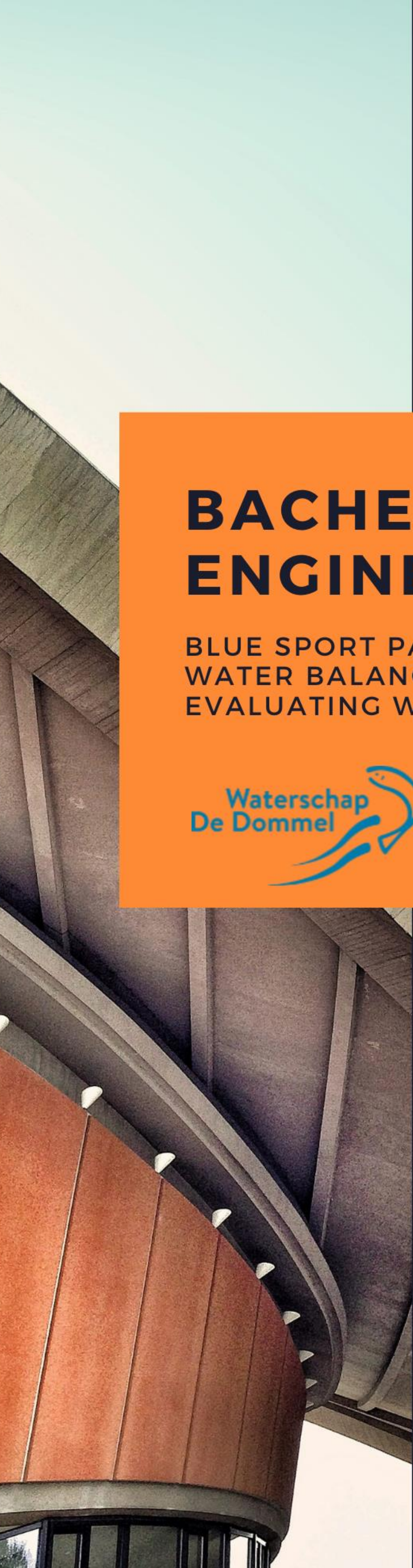

30 OCTOBER 2020

BACHELOR THESIS CIVIL ENGINEERING PROPOSAL

BLUE SPORT PARKS: DEVELOPING A MODEL FOR THE WATER BALANCE OF A SOCCER SPORTS FACILITY AND EVALUATING WATER ROBUST MEASURES

Waterschap De Dommel

Newae Adviseurs & Ingenieurs voor de buitenruimte

UNIVERSITY OF TWENTE.

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Glossary

This Glossary provides the most frequently used key concepts and its description for clarification.

Blauwe Sportparken	*Project "Blauwe Sportparken" (English: blue sports parks) focuses on improving the water balance and reducing water usage at sports parks.*
Water Balance	*Concept which describes the flow of water in and out of a specified hydrological system.*

Introduction

This research proposal has been developed in cooperation with water board Dommel, engineering company Newae and the University of Twente.

For the past years, the groundwater levels in the operational area of the waterboard Dommel have been decreasing. Extreme weather conditions occur more frequently, which results in waterlogging and severe drought. Traditionally, water management strategies tend to focus on water dissipation as their highest priority. The government has adapted a change of course; aspiring a climate resilient and water robust country. This affects even the sports industry; soccer sports facilities need to adapt. The project "Blauwe Sportparken" (Blue Sport Parks), focuses on the economical and efficient usage of (ground) water. Water board Dommel and engineering company Newae are originators of the project "Blauwe Sportparken". Currently, there is insufficient information about the water balance of soccer sports facilities. Effects of water balance improving measures are unquantified, therefore impeding further development and implementation. Water board Dommel and engineering company Newae are interested in the development of a model that identifies the water balance of soccer sports facilities and the effects of water robust measures. This report proposes a study based on the development of a model, to get better insight in the water balance of soccer sports facilities and the effects of water robust measures.

Reading guide

The context of the project is outlined in chapter 1. Thereafter, the problem statement is discussed in chapter 2. Chapter 3 focuses on the research objective for the assigned project boiling down from the context and problem statement. To specify the boundaries of this research, chapter 4 describes the scope. The research framework including the theoretical context is described in chapter 5. This results in chapter 6, where the research questions and the sub-questions are formulated. In chapter 7, the plan of approach for this bachelor's thesis is elaborated. To get a feeling of the future structure of the thesis, chapter 8 outlines the preliminary table of content. In order to obtain the desired results, the research planning in chapter 9 provides general guidelines and important deadlines. For completeness, chapter 10 summarizes some general information about contact information, agreements and personal goals.

