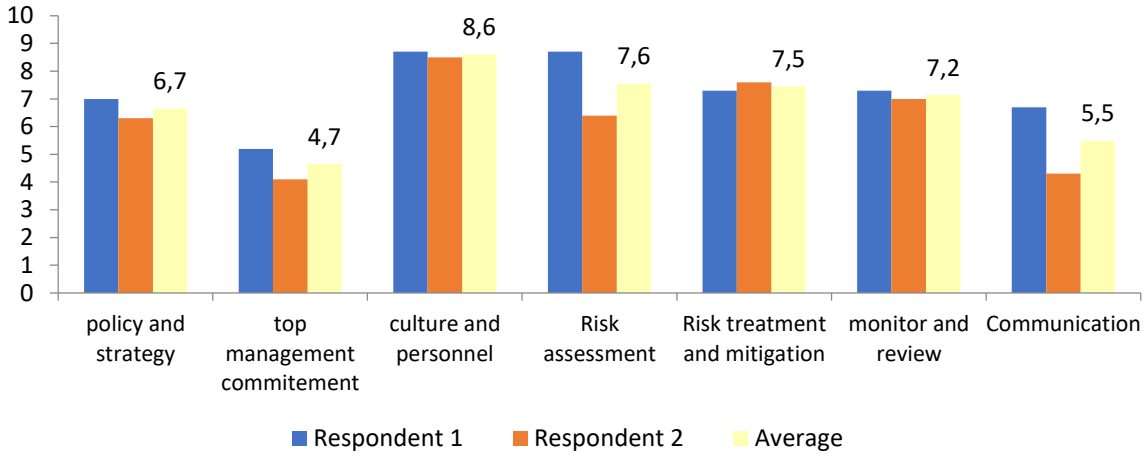
Aspect [-]	**Statement [-]**	**score [-]**
Policy & Strategy	The risk appetite document of the project is internally communicated and available	**0,0**
	The project has a documented process for risk management	**3,0**
	The project has procedures to report risk management to external and internal stakeholders	**3,0**
	There is a procedure for deciding risk reservation in the project	**3,0**
Top management commitment	Management encourages and supports risk management within the project	**3,0**
	Management communicates goals and strategies of risk management within the project	**3,0**
	Management uses risk management reports to make decisions	**3,0**
	Management defines roles) to perform risk management process within the project	**0,0**
Risk assessment	Key external stakeholders (besides the key internal stakeholders) participate in risk identification*	**3,0**
	There is a risk owner (either internally or externally) for each risk who is responsible for that risk	**3,0**
Treatment and mitigation	The costs/time of control measures are considered in the project costs/schedule	**0,0**
	Residual risks after applying control measures are quantified and considered	**0,0**
	The cost/ time of the most important residual risks are considered as cost/ time contingency	**0,0**
	A cost/ time contingency is assigned for the unforeseen risks based on the complexity and size of the project	**0,0**
	Control measures are applied	**0,0**
Monitor & review	Status of risk and control measures are updated	**3,0**
	New risks are added to the risk register and the previous steps are repeated for the new risks	**3,0**
	Cost/schedule documents are updated based on the status of risks	**0,0**
	The entire monitor and review process is based on the project risk management process	**0,0**

5.5 Risk management in Project C

The risk management practices for project C, are in this section described based on the findings of the model in combination with the knowledge gained during the interviews and observations.

5.5.1 Summary Results model

This project was given overall satisfying scores by respondents, except for the aspect top management commitment. Respondent scores for the aspect **strategy and policy** indicate that personnel, time and energy are dedicated to performing risk management. Risk management seems to be integrated in the project management approach; the objectives of risk management are understood and documented, implying that the project has a predetermined plan on how to execute risk management. Results indicate that procedures to report on risk management to internal and external stakeholders are determined. There is an indication that **top management commitment** can be improved. Within the project team the necessity of risk management is understood and there is an experienced person responsible for risk management (**culture & knowledge).** The results of the model show that the overall **risk assessment** aspect scores on a satisfactory level. Risks are described by cause, type, consequence, status and owner. They are quantify analyzed in time/money based on the risk matrix for the project and are stored in the risk register (**treatment and mitigation)**. Control measures for risks are all based on the 'reduce' strategy. A reservation for the residual risks in time and costs is in place. The **monitoring and review** aspect is also scored highly by the respondents, indicating that the status of risks, control measures and all related information is updated regularly.



σ(std)	0,5	0,78	0,14	1,6	0,22	0,22	1,78

Figure 31: Risk management scoring overview Project C

5.5.2 Discussion model results and interview/observation findings

The results of the model show a good score on almost all aspects. The good score for policy and strategy indicates that risk management is part of project management and that risk management is performed. The high score on culture and personnel knowledge implies that the project team is risk aware and stands positively towards performing risk management. The high score for risk assessment indicates that risk assessment takes place and that time and effort is put into treatment, mitigation, monitoring and reviewing of risks. Based on the average results shown in Figure 31, it looks like project risk management is overall well performed in this project.

Based on the results of the model, interviews and observations, it can be concluded that the project team performs risk management on a professional level. The expertise of a consultant company to assist with the risk analysis has been brought in. At the start of the project it was planned to do risk sessions (analyses) at project phase shifts. And this was indeed done according to the initial plan; during the project a total of three risk sessions was held, attended by the internal project team (PL/MPB) and the consultancy; knowledge of the f external environment was also brought in.

In the risk register there is an extensive list of risks and corresponding control measures. This indicates that there is an overall good understanding of the risks within in the project.

However, attention should be paid to the both the formulation of risks and to ownership of risks and control measures. In the risk register no personal ownership is allocated. Risks are only described on organizational level. On top of that the list includes risk described in a very vague way (how can trees be a risks?). Good responses require identifying a (single) risk owner (making a group responsible means that no one will be responsible) and making risks clear in formulation in order to assure effective management of them. No action list was found in which the activities/control measures were allocated to which individual risk/action holder. The risk after control measures is quantified and an overall risk reservation is determined. However, this sum of residual risk was eventually not used as a risk reservation for the project. Instead a fixed percentage, lower than the sum of quantified residual risks, was used as a risk reservation in the budget.

