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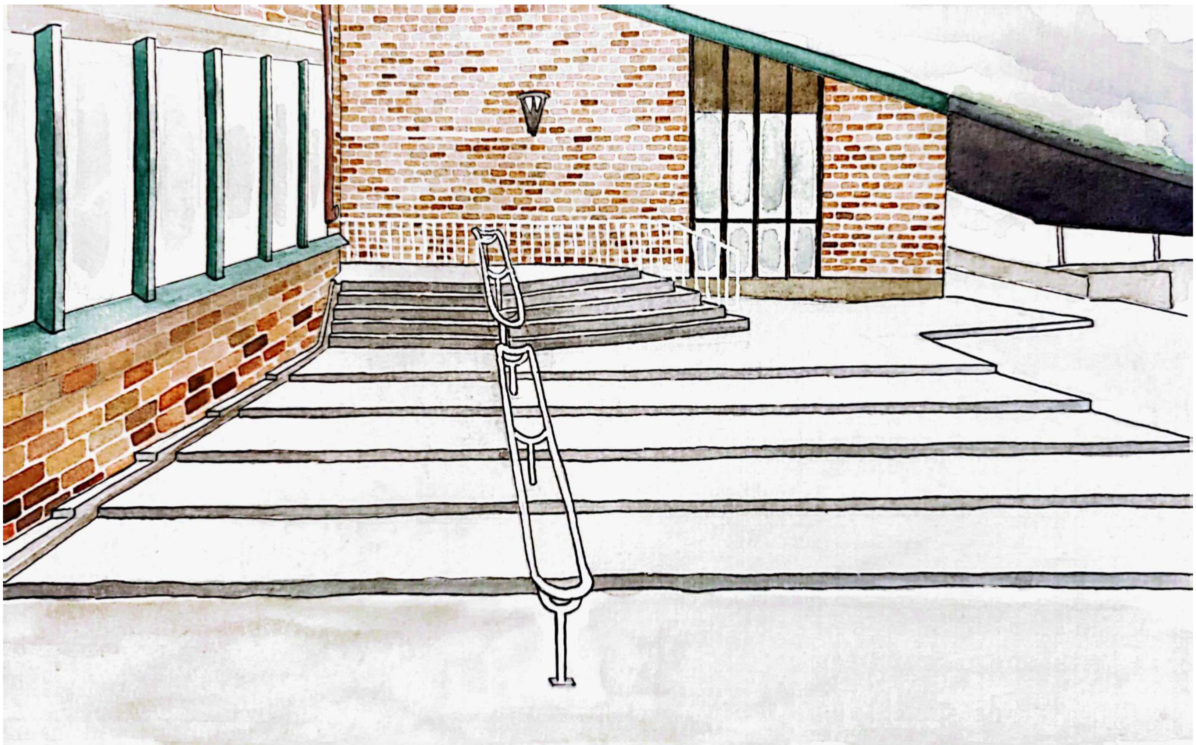

World’s Best Campus When It Rains

A development proposition of a part of the Chalmers campus area, focusing on stormwater management regarding flooding and copper pollution as well as improved social environment

Bachelor’s thesis in Civil engineering

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Abstract

This bachelor’s thesis examines stormwater and social spaces at Chalmers University of Technology, Campus Johanneberg, Sweden. The aim is to produce a concept proposal to help the campus become “The world’s best campus when it rains”. Issues regarding stormwater are prevalent in the area and prognoses show that the problems will only intensify in the future as a product of climate change. New precipitation patterns risk increasing stormwater flow, which raises the importance of efficient stormwater management. The chosen project area already suffers from minor flooding which causes difficulties for pedestrians and an unkempt appearance that does not reflect Chalmers’ reputation and standing. Another complication is pollution since the area includes buildings with copper roofing. Since stormwater measures can demand major redevelopments of an area this also provides an opportunity to improve the campus’ social space. The project therefore investigates how such additional quality factors can be integrated into stormwater solutions.

By researching literature on stormwater and social spaces, conducting interviews with scholars and stakeholders, simulating flooding and gathering opinions of the campus community through a survey, a list of requirements and requests was established. By examining this list while conceptualising, two area design proposals were created. These concept drafts included technical solutions such as rain gardens, stormwater ponds, stormwater reservoirs and permeable surfaces among others. These were then evaluated partly by the rational method and storage capacity to determine how each element of the proposals could handle stormwater flooding. The drafts were also examined based on how they met campus social space needs. When the selection process was complete, a final concept was created. It includes a reshaped pathway, a large rain garden for cloudburst management, a major redesign of a decorative pool into a stormwater deposition pond, a new green area and a new social area that protects from rain. Additionally a green roof and a smaller rain garden are added mainly for copper treatment.

When evaluating The Final Concept, it was found that the collective solutions could reduce stormwater flooding volume by almost 70%. However, the redevelopment of the project site could be considered very extensive. To mitigate cost and disturbances to campus activity implementation of the concept could be done partially or in stages. The discussion also held a general prioritisation of the solutions.

Keywords: Stormwater, Pollution, Chalmers University of Technology, Campus development, Social space

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1. Introduction

In the last century, climate change has become an increasingly prevalent issue (NASA, 2023). The rise of global sea levels along with increased temperatures contribute to an already increasing evaporation rate and thus causing more intense storms and drought in many areas (NASA, n.d.). According to the Swedish Meteorological and Hydrological Institute (SMHI), Sweden will experience an even more drastic change as the weather will become warmer and wetter (SMHI, 2021a). Due to changing precipitation patterns more intensive rain seasons and runoffs are expected, especially on the west coast (Statens Offentliga Utredningar, 2007).

To counteract these projections, the city of Gothenburg with its coastal position is preparing for upcoming challenges (Göteborgs Stad, n.d.a) and so does Chalmers University of Technology (Akademiska Hus, 2019). Alongside the arising climate challenges Chalmers also intends to expand. More people on campus combined with limited space implies a need to densify. Developments of campus areas therefore require planning of efficient workspace solutions which at the same time preserves the campus spirit and handles the climate stress and its consequences.

1.1 Aims

As an attempt to address these challenges, this bachelor thesis investigates the opportunities to redevelop the southwestern part of Campus Johanneberg. The purpose is to create an area design proposition in its first concept stage, which can lead the campus to become “The world’s best campus when it rains”. In an effort to limit the project, the area under investigation has been chosen to be a part of Campus Johanneberg that is severely affected by stormwater. The area is positioned in the southwestern part of the campus outside the Department of Architecture and Civil engineering (the SB House), illustrated in Figure 1. It is surrounded by the SSPA-building, the Student Union Building and the street *Sven Hultins gata*. Other notable constructions are a biker shed in the southern part and the campus owned tram *Tågvagnen*.

To improve drainage of rainwater and treatment of pollutants, the project’s goal is to propose a renewed stormwater management layout. Simultaneously, an opportunity presents itself to redesign the area to be more attractive as an outdoor space for students, teachers and visitors. In doing so, the campus area could be transformed into a socially and environmentally sustainable space, which gives the Chalmers community an opportunity to enjoy the outdoors and meet each other.

Figure 1. On the left, the project area on Campus Johanneberg is marked in orange. On the right, the project area in detail, marked by the blue border.