1. Context

In the Netherlands, predicted scenarios regarding climate change will have a huge impact on the whole water management system. Extreme weather conditions such as heavy rain showers and severe drought will occur more frequently. The Dutch government, provinces, municipalities and waterboards have embraced a collaborative goal of realizing a climate-proof and water-robust Netherlands in 2050 (Nationaal Deltaprogramma, 2020). In light of this plan, vulnerabilities have been mapped for each industry. The sport industry has experienced difficulties for the past few years in terms of drought and severe water disruption. Play fields needed to be irrigated and water damage restricted sports activities. The need for climate adaptation has been amplified and the search for functional and sustainable solutions have started. (Rijkswaterstaat, 2015)

In light of this tendency, the concept “Blauwe Sportparken” has been developed by water board Dommel and engineering company Newae. This refers to climate resilient sports parks which have significantly improved their water management and have been constructed in a sustainable way. The water balance of conventional playing fields can be constructed and used in a more efficiently and multifunctional way. A “Blauw Sportpark” focuses on the economical use of water. Rainwater is retained in rainwater collection reservoirs to prevent dehydration. These water storage tanks can also be used during severe rain showers or inundation for collection of excessive water. Moreover, stored precipitation water can be used for the irrigation of natural grass pitches. Besides the water management, a “Blauw Sportpark” focuses also on sustainability during the whole construction project. Re-usage of existing materials, LED light implementations and sustainable contractors are typical examples. (Roelofs & Van de Ven, 2018)

A practical example of such a “Blauw Sportpark” is the in 2018 realized sports park in Sint-Oedenrode named “De Neul”. Due to its location between the rivers Dommel and Dommelarm, high groundwater levels occur, which results in waterlogged fields. This park has been made futureproof, taking into account extreme drought, sever rain showers, inundation and high groundwater levels. Beneath the three synthetic turf pitches, an enormous water storage has been placed. By using controlled drainage, water is retained and, if needed, transported to the natural grass pitches for irrigation at the roots to avoid dissipation of water. (Provincie Noord-Brabant, 2018)

In conclusion, to ensure future usage of sports parks, it is necessary to adapt on short notice. This need results in the build of “Blauwe sportparken” which have been built climate resilient through water management to reduce water vulnerability, enhance water safety and ensure water availability.

2. Problem Statement

The region of the water board Dommel consists of partially sandy soils. These areas are depicted as regions which are dependent solely on rainfall. There are hardly any water trajectories, such as canals or rivers. It is observed that groundwater levels in these regions are slowly dropping. This is due to the fact that longer periods of drought occur interchanged by severe precipitation. Moreover, water systems in this area are designed in a conservative way, marked by water drainage as highest priority. Last but not least, groundwater is exploited more extensively by operations such as industries, agriculture, drinking water supplies and sports.

In the “Deltaplan Ruimtelijke Adapatatie” it is stated that The Netherlands should become climate-resilient and water robust in 2050 (Nationaal Deltaprogramma, 2020). Moreover, the country has a “Nationaal waterplan” for the years 2016-2021, a country wide policy regarding water (Rijkswaterstaat, 2015). One of the key elements is the desired development regarding protection and functioning of water systems in The Netherlands. This aims at the development of general acknowledgement to tackle projects in a way that is climate resilient and water robust by 2020. This has boiled down to the project “Blauwe Sportparken” (English: blue sports parks) in 2018 such as ‘De Neul”. However, further developments for sports facilities have not found their way through because of the lack of knowledge. One of these knowledge gaps concerns the insight in water balances of sports facilities. This lack of quantitative insight disables comparison between the traditional way and ‘new’ way of structuring sports facilities along the lines of “Blauwe Sportparken”. Parties are not willing to invest extra money in new unquantified measures for which the return on investment is not known. Consequently, this impedes the evolvement towards a water robust country.

3. Research Objective

A decreasing groundwater level is a common problem across the region of water board Dommel. This is a problem for sport facilities regarding synthetic turf pitches which cannot retain any water in most cases. Besides that, natural grass pitches require a high maintenance level in terms of water drainage and water irrigation. The project called “Blauwe Sportparken” focuses on enhancing the water balance water and reducing the water usage. In general, water board Dommel focuses on researching methods to improve water retention, complement groundwater and reduce water usage. The project “Blauwe Sportparken” concentrates on sport fields solely to improve the current water situation. It is necessary to acquire more insight into the water balance in the current situation in order to provide better targeted incentives that are genuinely effective.

The problem statement focuses on the problems existing in the operational area of the waterboard Dommel. In order to solve the aforementioned problems, the following research objective has been formulated:

“The objective of this research is to gain insight in the water balance at soccer sports facilities by developing a model, to enable taking effective measures to enhance the water balance by retaining water, recharging groundwater and reducing water usage.”

4. Scope

This research focuses on the development of a water balance model and the effects of water robust measures for soccer sports facilities. Different water flows result from the water balance which enables assessment of water quantity and quality (chapter 6.1 elaborates on this general concept). As a result of the identification of water flows, water quality can roughly be assessed by the different origin of water flows. However, water quality is not investigated in this research since it is of minor importance in this research. The primary focus is on water quantity; to retain water, recharge ground water and reduce water usage. In case of climate resilience and water robustness, only water usage is taken into consideration. Re-use of materials, sustainable contractors, sustainable materials and other sustainability aspects are not taken into account. For the development of this model, soccer sports facility “Zuideinderpark” in Schijndel will be used as a basis, which is representative of sport fields generally. The soccer sports facility “De Neul” will be used for measurement data from implemented measures. Other type of sports facilities (e.g. hockey, tennis, golf) will not be investigated. The developed model will provide more insight in the water balance of a soccer sports facility. Effects on the water balance can be quantified by hypothetically implementing new measures. This result can be compared to the water balance of a traditional soccer sports facility.