The overall importance of risk management is well understood by the project members and they find is both useful and interesting to do. According to the respondents it is vital to include the project environment in the risk analyses by holding public discussion meetings.

5.5.3 Deviations between model and interview/observations

Within project B some deviations between model results and what has been discussed during the interviews/document observations were observed. These are discussed below.

Risks are identified, causes and consequences are described in the risk register

Both respondents give high scores for this statement and indeed the risk register contains a extensive list of risks, consequences and causes. However, there is no clear risk meta-language used in the register. Inspection of the risk register revealed that sometimes questionable risks are described (e.g. how can trees be a risk)?

Risk ownership

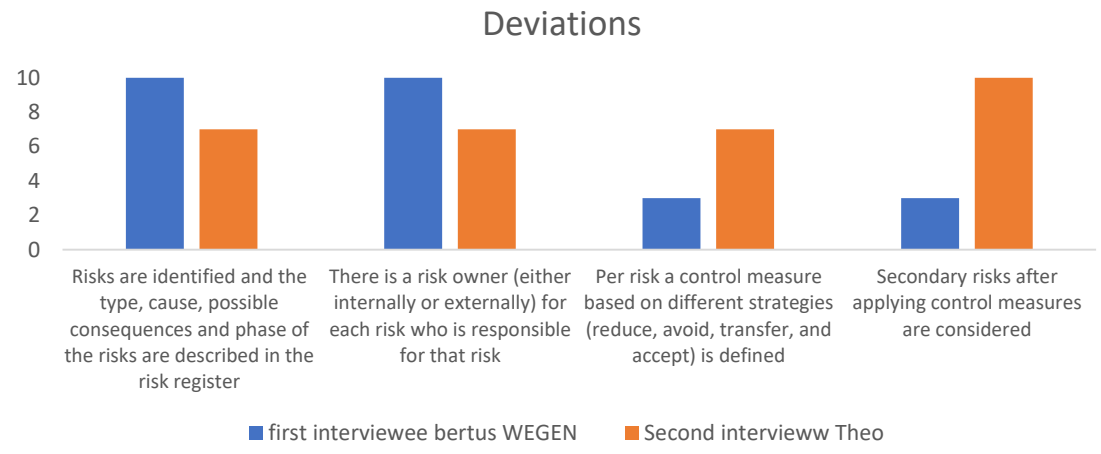
Both respondents give high scores for allocating risk ownership. And indeed risk owners are identified but only on organisational level. However, literature recommends to allocate risk ownership on an individual basis as making a group responsible does not result in one person being and feeling responsible.

Risk strategies

The respondent scores show a deviating score on strategies regarding the selection of control measures. In reality no different strategy on risk level was used other than reduce by control measures. The strategy avoid, or accept is not applied. However, on project level the overall sum of residual risks was larger than the actual reserved reservation. This means that some overall financial risk is accepted.

Secondary risk

Although the statement about secondary risks received high scores of the respondent, in reality the secondary risks are not considered in the project. Secondary risks are defined as risks that arise from implementation of an agreed response strategy to the basic risk (Hillson and Simon 2007). One of the respondents thought the statement was about the risks after control measures (residual risks).



5.5.4 Summary and areas for improvement project C

Based on the model results and observations it is concluded that overall risk management in this project is performed on a professional level. At the start of the project the project members discussed how to set up risk management and decided to request assistance from an engineering consultancy company. This means that the project team is aware of the need to think in risks and also spends resources and energy on it.

A total of three integral risk sessions were held. The risk register contains an extensive list of risks and for each risk e control measures have been formulated, which indicates that there is an overall good understanding of the risks within in the project. The overall importance of risk management is well understood by the project members. They find is both useful and interesting to do and allocate recourses to conducting risk management. According to the respondents it is vital to include the project environment in the risk analyses by holding public discussions. Conclusion: 1) it is a low complexity project, 2) three integral risk sessions allowed for a clear view on the risks, 3) housekeeping is performed efficiently with the use of an engineering consultant and 4) the project team understands the necessity of risk management, and finds it important and commits recourses to it.

Based on the GRMM(risk maturity model) low scores summarized in Table 9 and interviews and observations several improvement areas were pointed out. These are:

- Clarify the procedure for deciding risk reservation in the project;
- Use risks-meta language in order to have a clear understanding of the risks and to assure effective response (see section4.2.2) (Risk are not described in a clear way; risk, cause consequence);
- Connect individual persons to the risks and control measures to assure effective response to the risks (see section 4.2.3 of ideal risk management);
- Perform one 'risk sparring session' with an (external) risk expert before tendering to see if all important risks have been taken into consideration.
- Use the HHSK Standard instead of consultancy standard;
- Include knowledge of key externals;

Table 9: Overview of the lower scored statements by project members on policy and strategy

Aspect [-]	Statement [-]	Respondent score		
		1	2	Avrg
Policy & Strategy	The risk appetite of the project is defined and documented	3,0	3,0	**3,0**
	The risk appetite document of the project is internally communicated and available	3,0	3,0	**3,0**
	The project has a database for collecting the information about risk management	3,0	3,0	**3,0**
	There is a procedure for deciding risk reservation in the project	3,0	3,0	**3,0**
	The procedure for deciding risk reservation is based on the defined risk appetite of the project	7,0	3,0	**5,0**
Top management commitment	Management communicates goals and strategies of risk management within the project	3,0	3,0	**3,0**
	Management uses risk management reports to make decisions	3,0	3,0	**3,0**
	Management defines roles (with authority and accountability) to perform risk management process within the project	3,0	0,0	**1,5**
Risk assess-ment	Per risk a control measure based on different strategies (reduce, avoid, transfer, and accept) is defined	3,0	7,0	**5,0**
Monitor & review	Cost/schedule documents are updated based on the status of risks	3,0	7,0	**5,0**
	The outcome of monitor and review process is documented and communicated to internal and (if needed) external stakeholders	7,0	3,0	**5,0**

5.6 Cross project analyses

Figure 32 gives an overview of the project scores across the analyzed dimensions. The dimensions scores are elaborated below.