1.1.1 Objectives and Research Questions

The main aim of this thesis is to provide a design concept for a campus social space with specific regards to effective stormwater management. In order to achieve this, the project is divided into a number of objectives, which follows:

- Investigate current functions as well as malfunctions, needs and requests regarding stormwater management and social environment at the case study site.
- Investigate ways to improve the stormwater management and social sustainability in the campus community.
- Propose a new layout draft of the studied area which contributes to the goal of becoming the “Greatest campus in the world when it rains”.

To meet these objectives, following research questions have been formulated to help guiding the research:

- Which are the requirements and requests for the project site, as a social environment heavily affected by stormwater?
- How can stormwater management solutions be combined with other features to contribute additional value to the social environment?
- What in this case defines “the greatest campus in the world when it rains”, and how can that view be incorporated into a campus area layout?

1.2 Limitations

The project delivers a comprehensive but conceptual stormwater solution. It contains the approximate placement in the area, main functions of water storage, treatment and social aspects but does not include further investigations regarding dimensions, construction or material choices. Due to the lack of resources, aspects such as groundwater or current constructions underground are not taken into account.

When evaluating the proposed space redevelopment, costs are not calculated or considered in more than brief terms in the discussion. The primary focus is on water management as well as social and partially ecological sustainability. Regarding timeframe there is a limit set to the year 2050, meaning that any construction plans beyond that are not considered. Finally, all instances of roofing looking like copper will be assumed to be actual copper and not a substitute meant to mimic the characteristics. This is due to being very difficult to investigate and confirm.

1.3 Societal and ethical aspects

Due to one of the area's primary functions as a transportation path across Campus, there is firstly a need for precaution regarding accessibility for users of varied needs. This includes for instance people with disabilities such as impaired vision or limitations in mobility such as wheelchair users, but also carriers of goods as well as emergency transports to and between the surrounding buildings.

While densifying and reshaping a campus it's also important to pay attention to the local traditions and values. If any particular object or space in an area provides values for the campus community, cultural or otherwise, a developer should work to preserve these. A redevelopment should preferably be seen as a possibility to pridefully emphasise the community values and visualise the campus spirit. With that said, the area is not only a space used by members of the university. The new design should therefore aim to contribute to and fit the entire larger environment in terms of aesthetics, recreation, sense of security and ecological services.

General safety aspects should also be considered if the solutions end up in designs which can cause danger. Deep water ponds with high edges can for example be problematic with regard to animals and people who are not able to swim. In addition, the project should at least consider ecological aspects and and to some extent also be economically defensible in construction as well as during maintenance.

2. Theoretical background

Following chapter contains this project's literature study, based mainly on scientific reports, books and articles received from Google Scholar and through Chalmers library's scientific databases. These are supplemented with material from municipal and federal guidelines, contributing information for the local understanding. Additional sources such as SMHI, the Swedish Environmental Protection Agency [Naturvårdsverket], the City of Gothenburg [Göteborgs Stad] and other organisations active in stormwater treatment are also considered to be qualified to be used in the study.

The chapter presents a comprehensive overview about stormwater management including copper pollution but also restrictions and guidelines regarding management of rainwater in the city planning of Gothenburg. It also describes different design aspects of social spaces and multifunctionality.

2.1. Stormwater

Rain can be defined in many ways and has several concepts behind it. A way to differentiate them is by the frequency of occurrences called the *return period* and the time the rain proceeds, the *duration time*. A 15 minute 100-year rainfall describes a rain which proceeds for 15 minutes and statistically only occurs at a specific place once over 100 years (SMHI, 2021b). *Normal rain* in this report refers to lighter rainfall with shorter return periods while *Cloudbursts* are defined as heavy rain with a minimum of 50mm/h or one mm/min, according to Wern (2021).

All precipitation is a natural part of the hydrologic cycle (EPA, 2003). In nature, water infiltrates the ground and only about 10 % is diverted as surface runoff. In urban areas however, impervious ground prevents the infiltration and makes the runoff amount about five times larger. Due to the ground's inclination, the water accumulates at low points and results in flooding which prevents mobility and accessibility and also causes moisture related damage to buildings and infrastructures. In civil engineering, the word *stormwater* specifically refers to these rain- and meltwater runoffs from hard made surfaces (Göteborgs Stad, 2010).

Stormwater management considers water volume but also quality, since urban areas provide exposure to pollutants from streets, pavements and buildings (EPA, 2021). These can be litter, nutrients or metals. When gathered up in large quantities, they can cause heavy damage to the ecosystems in or on the way to the recipients. The concept *first flush* describes the initial surface runoff from a rainstorm where concentrations of pollutants are higher than average (Bach. P, McCarthy. D & Deletic. A, 2010). This event often correlates with common pollutants such as the metals zinc, lead and copper, with main sources as traffic and metallic building materials (Naturvårdsverket, 2017).

Dimensioning stormwater flow depends on properties of the rain and catchment area such as intensity, duration time, area size, slopes and percolation conditions (Svenskt Vatten, 2016).

Issues due to stormwater can thereby be handled in many different ways, but since conditions vary from place to place one solution does not solve every problem. Sewage pipes in cities for instance, are dimensioned to collect volumes for normal rain while extreme events such as cloudbursts demand capacity on a totally different scale. This makes it economically or practically impossible to handle with the same solution and highlights the necessity of other options such as detention areas (Rauch. S & Sokolova. E, n.d). These are important for their ability to reduce peak flow to prevent flooding in urban areas.

Still, if managed correctly, accumulated stormwater does not necessarily have to be destructive but can serve as a resource for a sustainable society (Naturvårdsverket, 2017). Collected stormwater can for instance irrigate green spaces and facilitated infiltration can help to refill groundwater levels. Open stormwater storage can be used recreationally as well as for other vital functions of smaller urban ecosystems. Hence, stormwater accumulation is a natural event with benefits but can also cause issues related to both quantity and quality and therefore needs to be addressed.

2.1.1. Precipitation and stormwater network in Gothenburg

The annual precipitation level in Western Sweden is about 1000mm per year, which is higher than the rest of the country that lays around 500-800mm (SMHI, 2022). Naturvårdsverket (2017) describes how the changing precipitation patterns lead to more intensive rainfall, especially during winter months as the evaporation rate is lower and the ground is saturated with water. According to the agency, Gothenburg is one of the top five cities in Sweden with the highest risk of being flooded.

To avoid flooding, stormwater is diverted into underground networks, which have mainly two different designs (Svenskt Vatten, 2016). A *separated system* means waste- and stormwater are led into separated pipes where the former goes through treatment plants while the latter releases directly into recipients. This alternative is robust and standardly used in new development areas. In older areas, *combined systems* are more commonly used, where both stormwater and wastewater are conveyed into one pipe then lead through a treatment plant before being released into the environment.

In Gothenburg, the networks are dominated by older combined sewer systems (Göteborgs Stad, 2017). However, the ever-growing urbanisation and increased rainfalls have shown that the current sewer system is vastly undersized (Göteborgs Stad, n.d.a) which results in water overloading during precipitation peaks (Svenskt Vatten, 2016). To prevent this from damaging treatment plants and causing sewage flooding in buildings, the system is designed to bypass the plants and release untreated water into the recipients. This phenomenon is also called *combined sewer overflows* and results in the spreading of pollutants and debris.

2.1.2. Pollutants in stormwater

As mentioned in chapter 2.1, stormwater has a widespread problem with pollutants. Some that are common in stormwater are nutrients such as phosphorus (P) and nitrogen (N) as well as metals which include copper (Cu), zinc (Zn), and lead (Pb). The sources vary for the pollutants as well as the effect that they have on the water. Nutrients often originate from agriculture and organic matter and can cause eutrophication, while the metals often are related to traffic or urban materials. The substances affect the water's quality and larger concentrations can be toxic for both humans and the ecosystems (Yang, Y & Lusk, 2018). The area studied in this report is not close to heavy trafficked roads or agriculture but is positioned in close proximity to copper roofs. Therefore, the remaining report will focus mainly on copper pollution.