5. Research Framework

The research framework provides theoretical information acquired from literature research and expert input. This information will contribute to the accountability and performance of this research. In general, the national policy “Nationaal Waterplan” outlines the legislation concerning water, and related measures (Rijkswaterstaat, 2015). Adhering to this policy automatically takes care of the requirements which can be derived from the Dutch water related policies: “Kaderrichtlijn water (KRW), “Richtlijn Overstromingsrisico’s (ROR)” and “Kaderrichtlijn Mariene Strategie (KMS)”. The conditions stated in the “Nationaal Waterplan” can be used for demarcating the most extreme (but still legal) water standards in the model (Rijkswaterstaat, 2015). The “Stichting Toegepast Onderzoek Waterbeheer” (STOWA), knowledge centre of water boards and provinces of the Netherlands, has constructed a calculation tool for establishing a water balance in cooperation with Witteveen & Bos and Waternet (Tanis, Schep, & van Dijk, 2018). This tool could be leading for this research by forming the basis on which the water balance model for sports facilities is constructed. Furthermore, Wageningen University & Research has conducted several researches into smart water reducing and water level management measures (Source) and synthetic turf pitches which could help (Boerenbond, 2017). Moreover, the industry “Sport- en Cultuurtechniek” has obliged an investigation about the water benchmarks of sports pitches (SOURCE) which should be achieved (Stark, 2011). In the following sections, there will be briefly elaborated on the concept water balance and sports facility.

5.1. Water Balance

For the preparation of a water balance an excel calculation tool has been fabricated (Kroes, Van Dam, Jacobs, Groenendijk, & Hendriks, 2008). For the maintenance of water quantity, it is of great importance to have insight in all sources and processes which have an influence on the water balance. It is necessary to create a comprehensive, quantitative overview of all ingoing and outgoing waterflows; this is part of a water system analysis. Moreover, the results can be used to draw up a balance of the water structure to discover origin and progression of water(flows). This is necessary for guaranteeing sufficient water quantity. The difference with other hydrological tools is that those tools focus primarily on hydraulic bottlenecks in terms of water drainage or water supply. (Tanis, Schep, & van Dijk, 2018)

5.1.1. Water balance elements

In the water balance introduced by STOWA, several water flows are quantified; the water discharge and the amount of water compounds. Using this balance, the origin of several water flows can be tracked as well as the different outflow routes. Moreover, insight is provided in the source, composition and retention time of water. A big advantage of this method is the fact that relatively few definitions of geographical areas are needed to provide an impression of the most important waterflows. A lot of geographical characteristics can be found online, freely available. For parameters such as precipitation, soil type and efflux of water, The Netherlands has a lot of key numbers available.

Important to note; formulating a water balance focuses in the basis on acquiring insight on the functioning of a water system and not on recreating reality as accurately as possible. It is an analysis instrument to predict the scale of several water flows and the effects of implementations. (Kroes, Van Dam, Jacobs, Groenendijk, & Hendriks, 2008)

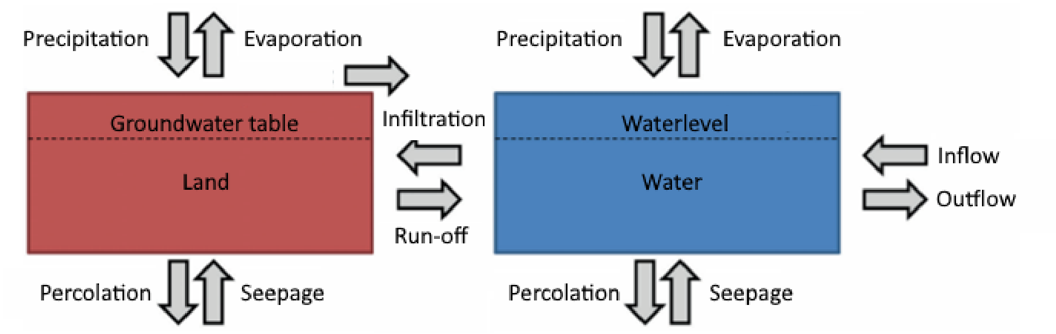


Figure 1: Schematic overview of a water balance (Tanis, Schep, & van Dijk, 2018)

5.1.2. Structure of a water balance

In short, the principle of a water balance is to track which processes or sources are important for the water quantity. The overview of al ingoing and outgoing water sources is called the water balance. If the sum of all inflowing water sources is equal to the outflow, the water volume in an area remains constant. The two other situations, where either the outflow or the inflow is larger, this results in water shortage or water drainage respectively. (Tanis, Schep, & van Dijk, 2018)

In the core, there are four elements which affect how much water flows in and out of an area:

- *The weather*

Precipitation can occur in terms of rain, snow or hail. A distinction is made for the precipitation on surrounding water systems or surrounding fields. This results in different water flows in terms of run-off, evaporation, soil saturation and water infiltration.

- *The landscape*

The type of environment, groundwater flow and soil properties have influence on the water flow. The following types of land surface are common: paved, unpaved and not drained, and drained and unpaved. Next, groundwater flow concerns the amount of seepage or infiltration. A distinction is made for surface water of surrounding water systems and adjacent fields.

- *Water level management*

The water level can vary according to the water-table decisions in a specific bandwidth. Often water levels are distinguished for summer and winter, to accommodate for agricultural use.