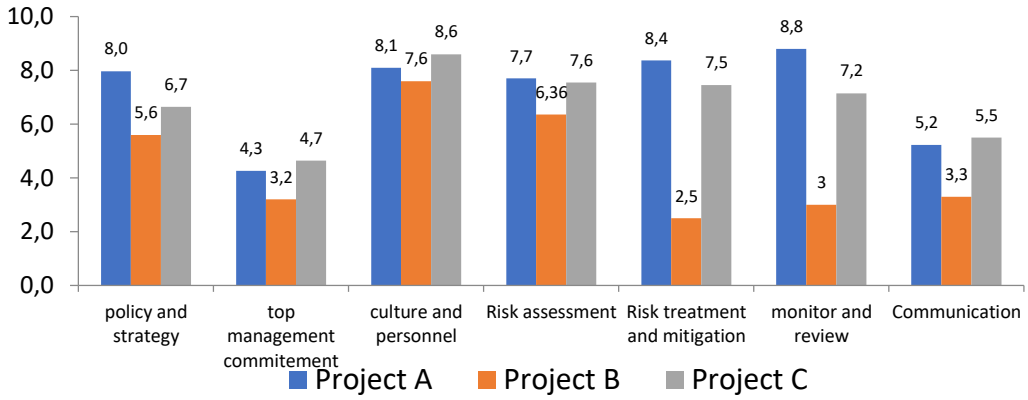


Figure 32: Risk management scoring across projects

The dimensions 'Policy and strategy' scores for risk management differs across projects, with scorings of 8.0, 5.6 and 6.7 for projects A, B and C. As mentioned in paragraph 5.2 there are no strict organizational guidelines (rules) in place for structuring risk management within projects. The most extensive strategy towards risk management is found in Project A.

The scores for 'top management commitment' are relatively constant across all projects. In all cases this aspect received low scores of 4.3, 3.2 and 4.7 for projects A, B and C respectively. (Note that top management is being defined as the department heads / project assignor.) . These low scores were given because management does not clearly communicate goals and strategies of risk management and consequently, project teams feel that the managers do not always take decisions based on risk management reports.

'Culture and personnel knowledge' received overall high scores of 8.1, 7.6 and 8.6 respectively. This reflects an overall positive culture/view on risk management within the projects. There is an open culture in reporting and negotiating on risks and the personnel's knowledge on risk management is at a sufficient level.

The first step of the risk management process, Risk assessment' was performed within all projects analyzed. The scores for projects A, B and C were 7.7, 6.4 and 7.6 respectively. Performing a risk assessment is likely to result in a good overview of the risks for each of the projects. The risk registers of the projects confirm this. Each project has an extended risk register which consists of several risks; each risk is described by cause and consequence, and is quantified in terms of monetary value and in time.However, across projects, risk ownership differs. In project A there is an individual risk owner for each risk, which assures ownership. Within project B limited allocation of risk ownership is applied and in project C risk ownership is only allocated on company level.

The scores for 'risk treatment and mitigation' differ among projects and are 8.4, 2.5 and 7.5 respectively for projects A, B and C. Compared to project B, projects A and C score relatively high on this aspect. There are several reasons for this difference in scores: project B did not explicitly consider the costs and time of control measures in the project planning and estimation and the residual time/costs of risks after control measures have not directly been translated into the project planning and estimation. This was, however, done in projects A and C.

The scores for 'monitor and reviewing' differ across projects, and are 8.8, 3.0 and 7.2 respectively for projects A, B and C. Also on this aspect Project A and C receive an overall good score whereas project B scores lower. The lower score for this aspect is mainly due to the lower scores for regular updating the risk register and the project planning and budget based on updated information. Unlike for project B, this was done on a regular basis for projects A and C.

The scores for 'communication' are relatively constant across all projects. In all cases this aspect received low scores of 5.2, 3.3 and 5.5 for projects A, B and C respectively.
This underpins that top management does not communicate on goals and strategies of risk management and that the risks are not always discussed during progress meetings with the internal client.

6 Discussion

This chapter discusses the findings of the interviews and observations on risk management in the regional water authority, including the risk management performance in the three different projects. In section 6.1 an answer is given to the second sub question of this research: "*How do Dutch regional water authorities perform risk management in project in practice?*"

This should contribute to answering the main research question of this research, which will be further addressed in the conclusion.

6.1 Overall view on project risk management performance based on the analysed projects

Based on the findings of previous researches, which concluded that risk management is either non existing (Scholten, 2007) or has to be completely developed as part of project steering and control (Taskforce ten Heuvelhof, 2010), It was expected to see an organisation that either did not know what project risk management was, did not perform risk management in their projects, or that did not take performing risk management seriously. It was expected that it would be easy to give recommendations on risk management based on literature. However, It has to be concluded that reality differs from initial expectations.

During this thesis three projects were analysed by using a risk maturity model, semi-open interviews and (document) observations. Visible is an organisation, which is aware of the necessity to think in risks and finds performing project risk management important. The organization supports and allows the project team to spend resources and time on performing risk management within the projects. Project workers received RISMAN training, there are lines of communication established for risk management information and these are integrated into existing work processes (VGR's , Projectcontract). Also, there is an overall understanding that performing risk analyses in projects is needed and beneficial. This view is supported by the high scores for the aspect culture and personnel knowledge, respectively; 8.1, 7.7 and 8.6 for project A,B and C.

Thinking in terms of risks is part of the history and culture of the WS organisation. This is underpinned by core activities such as 'safety against flooding', 'being prepared for a changing future' and 'public orientation'. The history and the resulting culture results in a risk aware organisation in which the necessity and importance of performing risk management in projects is naturally understood. The other side of the culture is that the WS organisation is also a risk averse organisation, which has implications on the overall project management. Taskforce ten Heuvelhof has insufficiently considered this 'risk averse' cultural aspect during the creation of the new HWBP financial regulations. These implications of the financial regulation and its effect on risk management performance are further discussed in section 7.5.