2.1.2.1. Copper as a resource and a hazard

Copper is a natural resource that has many areas of usage in society. It can be found in components in cars, electronics and pipelines (Fagerlund, S & Johanson, D, 2009). This is because it is considered to be relatively environmentally safe due to it being one of few metals which can be recycled without degraded quality (Copper Alliance, 2022). The article shows that during the last hundred years, two-thirds of all produced copper world wide is still in use. Due to its longevity and low maintenance requirements it has for a long time been considered an appropriate material for roofing, see Figure 2. Copper is also described as an aesthetically-pleasing alternative to roofing material compared to galvanised iron or plastic guttering (Pennington & Webster-Brown, 2008).

Figure 2. The building "Kopparbunken" at Johanneberg as an example of copper roofing showing signs of corrosion.

According to Pennington and Webster-Brown (2008) areas where copper roofs cover large parts of the impervious surfaces in the catchment can play a big role for the area's stormwater quality. While the metal is being exposed to the atmospheric environment, it is subject to the corrosion process and precipitation will cause the products to be flushed off into the surrounding environment (Galser, S & Helmreich, B,. 2022). The extent when it comes to copper runoff from construction varies widely between different rain occasions due to the environmental conditions prior to the event (Daban & Daoud, 2012). Previous studies have shown that the mean copper concentration in roof-runoff is at 2600µg/l (Göbel et al., 2007) but can vary from 10-100 times from measured levels from composite catchment areas (Malmqvist. P & Svensson. G, 2014). A study conducted by the municipality of Gothenburg regarding the large copper covered building Kopparbunken at Johanneberg campus (Göteborgs Stad, 2017), shows that high values of copper is present in the stormwater, even for the older roofs as they emits around 500µg/l copper in the runoff.

Studies have shown that higher concentrations of the metal makes the runoff water toxic and potentially harmful to biological organisms (Naturvårdsverket, 2019). The impact on organisms varies between different species, where humans can tolerate higher doses around 1000-2000µg/l compared to smaller microorganisms that have a negative effect already at concentrations as low as five µg/l (Rent Dagvatten AB, 2014). The effects can cause impaired decompositional ability of microorganisms that leads to a lowered quality of soil and viability of plants (Bali et al., 2021), or impacts the reproduction of fish which can eradicate entire populations (Yanong, 2010).

2.1.3. Laws, benchmarks and guidelines for water management

Swedish water management is regulated by several laws and policies (Svenskt Vatten, 2011). As a European country, it goes under the general Water Framework Directive [Vattendirektivet] which is implemented in Swedish law primarily through the Environmental code [Miljöbalken, (MB)] and aims to preserve and improve surface water quality to secure health and environment. Besides that, management also follows the Water Act [Lagen om allmänna vattentjänster, (LAV)] and the Planning- and Building Act [Plan och bygglagen, (PBL)] (Boverket, 2015).

Sweden is divided into five water districts, each one is responsible to set local benchmarks and create guidelines to make the municipalities live up to EU’s directive (Vattenmyndigheterna, 2022). Regarding stormwater however, the country lacks national guidelines and therefore measures across the country differ (Svenskt Vatten, 2019). The Municipality of Gothenburg has for instance recommended that copper as a building material should be avoided and set a reference value to 10µg/l for very sensitive recipients and around 22µg/l for less sensitive recipients (Göteborgs Stad, 2021b). This is not an absolute limitation, but a general recommendation as the guidelines are assessed individually (Miljöförvaltningen, 2020). It works as a template for the managers at the Environmental Administration to follow and reduce the risk of misjudgment, for instance during building permit applications. On the other hand, flooding guidelines from the Municipality of Gothenburg propose that roads with high priority for emergency services should not have a water depth greater than 0.2m (Göteborgs Stad, 2019). The Municipality also emphasises the importance of the roads that lead to buildings must be accessible for emergency service.

2.1.4. Stormwater management and technical solutions

Stormwater management has traditionally focused mostly on quantity (Sörensen & Wihlborg, 2019). However, with growing attention to climate changes and urban expansion it has evolved and integrated both quality factors and visual design. Beside volume diversion strategies the focus has shifted to source control to limit the initial pollution and *Blue-Green* infrastructure. The term Blue-Green describes technical solutions that utilises nature's ability to treat and delay water which reduces the negative impact of stormwater runoff and increases the evapotranspiration (Svenskt Vatten, 2011).

The publication P105 from Svenskt Vatten (2011) divides sustainable stormwater measures into four categories: *Local disposal*, *Delay close to source*, *Slow diversion* and *Collected delay*, all illustrated in Figure 3. Local disposal are solutions in direct proximity to the source while the last three regards measures further away, often using public means. They are characterised by efforts to delay rapid runoffs, facilitate infiltration and provide temporary storage for extreme events. Placement positions are selected with regard to low points and slopes so that impervious surfaces divert the water from sensitive areas into zones which either provides infiltration, temporary storage or facilitated flow downstream. Following sections present an outtake of such solutions along with ways to manage copper pollution.

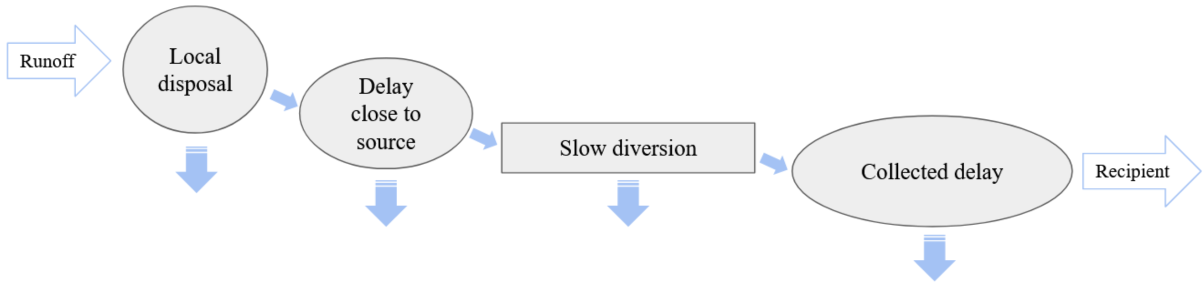

Figure 3. Categories and hierarchy of stormwater disposal. In order to minimise system strainage, disposing of the stormwater as close to the source as possible is preferred.

2.1.4.1 Local disposal solutions

The term *local treatment of stormwater* has been used since 1970 in Swedish descriptions of sustainable stormwater management (Alkan Olsson, Wihlborg & Sörensen, 2019). The definition has changed somewhat over the years but today Local disposal describes solutions that collect, treat and infiltrate precipitation directly on or in very close proximity to the landing site, without need for further diversion (Svenskt Vatten, 2011). Figure 4 and following sections show examples of different such solutions.

Figure 4. Example of a green roof.