- *The connection with other water systems*

The amount of water that will flow to adjacent water systems will be impacted by the type of connection and the type of neighbouring water system.

5.1.3. Necessary data

The first step in setting up a water balance is the demarcation of the water system or area that is investigated. It is useful to find a, hydrologically speaking, logical boundary of the area. It is important to note how the area is connected to adjacent areas. The following list displays the minimum set of data that is needed (Tanis, Schep, & van Dijk, 2018):

- Surface open water [m^2]
- Surface paved area [m^2]
- Surface unpaved area [m^2]
- Precipitation [mm/d]
- Evaporation [mm/d]
- Minimum and maximum water level [m+NAP]
- Water-table level [m+NAP]

5.1.4. Bucket model

The water balance is constructed with use of the bucket model. For simplification the region of investigation is scaled down to several small buckets. With the input data, classified above in the section necessary data, water will flow between those small buckets. The exchange of water is dependent on the four elements, mentioned in the section structure of a water balance, which are accountable for the eventual size of water flows. Each bucket has its own characteristics, such as soil type, permeability, size, paved, unpaved, drained, inclination, etc. Each region will be translated to several smaller buckets with their own properties to be able to analyse the eventual water balance. (Tanis, Schep, & van Dijk, 2018)

5.2. Soccer Sports Facilities

For the application of this research, information about soccer sports facilities is necessary. General information about the usual elements which are present is investigated. Moreover, information about grass pitches and synthetic turf pitches is valuable. The characteristics of these types of pitches and the accompanying requirements to which these pitches comply. Besides that, information about the traditional water system is needed. How are these fields drained, irrigated and designed? This chapter focuses on these elements of sports facilities. General knowledge about the most common practices is summarized and important researches are depicted to provide a solid framework to start analysing current and future situations.

5.2.1. Drainage

Regarding drainage several studies have already investigated controlled drainage systems, such as the drainage system that is constructed at sports park ‘De Neul’. The study “Is peilgestuurde drainage goed voor gewas en milieu” (Boerenbond, 2017) focuses on controlled drainage systems and its benefits and constraints.

5.2.2. Synthetic turf pitches

Typically, synthetic turf pitches are drained by horizontal strings which are positioned above the groundwater table. This does not lower the groundwater table, instead it targets the dissipation of water in the layers above. These pitches can accelerate the removal of rainwater. As a result, this can trigger a desiccating Effect. Previous research has already investigated drainage of synthetic turf pitches during extreme precipitation. However, little is known about the less severe rain showers. Better insight into the water balance could substantiate more specific measures. What is more beneficial, more intelligent irrigation, controlled drainage or are there other promising techniques? For synthetic turf pitches, the study “Watertoets voor sportvelden” has investigated the contribution of these type of pitches to the dissipation of water. (Lenders & Kool, 2010)

6. Research Question and Sub-questions

The research objective constructed in chapter 4 results in the following main question.

- *How can the water balance of a soccer sports facility be modelled and what measures are effective in order to create a climate resilient and water robust soccer sports facility?*

In order to design a model that can describe the water balance of a soccer sports facility and also investigate the measures that are effective to support a positive water balance, several sub questions are formulated. This will help narrowing down each specific element of the main question and helps structuring the report.

I. *How is the current water system of a soccer sports facility structured according to literature and expert input?*
   a. *How is a water balance of a soccer sports facility characterized?*
   b. *What variables have an influence on the outcome of a water balance model?*
   c. *How is the water balance of the project "Blauwe Sportparken" structured?*

II. *Which water balance improving measures can be taken at soccer sports pitches in order to retain water, recharge groundwater and reduce water usage?*
   a. *What irrigational measures are commonly used?*
   b. *Which water reducing measures can be used at sports facilities?*
   c. *What water drainage measures are commonly used at sports facilities?*
   d. *How can water be retained at sports facilities?*

III. *What are the effects of water balance improving measures for a soccer sports facility?*
   a. *How do water balance improving measures financially affect a soccer sports facility?*
   b. *What are the quantitative effects of water balance improving measures on sustainability in terms of water usage for a soccer sports facility?*
   c. *What are the quantitative effects of water balance improving measures on playability for a sports pitch?*
   d. *What are the consequences of precipitation on the drainage of water at synthetic turf pitches?*

With help of these questions a model can be developed, which will provide more insight into a water balance of a soccer sports facility. Moreover, effects on the water balance of soccer sports facilities can be quantified by hypothetically implementing new measures, such as introduced with the project "Blauwe Sportparken". The result can be held against a traditional water balance for comparison. Consequently, a more comprehensive overview of a general water balance and the effects of new water regulating measures is created.

7. Research Plan of Approach

In the previous chapters, the theoretical framework has been provided in chapter 5. Thereafter, the research questions are formulated in chapter 6. This chapter will focus on the combination of both and the development of a plan of approach to perform the research. A comprehensive overview per research question will be provided together with methods to investigate the matter. This will result in a tangible phased plan.

7.1. Research Methods

For a conveniently organized approach, each sub question will be elaborated on in further detail regarding the selected research method.