Throughout all the projects analysed, elements of risk management were found. The level of applying risk management (number of risk sessions, the extent to which risk management is integrated within project management, housekeeping, risk reservation) differs per project, but so do the size and complexity of the projects. Literature and experts recommend that risk management should be applied whilst considering that during risk management the use of resources must be justified. The risk management process should be fit for purpose and therefore, the level of project risk management applied in project B should not by definition be the same as the be the same as in project A.

During the interviews it became clear that the uncertainty on how large to set it up risk management in projects, in combination with no real clear instructions from the top management results in uncertainty. This then at times (could) negatively affect the risk management performance in projects. Model results where deviating scores for the aspect Strategy and policy between projects and an overall low score for top management commitment is observed underpins this observation. Low scores for the statements '*Management communicates goals and strategies of risk management within the project'* and '*Management defines roles to perform risk management process within the project'* are seen across the projects. This particular aspect with regard to the uncertainty on how large to set up risk management will be further discussed in section 7.3.

> *"There is no instruction or guideline on how to deal with risk management, as a project team you decide how you fill it in, and because there is no control if you actually do it, it can lead to not paying attention to it' – Respondent 2*

As has been mentioned, all projects analysed contained elements of the risk management process. Each project organized at least one integral risk session during the start-up phase and project risks were assessed from different perspectives /different disciplines. Risks that can affect the project objectives were identified and described by cause, consequence and probability and were prioritized. Model results confirm this view with overall satisfying results for the aspect Risk assessment, respectively; 7.7, 6.4 and 7.6 for project A, B, and C.

In the large HWBP (project A) most effort is put into the set up and execution of risk management. The project team really thought about how to let risk management be part of integral project management and how to deal with it as a project team. Clear agreements on risk session intervals, responsibilities, implementation and tracking of control measures and information to put in the risk register were made. The entire team performs two integral risk sessions per year. During project phase shifts an integral risk session is also held. Next to that, the risk manager examines the project risks and status of control measures with the IPM role keepers and updates all risk management information on a monthly basis.

The risk register of this project is the most extensive of the ones evaluated. It has a well thought of structure which contains almost all aspects mentioned in literature. Each risk identified has a risk owner, describes the initial risk, causes and consequences, is quantified (in terms of time, money, quality), describes control measures and their status, states whose responsibility they are and pinpoints the residual risk after control measure in terms of estimated time delay and residual cost consequences. Within project A, project risk management is an integral part or project management. Risk management information is used in the planning, in the estimation, in determining the scope, and in environment management and will be used in the marketing strategy and contract phase.

Also for smaller to average size projects such as project B and C, risks that can affect the project are identified, assessed and response strategies are determined and implemented. For all projects a risk register consisting of an extensive list of risks is set up. This indicates that there is an overall good understanding of the risks within the projects. Risks are described by cause, consequence and probability and control measures are assessed and implemented. However, for such smaller projects keeping momentum in updating the risk register and repeatedly holding big integral risk sessions is harder. Planning an integral risk session in which all internal stakeholders participate is found difficult and even unwanted. According to the project leader of project B it is not desirable to have more large integral risk sessions and attention should be paid not make it bigger than necessary.

One of the differences between the HWBP project and the internal projects – besides the amount of resources spent on applying risk management in the project - is that the internal projects work with a fixed percentage risk reservation based upon the context in which the project operates. Project B, did not quantify the residual risks. Project C chose to deviate from the sum of quantified residual risks. In the HWBP project however, the risk reservation is based upon the sum of quantified residual risk.

Conclusion: especially in the large HWBP projects, risk management is performed at a professional level at this particular WS and is integral part of project management. In all projects, recourses are committed to it, risks are identified, control measures are selected and performed and time and cost contingency is reserved for the financial control of risks. Risk management is also part of overall project management. Its necessity is well understood and performing risk management within the projects is supported. Throughout the projects the size of how large risk management is set up differs, but this is in line with literature that recommends that performing risk management should be fit-for-purpose.

Several improvement areas have been identified. Sections 5.3.4, 5.4.4 and 5.5.4. will further elaborate on the improvement areas on project level. The improvement areas on organisation level are described in sections 6.2 till (and including) 6.4. The discussion of the consequences of the HWBP financial regulation and its potential improvement areas are further discussed in section 6.5.

6.2 Top management commitment & communication

Within the waterboard top management are both internal clients (opdrachtgever) and department heads. Respondents scored the aspect 'top management commitment' low throughout all projects. The scores show a clear trend. The statements *'Management communicates goals and strategies of risk management within the project'* and '*Management defines roles (with authority and accountability) to perform risk management process within the project'* were given low scores by all the respondents in all projects. And the statements '*Management encourages and supports risk management within the project'* and *'Management asks for risk management information and reports'* scored highly.

It is quite striking is that Project A & C are rated as 'top priority' projects by the top management. They receive more attention for performing risk management, which is clearly visible in the results of the model. So there is a relation between how important the project is found by the top management and the attention that is paid to performing risk management. As discussed in section 4.1.1 top management commitment is considered to be among the critical Success Factors for project risk management.

According to the interviewees there is no direct steering or clear instruction on how to perform risk management within the projects. Also, no control of whether or not risk management is performed is in place. It is for a large part up to the project team to decide on how to set up risk management. Within average size projects like projects B is, there is no extra mandate available to assist on the risk management process. According to head of the department there is indeed uncertainty on how large to set up risk management in relation to the project size. This will be further discussed in the section 6.3

According to the respondents, internal clients do stimulate risk management by quarterly asking for the risk status in the projects via the progress reports that have to be filled in. However, the respondents also argued that especially with the average size projects this never leads to a real conversation between the internal client and the project leader. During the interview with the director and the internal client this indeed became clear. The reason resides in the workload of internal client, who not only guides several projects but also has a department to manage. This refrains him from paying equal attention to all projects.