Green walls and roofs

To combat the issues regarding decreasing vegetated exteriors, *green walls* and *green roofs* can be used. Plant mats placed on well drained surfaces and on roofs can provide green areas which in turn delay the water, reduce noise, benefit biological diversity and the quality of life (Manso, 2021). In the report written by Lau and Mah (2018), it has been shown that green walls can retain as much 45-75% of rainwater and could be even more effective on larger areas. Such vegetated areas can also effectively treat stormwater from pollutants such as copper. (Göteborgs Stad, 2017). There are several ways to design a green area, but in general thicker mats can handle larger amounts of water and pollution and require less fertilisation. It is important to note that thicker mats weigh more and can put a burden on the construction.

Rain garden

Rain gardens can purify incoming stormwater as the garden can be filled up with organic matter (Göteborgs Stad, 2017). Biofilter's purposes are to clean and delay the stormwater flow in addition to being aesthetically pleasing. The garden primarily handles everyday rain but can help to slow down the systems during heavy precipitation. This solution promotes reactionary values with green-space properties and has no impact on the area's accessibility.

To optimise the infiltration capability, the rain garden needs to be functional all year round (Andersson et al., 2019). This means a higher fraction of coarser material is recommended. Salt concentration is also important as plants with higher toleration of salt can hold more water and a good uptake of inorganic pollutants. If the garden's intention is to hold and delay stormwater, the infiltration rate should be between 50-300mm/hour.

2.1.4.2 Delay close to source solutions

If the water cannot be disposed of directly, the next step is to delay the runoff as much and early as possible by leading it across surfaces that allow infiltration and thereby conduct a decreased flow and trapping of pollutants (Svenskt Vatten, 2011).

Permeable surfaces and missing curbstones

The most common *permeable surfaces* for urban areas, except pure gravel beds and lawns, are pavers with open cells which are filled with grass or macadam, pictured in Figure 5. (Svenskt Vatten, 2011). These robust alternatives can replace impervious asphalt in parking lots, sidewalks and bike paths as those areas have lower abrasion than roads with high vehicle usage rates (EPA, 2021). Moreover, according to Brattebo & Booth (2003), permeable surfaces have potential to remove pollutants and their study shows that copper can be reduced from toxic concentrations to below detectable levels.

Figure 5. Example of pavers with open cells to allow for infiltration.

The efficiency depends on material composition, construction and maintenance which makes it hard to predict (Svenskt Vatten, 2011). Open cells, for example, risk clogging over time and cells filled with grass need a higher elevated grid to avoid being packed too densely. Permeable surfaces are also more challenging for people with disabilities to navigate as they often have more texture (Göteborg Stad, 2017). Another way to lower the consequences from precipitation peaks is to simply avoid solid edges on for example asphalt roads with adjacent lawns, or leaving strategic holes in the curbstone through which the water can escape to a more permeable area (Svenskt Vatten, 2011).

2.1.4.3 Slow diversion solutions

The main idea of slow diversion is to steer the water movement into a less harmful and more controllable path and on the way delay it as much as possible (Svenskt Vatten, 2011). Depending on the design can also have other additional properties.

Channels

To steer gathered stormwater in a preferred direction one option is to use *drainage channels* (Svenskt Vatten, 2011). These can be open or partly covered with grates or pavement to not hinder accessibility and the basic function leaves them open for varied dimensions and designs. By widening the channels into basins or adding friction material inside water can be retained and to some level also purified.

Infiltration pit or ditch

An *infiltration pit* or ditch refers to a depression in the ground with improved percolation capacity where stormwater can gather and infiltrate (Göteborgs Stad, 2017). Normal infiltration materials are large gravel or macadam and the construction can be complemented with a drainage pipe to avoid overflow (Svenskt Vatten, 2011). If adjacent slopes are covered with grass or other plants the crossing runoff can be detained and also somewhat purified. However, since the function depends on infiltration and vegetation it can be a slow working solution which also may prevent availability.

2.1.4.4 Collected delay solutions

Sudden cloudbursts and lasting downfall can result in rare but vast water volumes that substantially exceed ordinary solutions' capacity. For these occasions, a solution is to utilise so-called Collected delay where water flows further downstream are gathered in areas for temporary storage (Svenskt Vatten, 2011). This gives the rest of the stormwater system some respite and thereby prevents large-scale flooding.

Underground reservoir

An *underground reservoir* consists of a plastic skeleton and can be suitable for infiltration as well as delaying the stormwater (Göteborgs Stad, 2017). The reservoir is surrounded by a geomembrane/geotextile and the outlet flow is reduced. The volume efficient storage handles 95% of the reservoir's volume and the solution offers some purification of the water due to sedimentation. It mainly handles everyday rain but can be of help in heavy rains to slow down the systems. It works as such; incoming water can be led down to the reservoir directly through gutters and down into a reservoir and after that the water is infiltrated into the groundwater (Andersson, 2016).

Pond

Aside from being a landscape amenity, ponds can be used as stormwater storage (Persson, Somes & Wong, 1999). There are many components in a stormwater pond construction: Inlet and outlet for stormwater runoffs, flooding prevention or a network to keep the water from overflowing, a permanent water level and a storage for sediment (Al-Rubaei, 2017). Additionally, a pre-sedimentation method can be used to make it easier to maintain the system and a pump can be necessary to circulate the water in the pond (Svenskt Vatten, 2011).

The water quality of the pond is important and if not taken care of the pond will start emitting foul odour as well as contribute to other pollution. According to a study by Fraley-McNeal et al. (2007), the average purification efficiency for a wet stormwater pond is around 46%, compared to a dry stormwater pond where it is only 10%. When it comes to the purification of copper it treats up to 57% of the total copper in a wet pond and around 29% för a dry stormwater pond.

Detention basins

Dry *detention basin* is another solution to detain stormwater and reduce peak flow (EPA, 2021b). For the detention basin to provide a proper flow throughout the system, the slope around the dry detention site should not exceed 15%.

In a publication by EPA (2021b), dry detention basins can filter out some pollutants through settling but are ineffective at removing soluble pollutants due to the absence of a permanent pool. A typical vegetated detention basin has an aesthetic contribution for the surrounding areas, and they are easy to maintain with occasionally cutting and clipping (Ariluoma & Lähde, n.d.)

Wetland

Wetlands are areas where water covers the soil or is near the surface of soil for a long period of time (EPA, 2022c). The two types of wetlands are natural and stormwater/constructed wetlands. Both options provide removal of pollutants through settling and biological uptake, but since stormwater wetlands are man-made, they usually have lower level of biodiversity (EPA, 2021c)

Stormwater wetlands can manage highly contaminated runoff as long as there is a definite separation from the groundwater level. However, the drainage system for stormwater wetlands requires a large area in order to optimise the function of wetlands (EPA, 2021c).

2.1.4.5 Copper treatment

To reduce the copper pollution in stormwater, a promising way to manage roof rainwater is on-site infiltration as it provides the hydrological and geological conditions that allows infiltration (Athanasiadis et al, 2007). The pollutants are effectively removed from the runoff water before it enters the soil and groundwater through an artificial barrier and thus prevents it from accumulating in the grounds that could lead to highly contaminated sites.

Other options could be stormwater ponds that delay the flow of water so that the metall can sediment (Flemming et al, 1989). Though it is important to note that copper's presence in runoff water occurs mainly in its dissolved form. In this form sedimentation does not occur and thus sedimentation options for copper are not as effective.

Phytoaccumulation is another method that can purify water from copper, where it uses plants to remove various heavy metals from soils (Andreazza et al, 2012). To do this, different mechanisms including degradation, accumulation, dissipation, and immobilisation are used (Kafle et al, 2022). However, it is noteworthy that the method is still in the development stage and has not yet been widely applied. Much research into the effectiveness and application is still taking place.