1) *How is the current water system of a soccer sports facility structured according to literature and expert input?*

In general, this sub question will be answered with use of a literature study and expert input together with belonging datasets to support their claims. The first important thing to investigate is the visualisation and modelling of a current water balance of a football sports facility. The water balance model that is constructed by STOWA (Tanis, Schep, & van Dijk, 2018) will be used as a solid basis for modelling this water balance for an existing soccer facility in Schijndel. The required input data regarding size, structure and current water systems of this soccer sports facility will be offered via water board Dommel. The amount of paved area, drained area, sport pitches, roofs and groundwater facilities, and their internal dependency are suspected important aspects. Further information regarding hydrology of this specific location will be provided as well. The KNMI will be consulted for data sets regarding the weather. Engineering firm Newae will deliver data regarding the construction details of such a sports facility. Moreover, both waterboard Dommel and engineering firm Newae have been closely involved with the project "Blauwe Sportparken". Detailed information of this project, especially about sports facility "De Neul", will be supplied by them as well. Furthermore, datasets regarding the current usage of water at this facility will be retrieved from "De Neul" itself. Most of all this data is already documented. With use of an expert discussion, the missing elements will be identified at the local instances. This data can be used for calibration and verification of the model. Last but not least, literature research will provide more general information regarding the forming of a water balance. Also, the impact of different more technical details such as soil type, weather conditions and different type of pitches will be deduced from literature. This is all implemented in the model as input information and the result is a quantification of water processes dependent on the specified input data. In this way the model can be used for different soccer sports facilities.

2) *Which water balance improving measures can be taken at soccer sports pitches/facilities in order to retain water, recharge groundwater and reduce water usage?*

To be able to answer this sub question, a literature study together with expert input will be leading. This question is widely formulated in order to have a wide range of possible measures that can be implemented. This range of possibilities concerns irrigation, drainage, water reduction and water retention with several individual solutions per topic, leading to a massive amount of possibilities. However, due to time constraints, an elimination of this list of measures will be needed. The selection of criteria on which this elimination is based will be constructed with use of expert input from Newae. The engineering firm is experienced on this topic and will be leading. Besides that, literature study will help constructing this decision framework with use of sound reasoning. There will be looked at effectivity, amount of usage and research results. Information about each individual topic will be retrieved from Smits Beregening B.V. a company specialized in drainage and irrigation. Furthermore, the company Field Factors will be contacted via water board Dommel to provide information about synthetic pitches and groundwater retention. The pilot study about water retention at natural grass pitches; "Pilot Hoge Bomen: Waterberging op een natuurgras sportveld" (Köster, et al., 2012), provides also more information about water retention possibilities. The project "Blauwe Sportparken" focuses specifically on improving the current water balances at sports facilities. By looking at direct result of this project; sports facility "De Neul" a few common measures can be deduced. Eventually approximately 3 up to 6 water balance improving measures will be implemented in the model which can be used for evaluation of the effects.

3) *What are the effects of water balance improving measures for a soccer sports facility?*

This sub question will be addressed with use of data analysis for the largest part. At this stage, the model output is most accurate and extensive as it gets; a water balance is modelled for soccer sports facilities depending on their own characteristics. Even more, the selection of water balance improving measures can be implemented and the results of this improvement can be compared to the original situation. This comparison is essential for determining the effects and evaluation. The different aspects on which the measures will be evaluated are financial, sustainability and playability. For the design of soccer sports facilities, the users can decide which aspect they would prefer most. For the financial part there will be looked at the quantitative effects of the (reduced) water usage and investment costs. Sustainability can be assessed using the modelled effects in terms of water usage for different scenarios. For each measure the effects in terms of water use and re-use can be quantified. Furthermore, a small section of the water sustainability assessment, which is discussed in literature reports such as "Sustainability Performance in Sport Facilities Management" (Lucas, Pinheiro, & Del Río-Rama, 2017), can be applied on sports facility "De Neul" as an example. Furthermore, playability can be assessed by looking at the current norms, drainage capacity during different precipitation scenarios and the effects of the measures in comparison with these norms (Stark, 2011).

7.2. Research Model

The research methods described in section 7.1 are visualized in the following research model (Figure 2) to provide a concise overview of the research methods.