Improvement areas

Maintaining momentum (updating) in performing risk management can be a challenge for average-sized projects, because both the project leader and the internal client sometimes pay too limited attention to it. The advice that is given in section 6.3 will stimulate the project leader in such projects to critically think about risks and will at the same time reduce the workload of the top management.

Considering the above the following recommendations are given:

- Put in place a guiding framework that allows matching the project size with the set-up of risk management (see section 6.3 for an initial proposal);
- Implement control measures to assure risk management is performed, for example only allow a project to shift phases if a risk analyses is performed;
- Assure that communication /interaction between project leader and internal client is integrated in the risk management process as this will motivate the project team;
- Explicitly define how risk management on project level can be made "fit-for purpose" during the project kick-off session.

6.3 Uncertainty on how large to set up risk management

Based on the interviews with project members, with department's heads and the director, it was discovered that there is uncertainty in how large to set up risk management in relation to the size of the project and that there is no clear guidance how or if to perform it. In the current situation there is no steering involved from managers on higher level, in the way the risk management process is set up. It is up to the project leader or project team to decide.

> *"There is no instruction or guideline on how to deal with risk management, as a project team you decide how you fill it in, and because there is no control if you actually do it, it can lead to not paying attention to it' – Respondent 2*

Not setting no clear guidance of procedures has both positive effects as negative.
It allows for creativity and innovation. (Newell, Robertson et al. 2009) argues that the management of projects is knowledge-intensive and requires high knowledge workers. The author stated that high knowledge workers and knowledge intensive work requires a form of independency and freedom and organizing as an adhocracy fits this type of work. Direct control characterized by supervision, and coordination through explicit rules and procedures which is a form of bureaucracy organization is not effective for managing high knowledge workers and high knowledge work.

However, literature on risk management says that setting clear objectives and guidelines, enables the organisation to internally and externally communicate, coordinate tasks and responsibilities which enhances effective risk management (Crawford 2001, Bosler 2002). Hunter (2002), states that the structure and processes of an organization are the most effective when their design functions match their environment. And also other authors see that applying risk management in a project should be in accordance with the size of the project (Hillson and Simon 2007). And also I concluded that project risk management should be 'fit for purpose'. Because projects differ in size and complexity, no one best management practice will exist, it always requires weighing the costs of the level of risk management set up vs the possible benefits.

Recommendations

Considering the above the following recommendations are made:

- Put in place a guiding framework that allows matching the project size with the set-up of risk management (see below for an initial proposal);
- Explicitly define how risk management on project level can be made "fit-for purpose" during the project kick-off session.

It may sound contradictory to create a framework on how to set up risk management in a project versus allowing creativity and innovation in deciding how to organize it. However, both sides perceive this as an uncertainty and therefore, a basic framework that allows project members to decide what is fit-for-purpose seems reasonable.

"We are uncertain on how large we should set up risk management in smaller projects" – Respondent 1

(Well-Stam 2004) argues that in order to perform effective project risk management, it should be integrated into existing work processes. Therefore, the project risk management-sizing framework is based on the existing differentiation of project size and complexity of the water board organization. The sizing framework is summarized in Figure 33 and can be found in the appendix.

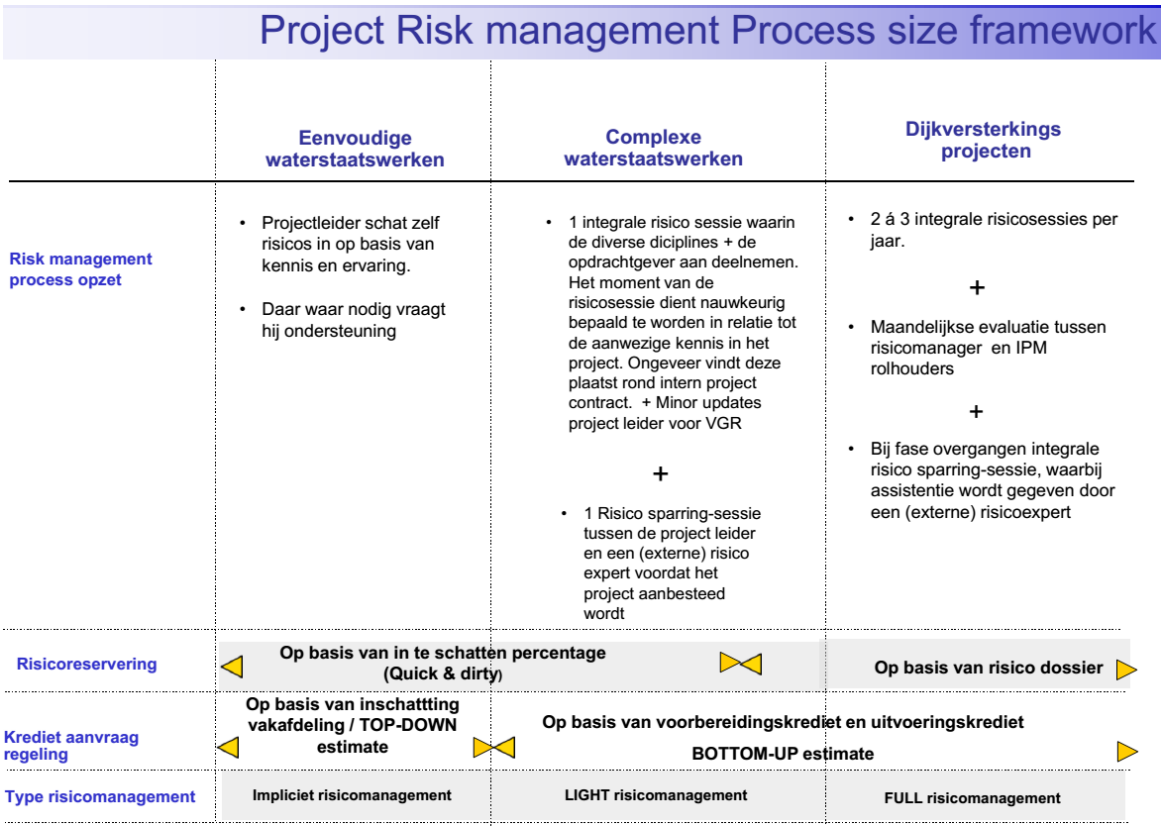


Figure 33: RM sizing framework

6.4 Sharing knowledge across projects

Project-management methodologies recognize the importance of inter-project learning and including best practices aimed at exploiting knowledge that is gained during the project. Typically this consists of maintaining project documentation and project learning reviews. (Raelin 2001). Literature on risk management acknowledges the importance of post-project reviews and to hold meetings on lessons learned, in which these are discussed, reported and documented (Hillson and Simon 2007) (Well-Stam, Lindenaar et al. 2007).