2.2. Design of campus environment

Maintaining social spaces is an important aspect of promoting a sense of community, wellbeing, safety and inclusivity (Francis et al, 2012). In a university campus aspect, it can foster a sense of belonging, which could have an impact on academic success (Danoon & Mustafa, 2020). While designing a campus social space it is important to consider what purposes the space should serve to the campus community. Such factors include accessibility, safety, seating, weather protection and green space, that all combine to allow for social interaction. These aspects are therefore discussed in the following sections.

2.2.1. Accessibility

One of the main objectives of urban planning is to ensure the accessibility of spaces (Danoon Mustafa, 2020). This is essential in allowing anyone to use an urban space in a comfortable way, no matter the individual or time of day.

According to chapter 8 §9 of the Planning and Building Act (SFS 2010:900), a plot "should be arranged so that [...] people with reduced mobility or orientation ability should be able to access buildings and use the plot in other ways, if it is not unreasonable considering the terrain and other conditions, and the risk of accidents is limited." In the context of the project area, this means that anyone, regardless of any disability or age, should be able to traverse the pathway and also be able to enjoy the social aspects of the area. In order to meet accessibility requirements, The Swedish National Board of Housing, Building and Planning [Boverket] (2013) recommends avoiding large slopes and steps, bad lighting, loud noise and lack of proper signage. For elderly people or others who may find difficulties in walking longer distances, it is important to provide seating at regular intervals along designated walkways (Legeby, 2022).

2.2.2. Safety

When planning a community space, it is important that rules and regulations regarding safety are met. Such rules are primarily in place to avoid accidents such as falling or drowning, and are specifically targeted towards children (Boverket, 2021). In order to avoid such incidents, space intended for public use must be accessible, and be planned in a way where any risk of accidents are minimised.

Another aspect of safety is crime prevention. Although crime rates are heavily dependent on the area where the public space is located, criminal acts such as vandalism or drug dealing can be prevented through the application of clever urban planning (Boverket, 2023). This process is called "Crime Prevention Through Environmental Design" (CPTED). The method is based on six principals, five of which are of relevance to the project area around A-dammen:

- Territorialism - If residents or users of the social space feel connected or in some way responsible for it, they are less likely to commit a crime there.

- Access - By restricting access through the use of locked gates it becomes harder for individuals with the intention to commit a crime to do so.

- Surveillance - An area can be designed such that any crime that was committed would be seen by others or by CCTV, for instance by keeping all areas visible by maintaining greenery and lighting.

- Increasing difficulty to commit crimes - A planner may increase the difficulty to commit crimes by for instance constructing fences, using locks or installing alarms.

- Image - By maintaining a good image of a space, its owner signals that it is commonly used and taken care of. This can be achieved by repairing broken lights, trimming greenery, and disposing of litter.

- Usage - If an area is active and used during all parts of the day, it is also under surveillance. One example could be to offer nightly activities

2.2.3. Seating and weather protection

A majority of social activities are conducted while stationary, in most cases seated (Mumcu & Yilmaz, 2016). In total, as much as 47% of all activities in a community are conducted while seated or lying, highlighting the importance of sufficient seating space in areas meant for social interaction and recreation.

To create an accessible social space, it is important to include a variety of seating options. For instance, straight seating like ledges, steps or straight benches offer good spacing options, allowing for both single individuals or groups to sit (Mumcu & Yilmaz, 2016). Other options include circular or semi-circular seating, such as in Figure 6. These allow for social interaction when sitting inwards, and offer to avoid unwanted social interaction when facing outwards.

Figure 6. Example of circular seating.

Along with shape, it is important that weather also be considered when designing a social space, in particular regarding seating. Studies have shown that sunlight is a major attraction for use of public spaces during winter and fall (Mumcu & Yilmaz, 2016). When sought after, shade can be achieved in a variety of ways, but a common option is through the use of trees, which also add interesting texture and colour.

2.2.4 Green space

An important aspect of urban environments are green spaces. Some of its benefits include added biodiversity, improved stormwater management, and cultural value (Boverket, 2022). In addition, green spaces are beneficial for human health, as they have been shown among other things to decrease stress and stimulate physical activity.

When planning a property, there are no regulations requiring any certain amount of green space to be added (Boverket, 2020). It is however recommended that any publicly available space does contain an amount of green space. In Gothenburg, like most cities and towns in Sweden, a “Green-Plan” is in place with the purpose of ensuring that green spaces are included in urban planning (Göteborgs Stad, n.db). Although the plan solely acts as a directive document for municipal urban planners, it requires these planners to encourage green infrastructure in detailed development planning. This means that private landowners that own publicly accessible property can be incentivised to add natural elements when developing.

2.3 Multifunctionality

The natural environment provides cities with so-called *ecological services* which are essential to humans and improve life quality and welfare (Naturvårdsverket, n.d.). *Regulating services* facilitates pollination and treatment of water by natural infiltration. *Cultural services* provide an appreciated environment for recreation, pedagogy, wildlife experience and cultural heritage. Reinforcing these functions in urban areas by creating multifunctional surfaces can be a way to handle the combination of limited space, functional demands and climate challenges. The Swedish project Rain Gothenburg (Rain Gothenburg, n.d.) and the north European project BEGIN (Interreg, n.d.) are two examples of Blue-Green infrastructure investments which have aimed to merge stormwater management with a special design.

Multifunctionality can many times be achieved by thorough design- and construction features, where several of the technical solutions used for stormwater management already existing have multiple purposes. For example: A rain garden, as described previously in chapter 2.1.4.3, is both a water detainer, where it treats the inflow by infiltration and can be a beautiful aesthetic element as well. Another example are immersed surfaces for recreation or physical activity which can serve as detention basins during cloudbursts while edges and embankments can form seatings and places for rest during dry periods (Göteborgs Stad, 2017). Figure 7 shows an example of this.

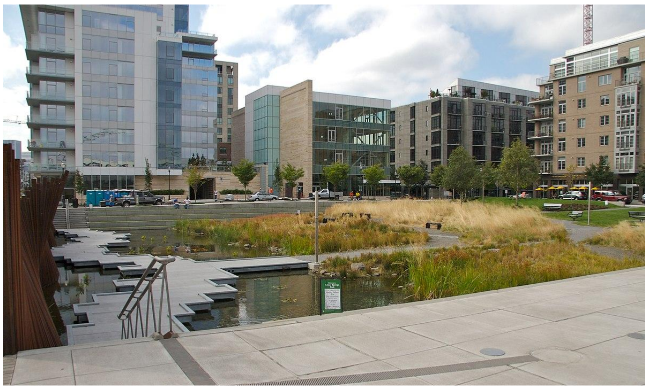

Figure 7. An example of a multifunctional stormwater solution. The image depicts Tanner Springs Park in Seattle, USA. While offering a green space and meeting space, the park also acts as a stormwater retention pond during heavy rainfall and flooding. From *Tanner Springs Park* [Photograph] by Cord Rodefield, 2007, Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Tanner_Springs_Park.jpg. CC BY 2.0.

The next step from a sustainable perspective is to not only hinder the water from being bothersome or hazardous, but to use the free liquid volumes as a resource. Water reuse is gradually becoming more implemented across the world on varying levels, from small scale garden irrigation to more complex shower- and toilet flushing installations (Adeeyo et al., 2020). Aquaponic stormwater management is another biofiltration technique where pollutants in stormwater are used nourishment for cultivating of plants (AquaShield, n.d.) Open water mirrors and rippling sounds of streams or fountains are features that can amplify wellbeing and lower stress (BBC Radio 4, 2020). Thereby human recreation can be combined with provision of the unique prerequisites necessary for many water based ecosystems and biodiversity (Göteborgs Stad, 2017).