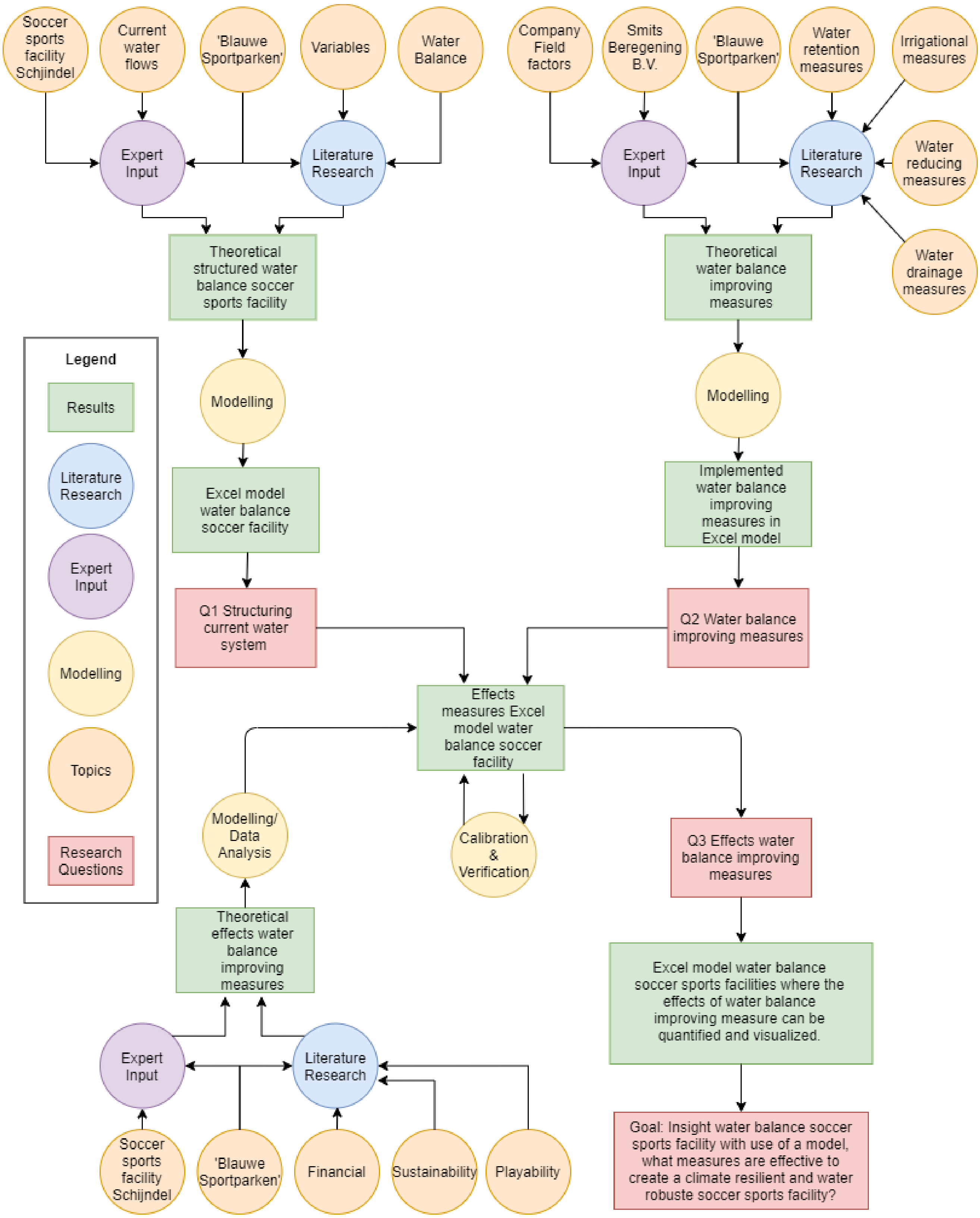


Figure 2: Comprehensive flow chart of the research methods

7.1. Excel Model

With use of the description of the research methods in chapter 7.1 a model will be constructed. This model will most likely be designed with use of the program Excel and with use of a more specific program which focusses on water flows only, such as SOBEK. The most crucial consideration in this decision process is the fact that the final product in the form of a model should be usable and understandable for each person. Excel is a commonly used program for companies, is actively supported with instruction manuals and highly intuitive, therefore enhancing user friendliness. Another benefit of Excel is its primary function; organizing lots of data into logical spreadsheets and charts which is useful for data representations and clearness of the model outcomes. Multifunctionality is an advantage, it can model and process almost every data set. A disadvantage is that there are no programmed functions for specific features such as modelling water processes in this case. This could become a problem, because most of the model (except the basis water balance) needs to be built from the ground up. Nevertheless, this also creates the opportunity to incorporate various extra aspects to adapt the model to specific needs. The Excel model that is created by STOWA (Kroes, Van Dam, Jacobs, Groenendijk, & Hendriks, 2008) will be used as a basis water balance model which will be expanded.

Following Figure 3 displays the general scheme which will be followed to construct the model according to the research questions and to support the goal of this research. This is a more technical overview of the input, process, output and (inter)dependent relationships between variables and processes. Because of the numerous inter dependent variables, only the most general relationship is visualized to avoid confusion. In the bachelor's thesis itself the detailed model will be established and implemented.