According to the interviewees there is a risk register on department level in which all risks of all projects can be collected and shared. The interviewees also state that after projects there should be a project learning review in which the knowledge and learning is captured in a "lessons learned" report. This indicates that the organization has recognized the importance of cross-project learning. However, they also indicate that currently this register is not being used. According to the interviewees it is just not workable, because risks are described on such level that they are not usable in their own projects, they are not updated and, therefore, they simply do not use them. The interviewees also state that capturing lessons learned, especially for internal projects, is not always done.

(Newell, Robertson et al. 2009) acknowledge that exploiting knowledge that arises from projects is not easy. They condense three important criteria in relation to successful knowledge exploitation from projects: 1) knowledge must be created at the project team level, 2) the team must be knowledgeable enough to realise that relevant knowledge beyond their own project exists and that it could be useful for them, and 3) documents that have attempted to capture the 'lessons learned' must be useful to others. However they also state that these criteria are often not satisfactory, because there is limited project learning, lack of awareness that there is knowledge available, and – when the knowledge is captured - it is often not the most useful knowledge for other projects to learn from.

Taking the above in consideration the following recommendations are made:

- Assure that the general risk register is brought to the attention and only list those risks that actually fired in previous projects. Link them to the 'lessons learned' report;
- Learning points formulated should make a split between specific content-related learnings and process,- and/or organizational learning points; the latter may have a longer 'shelf life'
- Make capturing 'lessons learned' the responsibility of the project leader (maak & haalverplichting).

6.5 The current HWBP financial regulation and its effect on the risk reservation

The goal of the HWBP is to strengthen the entire infrastructure system against flooding before the year 2050. This should be done with effective use of money, meaning an optimum price per kilometre of dike.

The new financial regulation of the HWBP was introduced and implemented by the ministry of infrastructure and environment (I&M) on April 1st, 2014. It replaced the old HWBP-2 financial regulations, in which 100% of costs for strengthening the primary dikes under supervision of the WS was subsidized by the ministry of I&M (Het Rijk). This change was made because the costs of the HWBP were running out of hand (see the introduction of this thesis).

The new HWBP financial regulations introduced a new dynamic into the system, because costs were no longer fully subsidised by the ministry of I&M as under the HWBP-2. In the new financial regulations the costs are co-financed by the HWBP and the WS. There is a combined/shared 'dijkrekening' payment account in which the WS together put in 40 % and het Rijk 50%. The remaining 10% consists out of a project-based share. This 10% share has the purpose to stimulate effective use of the money in the projects.
This means that with a new project the WS receive a 90% subsidy out of the shared account (HWBP) and the rest they pay themselves. If the WS fall short, no recalculation is performed; the WS is the risk owner. The WS request the money by delivering a plan for the project and a P(50) SSK estimate for projects larger than 40 million (see section 2.5.1 till 2.5.3) and they can request a risk reservation based on a substantiated risk register in order to compensate for possible risks. The risk reservation consists of the sum of average residual risks and an unforeseen reservation (5-10% of the direct costs). (Ministerie_van_Infrastructuur_Milieu 2014).

Ideally the project cost exactly match the cost of the estimate with the HWBP (het Rijk) paying 50% of the project costs the WS paying the other 50%. But what about the risk reservation? The system is based on a bonus-malus system. This means if short of money, the WS pay themselves, if money is left, it remains with the WS. This was decided under the umbrella of 'The one who can manage the risk bares the risks'. An example:

Several kilometres of dikes within the controlling area of Water board X are identified to be too weak and need renovation. It is a large project, called project X1, with costs +/- 200 million. Under the HWBP regulation the WS has an own contribution of 20 million (10%), which will be in the forecast books of the WS. However, estimates are estimates and per definition the actual costs will differ from the estimate. According to previous researches, e.g. Cantarelli, Flyvberg et al. (2012) and de Ridder (2016), infrastructure projects have the tendency to go over estimate. Let project X1 at the end be 10 % over budget. The water board that was counting on 20 million now have to pay 20 million extra (WS is risk owner). This means an over budget of 100 %, while the project only went over with 10%.

It does not take a genius to see the resulting incentive. It is in the direct interest of the WS to enlarge the risk reservation. Since a P(50) estimate has a 50 % probability to be more expensive. History teaches us that costs are more likely to under estimated than to be over overestimated (Verbraeck 2015, Ridder 2016).

"Yes we see the incentive in the financial regulations to enlarge the risk reservation as well, and with requesting the risk reservation there is always discussion about it between WS and HWBP, which is very subjective " – Respondent 6

Within the WS, where his thesis research has been conducted, the incentive is recognized. But at the same time they consider it to go their morale / ethics to misuse this risk reservation. Speaking to other risk experts it was found that other WS are putting their own stake first. Comments such as 'Give a WS the time and they will produce long lists of 300+ risks just to enlarge the reservation' are common.

Recommendations

The 10% own input is an incentive that stimulates effective use of money. However, the regulation to make the WS risk owner and allow for risk reservation to function as 'airbag', results in an incentive to make the risk reservation as large as possible. This means that WS are spending time on making long lists and the HWBP is spending time on trying to reduce the reservation, all on a subjective basis.