Multifunctional urban stormwater design highlights the ambition to make people appreciate solutions not only despite surrounding conditions as the weather, but because of them. During a pre-study for Rain Gothenburg for instance, citizens express wishes for events connected to the recurring downpour (Göteborgs Stad, 2017). The project group then developed a scenario where the city during rainfall periods should be "awakened". Unfolding of colourful rain roofs, activation of hydraulic art installations, rain-sales in stores and other innovative solutions would transform the environment and make the weather seen as a proudly distinguishing city signature instead of an annoying obstacle. The project also carried out several subprojects in Gothenburg where for example well-cap-poetry, water resistant paintings on sidewalks and a stormwater playground for kids showed how stormwater can provide aesthetic, social and cultural values.

3. Method

To achieve efficient and an appropriate user focus, the process of this project was inspired by modern product development theory, presented by Johannesson et al (2013). First by generating a prestudy to base and frame the problem, then by proceeding into a synthesis phase where existing knowledge and creativity was applied to gradually develop a suitable final concept. The following sections describe how the project was carried out. It explains how data additional to the literature study was inventoried by a survey, interviews on-site visits as well as modelling tools. It also contains different methods for innovation and evaluation as well as calculations of storage and flow capacity. Figure 8 in section 3.1 gives a graphical overview of the process' three phases which are also described in text.

3.1 Overview of project procedure

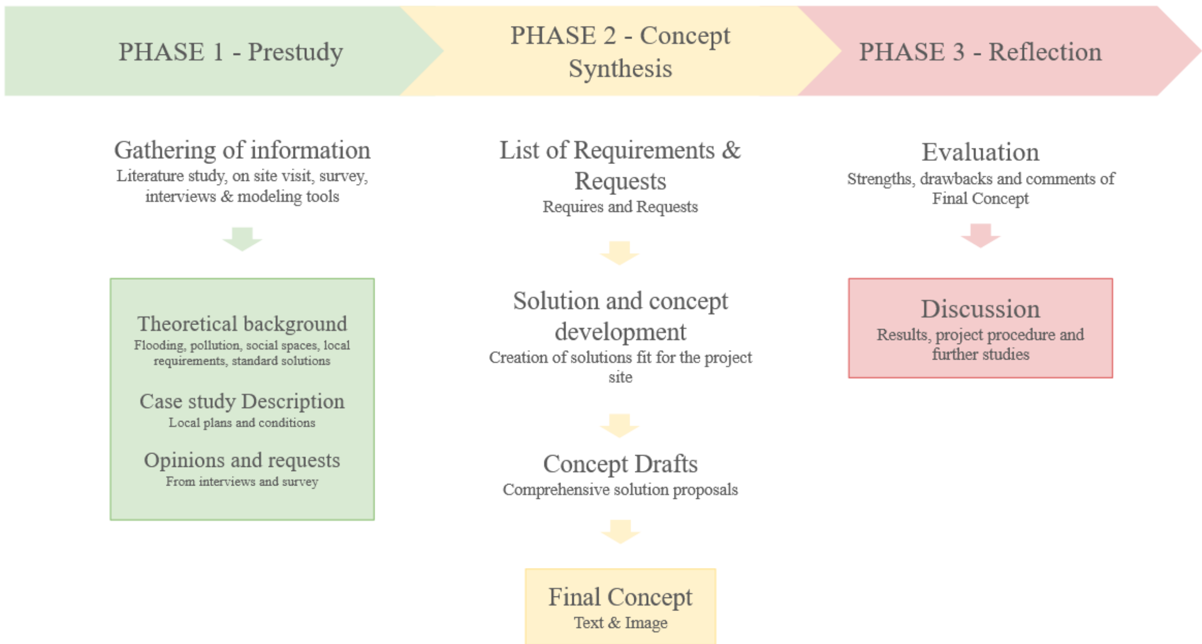

Figure 8. Graphical overview of the project's procedure, divided into three phases. The coloured boxes symbolises the main contribution of each phase to the project.

PHASE 1 - Prestudy: The project commenced with investigation of current conditions. The information was primarily based on literature; scientific articles and reports of city planning, but also on personal experience of the project site and interviews with people of relevance. For deeper understanding of subjective factors such as cultural values, a survey was carried out with the aim of collecting opinions and requests among Chalmers students.

The gathered information covers the project's three underlying issues: stormwater flooding, copper pollution and social area design. These were investigated in more detail which lead up to presentations of standard solutions. Other collected information regards stormwater flow and was based on simulations of the project area made in the computer programmes SCALGO and MIKE.

PHASE 2 - Concept Synthesis: To sum up the relevant conditions and demands a list of requirements and requests was formulated to work as a sounding board for the concept development. The project proceeded by discussing presented solutions in regard to the specific project site. By steps of iterations, two concept drafts were proposed and then narrowed down to a single suitable final concept.

PHASE 3 - Reflection: Finally, The Final Concept was evaluated in terms of strengths and drawbacks, followed by a discussion covering the entire working process. It reflected on the methods used, possible needs of further iterations but also gaps in knowledge and areas of interest for future studies.

3.2 Survey

When reshaping Chalmers campus it is important to keep in mind that the changes are mainly meant to offer the students and staff a better environment. Therefore, asking what the demographic wanted seemed to be a beneficial start. Considering that the area in question contained unique objects and spaces which may hold both practical use as well as sentimental and cultural value, it seemed highly important to apply a method which could possibly identify these values and opinions among the affected people. Thus, a survey was carried out and the gathered data is presented in section 5.1.2. The entire questionnaire is featured in Appendix A.

3.2.2 Motive

The goal of the survey was to map out opinions of the users regarding experienced issues, objects worth preserving but also which changes were considered of high priority. To keep the questions specific, the area was divided into three different parts illustrated in Figure 9; a pond called *A-dammen*, a green area named *Geniknölen* and a pedestrian passage between the Union house and the SB-house entrance. Each part has different functions and therefore required different question approaches, depending on what information seemed relevant for the project.

The passage for example, had affirmed stormwater problems, a major topic of which the thesis aims to address. Therefore, the survey intended to clarify what the users experienced as issues to search for possibilities to address those. Changing Geniknölen on the other hand was not the project's main ambition, but the area still seemed reasonable to investigate as it could be affected by adjacent solutions. A-dammen was the main focus of the survey, since it takes up lots of mainly unused space and therefore showed large potential for changes and improvements. However, its fountains and large water surface still contribute aesthetically to the area, hold traditions and enable unique water activities. Because of this, it seemed sensible to investigate the opinions on the matter, to not risk destroying anything unreplaceable.