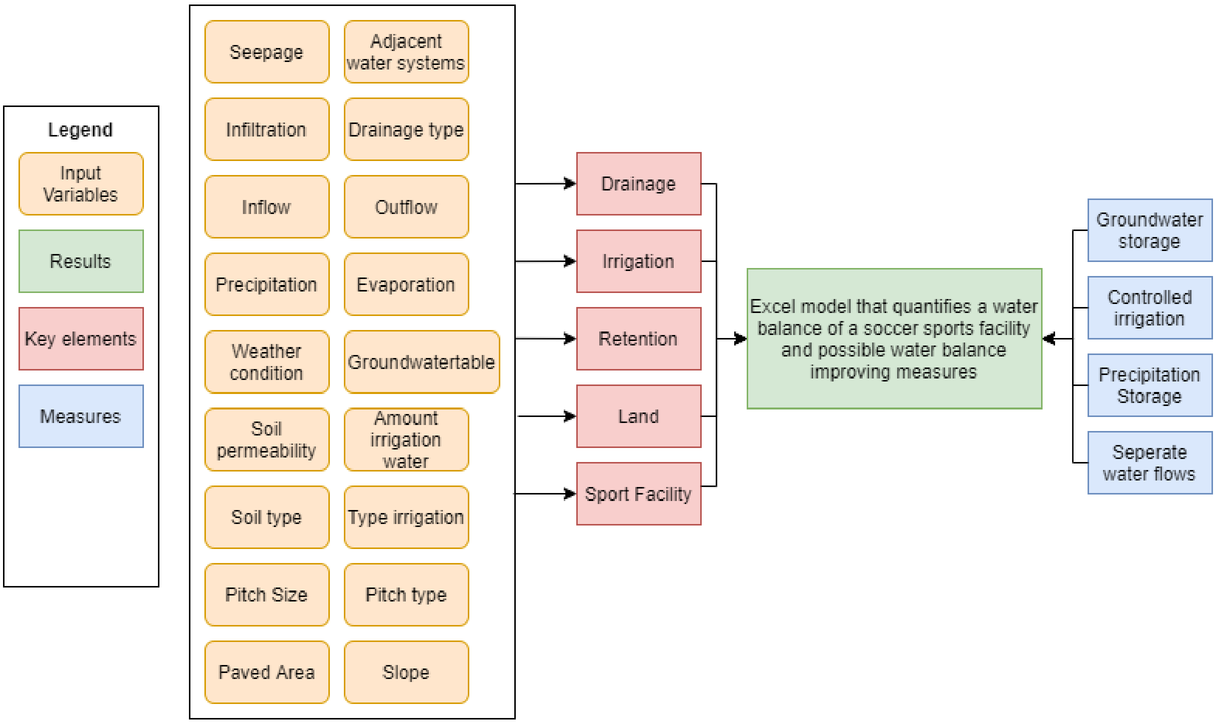


Figure 3: Comprehensive Excel model for the water balance and improving measures

8. Table of Contents Bachelor's Thesis

This chapter will list the main topics that are evaluated in this bachelor's thesis and provides a preliminary table of content of the final bachelor's thesis report:

1) Titlepage
2) Preface
3) Abstract
4) Table of content
5) List of figures and list of tables
6) Glossary
7) Introduction
    a. Context
    b. Research aim
    c. Research questions
    d. Method
8) Research results
9) Discussion
10) Conclusion
11) Recommendations
12) References
13) Appendices
    a. Excel model
    b. Data sets
    c. Expert discussion

9. Research Planning

The planning for the bachelor's thesis will be discussed in this chapter. The most important data will be listed with internal and external deadlines. Furthermore, a contingency planning will be provided. The overall planning is attached as well for a comprehensive overview of most general steps of action as a guidance. Some deadlines are not official deadlines but more of an internal deadline as guideline in the research and writing process.

9.1. Essential Data

First, the most essential data is listed below in table 1. Not every date is established yet, but this will be adapted later.

Table 1: Essential data of the bachelor's thesis

Week	Date	Activity
42	14-10-2020	Conceptual Design + Technical Design report deadline
43	22-10-2020	Poster market
44	30-10-2020	Final Proposal
46	09-11-2020	Start bachelor's thesis at water board Dommel
48	25-11-2020	Research question 1 finished and reported
48	26-11-2020	Progress meeting water board Dommel & Newae
50	9-12-2020	Research question 2 finished and reported
51	18-12-2020	Mid-term progress report just before winter holiday (can be used backup)
3	12-01-2021	Research question 3 finished and reported
3	15-01-2021(?)	Deadline draft report
4	22-01-2021(?)	Deadline final report bachelor's thesis
5	TBD	Examination session
5	29-01-2021	Evaluation report

9.2. Contingency schedule

In this section potential obstructions are identified; it focuses on the most general pitfalls and the potential solution in general form. The risks that could happen are listed in table 2 together with their contingency.