Since the risk reservation is based on the sum of residual risks, which are quantified based on a consequence/probability matrix, it cannot be objective. According to (ISO 2012) the limitations of an consequence/probability matrix are:

- It is difficult to define the scales unambiguously;
- Use is very subjective and there tends to be significant variation between raters;

Considering the above the following recommendations are made:

- Hold on to the incentive for effective use of money, let WS pay a project base share. Perhaps even enlarge the share from 10 % to 12 %;
- Stop making the WS risk owners, but allocate a risk reservation on program level because then risk can be born collectively in a true alliance.

6.6 Validation results

The findings in this chapter were discussed with two experts in the field of risk management and water board authority. The resulting findings are discussed below.

6.6.1 Satisfying risk management performance by WS

The experts were asked if other WS also perform risk management at a satisfying level in their projects.

According to the experts, there is indeed an overall professionalizing of the entire project management by WS. The WS that had projects within the program 'Ruimte voor de rivier' professionalized project management even before the HWBP program. The other WS involved in the program HWBP are now also professionalizing. Hence, the experts agreed that risk management is indeed performed more professionally within the WS organization than some years ago.

6.6.2 Uncertainty on how large to set it up in other projects

The experts were asked if they recognize the uncertainty on how large to set up risk management within other smaller (more regular) projects at other WS.

According to the experts, this uncertainty resides not only within the WS but is also present in other organizations. They say that it is indeed a process of iteration in finding the right set up of risk management. They also concluded that risk management should not be made bigger than necessary and to watch out that it does not become a paper tiger.
The core of risk management is to sit down with several disciplines and to look for risk from different perspectives, creating risk awareness, making risk explicit and controlling them in a pro-active way. For larger projects more risk sessions than for smaller projects are required.

"Do not make risk management bigger than necessary, it should be undertaken with full consideration of the need to justify the resources used in carrying out" – Expert 1

6.6.3 The effect of the HWBP regulations on risk reservation

The experts were asked if other WS also see the incentive to enlarge the risk reservation.

They answered that other WS also recognized that it is in their direct interest to enlarge the risk reservation. According to the experts some WS are making long lists with the to enlarge the risk reservation. However they also state that it is in everybody's interest to keep the price per km dike reinforcement as low as possible. There is only a certain amount of money available per period. When projects become more expensive because of the risk reservation, less km's dike reinforcement can be done and the overall program will take longer.

7 Conclusion and recommendations

"How do Dutch regional water authorities perform Project Risk management in practice in infrastructural projects, and which improvement areas can be identified?"

The initial hypothesis prior to this thesis research was that risk management is almost non-existent within the water authority Scholten (2007) and that project risk management performed by water board authorities should be completely developed and be part of project steering and control.

To assess the validity of this statement both literature research, case study evaluation and model matching (Hoseini) of three different projects at the Water Board (WS) was conducted. Literature and model were used to create an 'ideal' approach; in depth interviews and model were used to assess the current practices of risk management in the WS in order to understand if the hypothesis is true or not and to identify areas for improvement.

The overriding conclusion is that risk management is currently part of integral project management at the WS. For all projects analyzed, elements of risk management were found. Risks were identified from different perspectives and assessed, control measures were selected and performed and time and cost contingency for risk control were in place.
Experts recognize that other WS also professionalized their entire project management practices. Those WS that participated in large projects for the program 'Ruimte voor de rivier' already professionalized and also WS that are now conducting large projects in the HWBP are professionalizing the project management practices, which includes risk management.
In order for risk management to be effective, two areas must be addressed being "Organization" and "Process & application". The thesis research found that it is especially in the area of "Organization" where steps towards an even more effective risk management process can be made. These areas are:

Top management commitment
Within the WS there is no direct steering involved nor are there clear instruction by top management on how to perform risk management within projects. There is no control mechanism in place to assess if risk management is performed or not. It is for a large part up to the project team to decide on whether and how to set up risk management. Another point mentioned by the respondents is that based on the reported risk status in the progress reports, a real conversation between the internal client and the project leader about the project risks rarely takes place. However, also the top management finds it an important aspect of project management. Conclusion: top management can provide a more facilitating context and support for the effective use of risk management. (See section 6.2)

Uncertainty on how large to set up risk management

It was discovered that there is uncertainty on how large to set up risk management in relation to the size of the project and that there is no clear guidance how or if to perform it. In the current situation higher-level managers provide no steering as to the way in which the risk management process is set up. It is up to the project leader or project team to decide whether and how to perform risk management. (see section 6.3)

Sharing knowledge across projects

It was found that within the HWBP project, knowledge from other HWBP projects was included in the organisation of the project, but also that quite some time had passed since knowledge was shared with other project teams. Furthermore, it was found that there is a risk register on department level in which all risks across projects can be collected and shared. The interviewees stated that after each project there should be a review in which the knowledge and learning is captured in a 'lessons learned' report. This shows that the organization has recognized the importance of cross-project learning. However, they also indicate that this register is not being used. According to the interviewees it is just not workable because risks are described on a level that it not usable in their own projects, it is not updated and therefore, they simply do not use it. The interviewees also state that capturing lessons learned, especially for the average internal project, is not always performed. (see section 6.4

The HWBP financial regulations and its effect on risk-, reservation and management

It was found that in the financial regulations of the HWBP an incentive is in place, which 'can' and probably does influence the performance of risk management in the projects executed within the new HWBP. The direct consequence of the new financial regulations (HWBP) is that it is in the direct interest of the WS to enlarge the risk reservation as it acts as an extra financial reserve. With the current system being based on a bonus-malus system, unspent money remains at the WS. The consequence of this could be a more expensive program, less km of dike renovation, an overall longer duration and a more expensive programme overall. (see section 6.5).

"Within the current financial regulation it actually pays out to identify risks" – respondent 5

7.1 Recommendations for improvement

In this subsection the recommendations discussed in chapter 6 and 7 are specified:

1. **Provide leadership from top management (top-down):**
   A. Put in place a guiding framework that allows matching the project size with the set-up of risk management (see section 7.3 for an initial proposal);
   B. Implement control measures to assure that risk management is performed, (only allow a project to shift from phases if a risk analyses is performed).
   C. Assure that communication / interaction between project leader and internal client is integrated in the risk management process as this will motivate the project team;
   D. Explicitly define how risk management on project level can be made "fit-for purpose" during the project kick-off session.