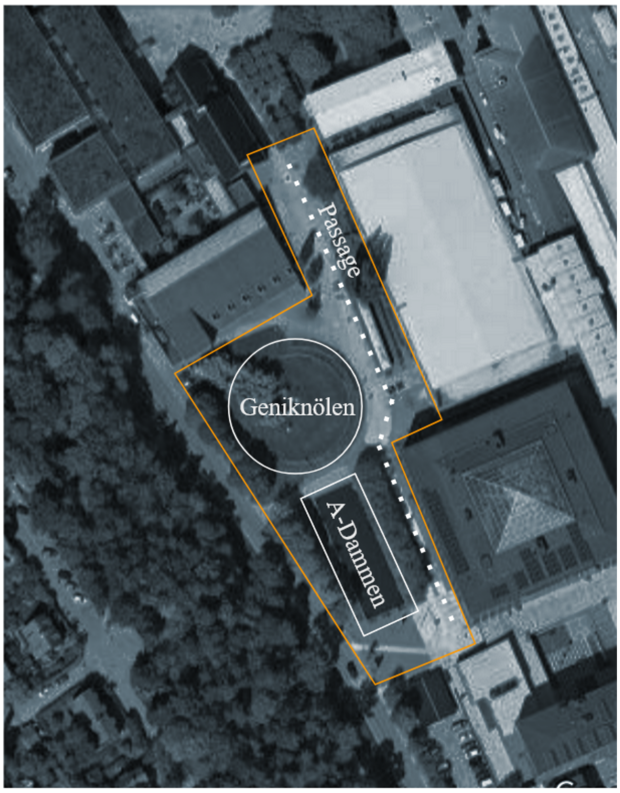

Figure 9. Overview of different areas covered in the survey.

3.2.3 Target group

The survey was aimed at respondents who were considered to become affected by eventual changes in the area. That included people who regularly crossed the space, ate lunch on Geniknölen, participated in events in Tågvagnen or at A-dammen etc. During the data analysis respondents who regularly visit the area were therefore primarily considered of greater relevance than people who don't. Participants were found by direct communication through the student community.

3.2.4 Design of survey questionnaire

A survey guide written by Malhotra (2006) describes how to form a survey suited for intended motives and targets. A main point the author highlights is the need to avoid bias and confusion to represent thoughts of the responders in a proper way. The questions of this project's survey were therefore designed with this in mind.

The survey consisted of 16 questions, a short introduction of the project as well as questions aiming to depict information about the participants. Following that, a series of questions related to the three main topics: Geniknölen, the passage and A-dammen. The questionnaire contained different formats including multiple alternative choices, drop-down menus, scaling from one to five and open text. The questions focused on peoples' experiences with stormwater, the outside social environment on campus, what value the area has to them and resistance to remodelling. Trying to achieve a high answering rate the survey was accessed by

Quick response code (QR-code) or link through the digital platform google formula and was constructed to take five minutes to answer.

3.3. Interviews

Interviews are a common way of collecting qualitative data (Gubrium & Holstein, 2001). This study aims to use them to add opinions and objectives from stakeholders and experts to the information gathered from the literature study and survey. The results are presented and discussed in chapter 5.1.1.

3.3.1. Target groups

The interviews were held with people well-versed in stormwater management but also representatives of companies and organisations who own or appeared to have an interest in development of the Chalmers campus and therefore may provide the study with extended knowledge. The interviewees were:

- Sara Karlsson, a Strategic Property Developer of Outdoor Environment at *Akademiska Hus*.

- Anna Zahlbruckner & Freja Frenberg, both titled as Campus and Local Developer at *Chalmersfastigheter*.

The two companies own different parts of the Campus and could thus give different insights in questions regarding planned developments and where the responsibilities for the area lies.

- Jens Thoms Ivarsson from *Kretslopp och Vatten* at Gothenburg's municipality, who held knowledge of general city planning and reconstruction of urban spaces in Gothenburg. He also had experience of stormwater management and multifunctional design as creative director on similar projects, for instance "Rain Gothenburg".

3.3.2. Design of interview questionnaires

For this study, the interviewees were contacted by telephone and email. The following interview session was held both face to face and over zoom during a total of 45 minutes with about 30 minutes active time for questioning. To conduct these interviews effectively from a data collection standpoint, the questionnaires were designed in what Gubrium and Holstein (2001) defines as a "semi-structured way". This means open-ended main questions for the interviewee to answer and a possibility to ask follow up questions which allows in-depth data to be collected while still focusing on topics of relevance. Imitating this structure, every interview session was prepared with three to six main questions or themes with following subquestions, withholding time for discussions and digressions. Due to the interviewees' different areas of expertise, the questions differed and were more specified when sorting out technical information and more open while discussing for instance inspiration to possible solutions. The prepared questions for each interview can be seen in Appendix B.

3.3.3. Ethics of interviews

In order to ensure scientific integrity, the interviews are to be conducted in an ethical way (Gubrium & Holstein, 2001). To ensure that the interviewer conducts themself in an ethical manner regarding the interaction and the analysis of the collected data, the interviewer should:

- Obtain consent from the interviewee.
- Respect privacy and confidentiality.
- Highlight the relationship between the interviewer and interviewee.
- Be mindful of their own biases.

The ambition was to carry out the interviews in this study with these recommendations in mind. For example, each interview session began with clarifying the interview situation with aims of the project and responsibilities of different participants. Consent regarding audio- or video recording was also verified and through the session the interviewers strove to behave as polite and perceptive listeners. Afterwards, the recordings were transcribed, with the full version available in Appendix B. To avoid one sided perspectives and identify possible bias, the received information was later analysed by the interviewers themselves in addition to remaining members from the rest of the project group.

3.4. Visit on site

In order to improve the area, it seemed important to first investigate its current state and issues. Therefore the site was visited, both during dry weather and rainfall. The aim was to get an overview of already applied drainage solutions and collect knowledge of flooded areas and possible reasons behind the water gatherings. These results are gathered in chapter 4, the Case study description. The visits were also an opportunity to get a feeling of the space on a whole, to later on create better proposals for technical solutions and landscape layout.

3.5. Digital flooding simulation

The following segment describes the implementation of flooding simulations. The purpose is to provide a better understanding of the risk of flooding that exists in the area and locate the zones with higher risk of great water collection.

3.5.1. SCALGO

SCALGO is a digital modelling tool that uses terrain data to map out elevation structures and depressions and with a chosen amount of rainfall, the tool simulates the amount of water collected in different low points (Scalgo, n.d.). The calculated output consists of volume and depth of the water gatherings, along with catchment areas and watersheds, meaning catchment area dividers. This helped identify accumulation areas and the amount of water that would need to be managed and also indicate if certain accessibility requirements are at risk.

Since the program is static it does not consider the runoff rate or delay of the water, nor the duration of the rainfall. However, not accounting for time-dependent parameters leads to several complications. In particular the lack of consideration for delay makes it difficult to quantify the effectiveness of open stormwater solutions. This could affect the outcome by projecting an exaggerated flooding with higher water levels. Additionally, the program does not account for infiltration of water which could result in pictures of flooding where the water in reality seeps into the soil. When using this software, these shortcomings needed to be considered to avoid inaccurate conclusions.

Application

In the project, SCALGO was applied to simulate the accumulation of water in case of high annual rainfall as well as how the water will flow and where streams will form. The tool "Flash Flood mapping" was used for both locating flooded areas and visualising flow accumulation. The amount of rain was set in the simulation based on statistics from Svenskt Vatten (2020). Bodies of water with a depth greater than five cm were set to be shown in the flood analysis. More shallow bodies of water were considered to be irrelevant in this project since these were assumed to be able to run off relatively quickly before creating problems for accessibility or buildings.

The input used in the project was selected to represent extreme weather with values based on 10-year rain and 100-year rain, measures used to define the heaviest rainfall of respective time periods. Statistics about stormwater volume represent the south west parts of Sweden and were taken from Svenskt Vatten (2020). The amount of rainfall and inputs used can be seen in Table 1. Since SCALGO does not consider duration time the stormwater statistics was modified to represent the amount of flooding after a specific time period. The analysis therefore became the amount of flooding after 15 minutes and 60 minutes of rain.