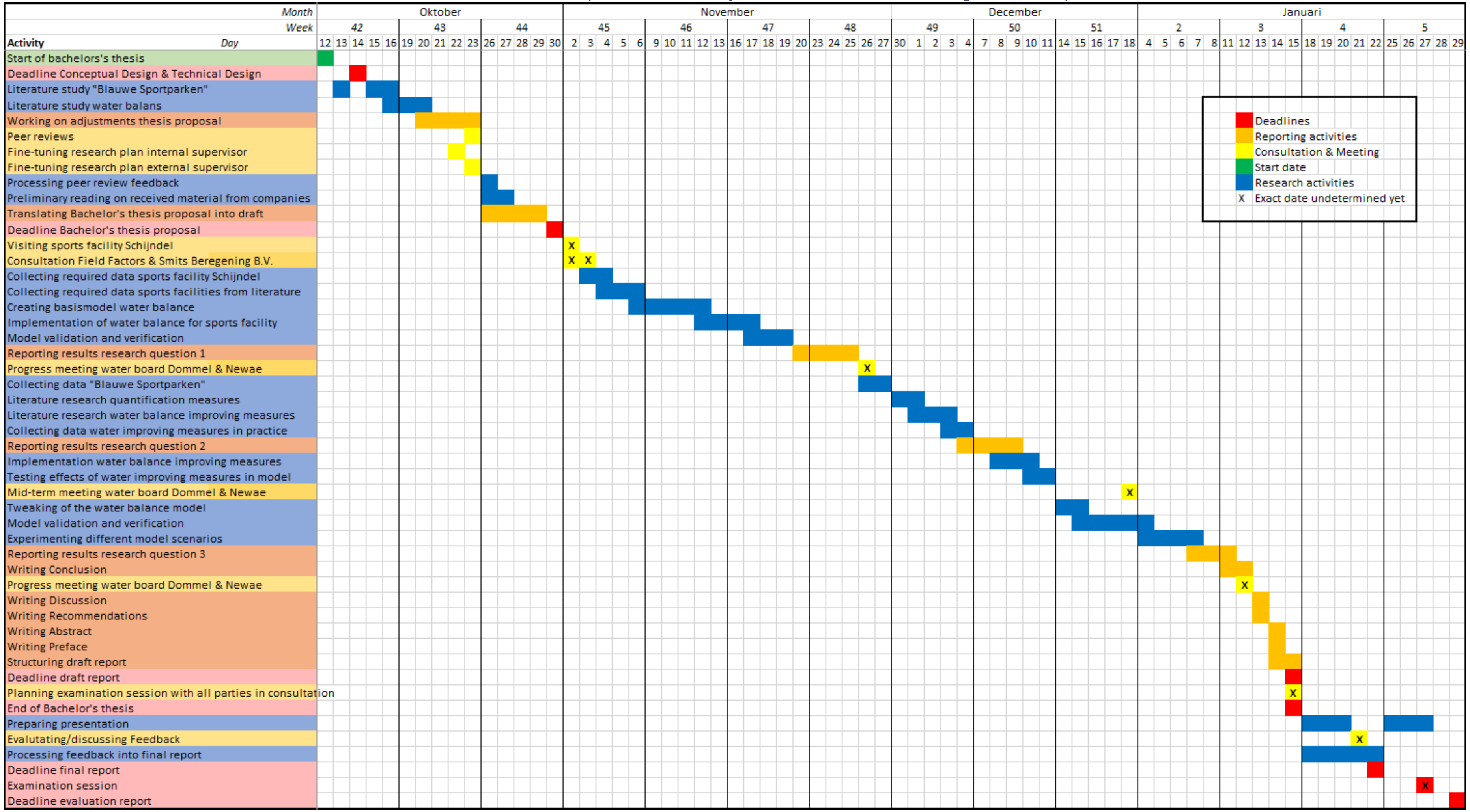
Table 2: Overview of potential situations with their obstructions and contingencies

Situation	Contingency
Scheduled activities take unexpected turns and results in deceleration of the research process	The current planning is focussed on working days from 9 till 5. This can be prolonged by using evenings or weekend days for extra time. Additionally, the Christmas break can be used as a back-up period of 2 weeks.
Personal problems (i.e. sickness)	Together with both the internal and external supervisor the planning could shift due to the circumstances.
Some desired elements (e.g. model predictions) fail	This could be due to time limitations or knowledge limitations, in consultation with the supervisors an adequate solution can be realised, or the particular failure could be removed or slightly shifted in focus.

9.3. Gannt Chart

The following schedule visualizes the most important activities and both internal and external deadlines for the bachelor's thesis. The time span for different activities is based on estimates so could differ in practice but will be used a general guideline to avoid delay and keeping track of progress.

Table 3: Gannt chart with all steps and deadlines of the bachelor's thesis and assignment incorporated



10. General Information

This chapter serves as information page for general information regarding the bachelor's thesis. The contact information of the most important concerned parties is listed. Furthermore, student's personal goals are described. Last but not least, the agreements made with the bachelor assignment commissioner are provided.

10.1. Contact information

In brief the most important details about the bachelor student, the internal supervisor and the external supervisor are listed.

10.1.1. Bachelor Student

Naam: *Ruben Borst*
Student number: *1968343*
Residence: *7545WE, Enschede*
Institute: *University of Twente*
E-mail address: *r.h.c.borst@student.uwtwente.nl*

10.1.2. Internal Supervisor

Name: *Katrina Vink*
Institute: *University of Twente*
E-mail address: *k.vink@uwtwente.nl*

10.1.3. External Supervisor

Name: *Hans Roelofs*
Company: *Waterschap Dommel*
E-mail address: *hans.roelofs@dommel.nl*

Name: *Jeroen van de Ven*
Company: *Ingenieursbureau Newae*
E-mail address: *j.vandeven@newae.nl*

10.2. Personal goals

The main goal of this proposal is to be able to create a project plan for a research project in the field of Civil Engineering. With this proposal, theory learned in module 11 of the bachelor Civil Engineering is put into practice. Research questions, research methods and planning are implemented in this proposal as a result. For the bachelor's thesis itself the main goal is to perform a research concisely, structured and qualitatively. This boils down to the execution of the proposed research project in this proposal. In this way experience in the work field of Civil Engineering is acquired.

10.3. Agreements

Some general agreements that have been made for a proper course of this bachelor thesis and bachelor assignment:

- Bachelor assignment at water board Dommel from 02 November up and till 29 January
- Head supervisor is Hans Roelofs (Waterschap Dommel)
- Close cooperation and supervision from Jeroen van de Ven (Newae)
- Weekly meetings with external supervisor(s)
- Internship agreement signed at the waterboard Dommel

11. References

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