2. **Assure sharing knowledge across projects:**
   A. Continue sharing information and knowledge within and across projects (especially for big cyclic HWBP projects). Earlier mentioned (section 6.4) specific recommendations on how to do this on project level are:
      - Regular meetings with other project teams to exchange (risk) learning points;
      - Invite people with execution knowledge -other than only from the engineering company -, to the risk sessions;
      - Include external risk experts to assess the risk register prior to important project phase transfers and decisions;
      - Carefully weigh costs of potential benefits of the reduced risks vs costs of control measures and select a strategy (reduce, avoid, accept, transfer);
      - Increase involvement/reviews from other (internal) project leaders in risk sessions;

   B. Assure that the general risk register is brought to the attention and only list those risks that have actually fired in previous projects. Link them to the 'lessons learned' report. Learning points formulated should make a split between specific content-related learning points and process,- and/or organizational learning points; the latter may have a longer 'shelf life'; Make capturing 'lessons learned' the responsibility of the project leader (maak & haalverplichting) (section 6.4).

3. **Reconsider the HWBP financial regulations**

Keep the 10% own contribution by WS in place as an incentive to assure effective use of financial resources; at the same time, reduce the incentive to enlarge the risk reservation by taking WS out as risk owner and by allowing post-project calculation (see section 6.5).

8 Future research and limitations of this research

8.1 Future research

How top management can best provide leadership to assure effective employment of risk management should be internally discussed and negotiated between project leaders and top managers.

How to stimulate effective learning across projects deserves its own research. Risk management literature advices to report the lessons learned and assumes that other project teams or organizational members can search these lessons learned and assimilate the knowledge it contains, thereby learning of previous projects. However, evidence is accumulating that in practice this is not very effective (Newell, Robertson et al. 2009).

And last that it should be further researched if the 10 % own contribution and allow for post-project calculation assures effective project control on its own.

8.2 Limitations of this research

This thesis research has several limitations due to the nature of the research and choices that were made. In this section the main limitations of this research will be pointed out. This study relied on different methods used for the analysis and for each of them the main limitations will be discussed, next to the general limitations of the research.

8.2.1 General limitations

The main limitation of this research is that it was conducted with only one WS. Consequently, in-depth knowledge was gathered within one WS but the knowledge of other WS is limited. The main conclusions derived from the WS researched were discussed with experts in the water board organization that are familiar in risk management in order to see if they recognize the same in other WS. Although most the conclusions were recognized, it would still be better to conduct this research at other WS as well. This choice to stay with one WS was made because of the nature of the research in which the focus was on gaining an in-depth understanding on risk management performance. To observe something in its natural context means gaining trust and openness. Interviewing other WS about such sensitive topics without having a relationship based on trust, would most likely result in less openness. This would limit in-depth understanding.

8.2.2 Limitations of the literature study

During the first stage of this thesis, specific papers and methods about project risk management were analysed. During this phase it was agreed to analyse the ISO31000 standard on risk management, ATOM project risk management, Nicholas & Steyn, RISMAN Method. In general, literature mentions the important aspects of performing risk management. However, during the empirical study it was found that risk management is more integrated within other project management aspects, like cost estimation. The literature on risk management that was analysed did not highlight this sufficiently. Therefore more literature about cost estimation was studied halfway this thesis (the SSK 2010 methodology).

8.2.3 Limitations of the semi-structured interviews

In order to acquire in-depth insight into risk management performance, interviews with experienced project managers of different projects, the team captain and the director and with experts outside the WS were conducted. A disadvantage of conducting interviews is that the quality of the data depends highly on the skills and experience of the interviewer (Kumar, 2011). At times the interviews went its own course, which resulted in rich data, but also made knowledge extraction difficult.

8.2.4 Limitations of the model results

One of the limitations of the model is that is had not been tested before. This thesis research was in a way a pilot study to see whether and how the model works. To overcome the limitation, interviews and observations were also used to observe the current practices.

9 Feedback model

In this chapter feedback is given to the GRMM model by Hoseini (2017) that was used and tested within this thesis. Generally the model was fun to work with and allowed to gain insight into the risk management performance of the projects analyzed. The model managed to pick out the projects rated as 'top priority' for the water board; these were scored higher than the other project. However, some recommendations can be given and this will be done in the following sections.

9.1 Model scoring results

The model allocates a score between 0 and 10 for different aspects in risk management. However a clear scale with which the scores can be compared is not included.
A score of 8 sounds satisfying and a score of 6 is less satisfying. But what exactly do the scores mean?

9.2 Statements related to risk appetite

According to the model, the risk appetite of the project should be:

- Documented, internally available and communicated;
- Reflected in the risks reservation;
- The basis for important the treatment and mitigation of important risks.

However in practice there is also a lot of uncertainty in answering the questions/statements related to risk appetite. The respondents did not entirely understand what was meant. They thought that risk appetite merely referred to whether or not they were interested in risk management. The full implications of 'risk appetite' were not understood.
However, according to literature organizations have a risk appetite, and projects have a risk profile. The risk profile of a project depends on the amount of risk that is directly connected to the project. Depending on the organization's willingness to take risks in pursuit of value (risk appetite) an organization decides if a project is too risky to perform or not. The risk appetite is unlikely to be a fixed number but rather a soft element that lies in the genes of the organization. It depends on the culture of the organization and the circumstances under which the organization operates. (An 'hungry' contractor will likely take more risks than one who has enough work).
Considering the above, it is recommended to reconsider the questions/statements regarding risk appetite. Possible questions/statements can be:

- Is the project risk profile determined?
- Is the project risk reservation based on the risk profile of the project?;
- Is there focus on the risks, that have the largest stake in the risk profile;
- Is the risk profile of the project below/above the risk appetite of the organization?

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11 Appendices