Table 1. Stormwater volume in mm after a duration of 15 minutes and 60 minutes for 10-year and 100-year for the south west parts of Sweden (Svenskt Vatten, 2010).

Duration [min]	**10- year rain [mm]**	**100-year rain [mm]**
15	18	35.1
60	24.5	45.2

3.5.2 "Vatten i Staden" - MIKE

Vatten i staden is a digital simulation tool provided by the municipality of Gothenburg. It is based on multiple formulas of different applications of the computer program MIKE (Göteborgs Stad, 2021a). Here, the simulations visualised flooding and the direction of water streams caused by cloudbursts (Göteborgs Stad, n.d). The data was used to complement the data generated by SCALGO.

The formulas used in MIKE are developed by Danish Hydraulics Institution (DHI) and uses hydrological and hydraulic models to describe rainwater runoff on the ground and flow of water in the sewage system (Thorén, 2015). The calculations by the tool Vatten i staden are based on the input of six hours of rainfall in a 100-year rain.

3.6. Concept synthesis

The book "*Design i fokus*", (Österlin, 2016) promotes three principles to provide efficient and innovative problem solving: 1: A clear goal definition, 2: A large range of initial ideas and 3: Methods for creative thinking and evaluation. For complex issues that helps with prioritising focus, avoiding getting stuck in old ways and providing equal judgement of solutions. The book aims primarily at product development but since city planning is a form of design, it was still considered a useful approach. The methods were chosen to utilise the group members creativity to create a wide range of ideas and then methodically narrow these down into a refined comprehensive concept. Figure 10 illustrates the entire synthesis procedure and following sections present in more detail the different methods used for creativity, calculation and evaluation.

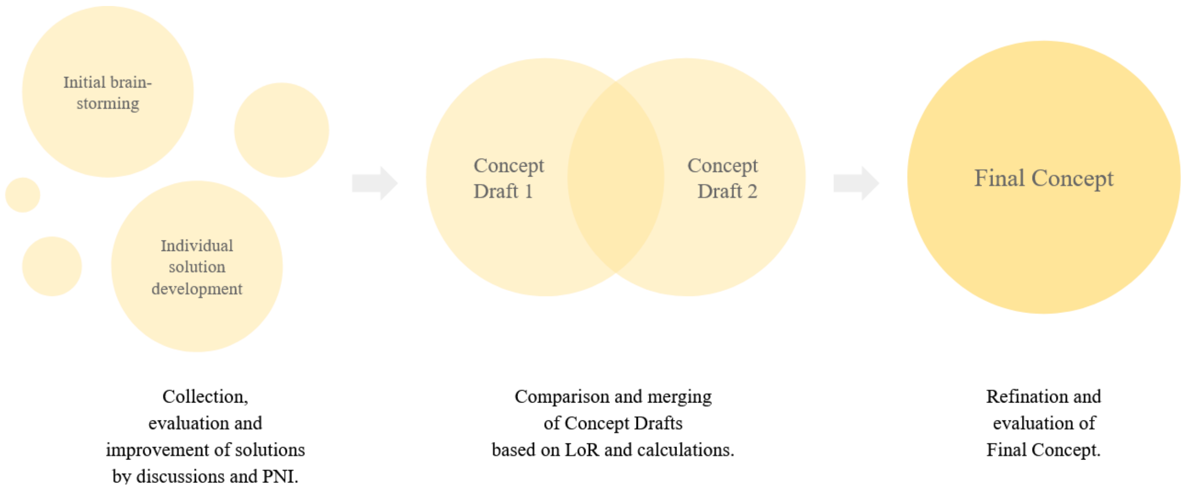

Figure 10. Overview of concept synthesis procedure.

3.6.1. List of Requirements and Requests

A promoted milestone in product development is the so-called Requirement Specification (RS), a list of foundational demands which upcoming solutions need to fulfil (Österlin, 2016). The process of creating it starts with breaking down the problem into basic functions which solutions are then investigated one by one. This helps focusing on the issues and avoid getting stuck in predetermined solutions so the list becomes a tool used for evaluation of concepts but also creative thinking.

For this project, that strategy was imitated in order to find a comprehensive solution to the project's different issues. Discovered conditions and demands were boiled down into a so-called list of requirements and requests, shown in section 5.2.1. This can be viewed as a light version of an ordinary RS and hold quantitative demands based on literature and simulations as well as qualitative needs gathered from the survey- and interview answers as well as own experiences. Since the vision of "The greatest campus in the world when it rains" depends on perspective, it was used to communicate different standpoints and outline a common approach.

To help construct a social space with controlled stormwater issues the List of Requirements and Requests (LoRR) covers three main topics. "Stormwater", "Safety", and "Recreation, Social Interactions and Campus Spirit", are all represented in one table each, Table 4, 5 and 6. Each table presents the four weather situations "Always", "Cloudburst", "Normal Rain" and "Dry Periods", which hold different demands categorised as either "Requirements" or "Requests". Target groups are the members of the Chalmers community including people with reduced sight and mobility, visitors as well as service- and emergency personnel.

3.6.2. Creative and evaluative methods

Following paragraphs describe the methods used for creation and evaluation of solutions to the projects' different issues.

3.6.2.1 Initial brainstorming

These sessions were open discussions of possibilities, aiming to widen creativity, inspire group members and document already existing ideas. At the same time, the discussions clarified boundaries and focus areas which helped in finding relevant information. The results are therefore primarily integrated in the report's Introduction, theoretical parts and the Case Study's LoRR.

3.6.2.2 Individual solution development and PNI

When the group members had become familiar with the theoretical background, they worked individually to apply and modify standard solutions to fit the case study site. The next meeting was held as a workshop where the new ideas were presented and evaluated. For that, the method PNI (positive, negative, interesting) was used, as a quick and easy way to elaborate the understanding of the part solutions (Österlin, 2016). Appendix C contains a table with the entire list of solutions from this workshop.

3.6.2.3 Production of comprehensive concept drafts and evolvement to final concept

Due to the range of technical solutions the stormwater issues could be solved in different ways. Therefore, the group splitted into two teams, creating one comprehensive concept draft of the case study area each. The idea was to generate two solution drafts which fulfilled the LoRR as well as possible. Then these would be compared with either one chosen as the best alternative or the two merged to a final concept. To support the solution choices approximative calculations were made to estimate differences in flow and water storage capacity, which are described more thoroughly in section 5.2.4.2. A thorough description of the two drafts are available in Appendix D while the Result chapter summarises the content before presenting The Final Concept in section 5.2.4.

3.7 Calculative methods

Following section contains methods for calculations that were made for the two concept drafts and The Final Concept. The aim was to provide approximate but impartial comparisons between different solutions' stormwater capacity and therefore consider both runoff flow and available volume for water storage.

3.7.1 The Rational Method

To examine how the proposed solutions capacity to handle stormwater flooding, the Rational Method was implemented. It is a mathematical equation used to calculate stormwater runoff flow of a specific area while taking various surface properties into consideration (Bondelind & Hägglund, 2018). With this method, calculations for maximum stormwater runoff in an area with a certain amount of rain and within a certain return time can be made (Svenskt Vatten, 2011).

When doing this, the total area was divided into different fields based on the surfaces' different runoff coefficients (Bondelind & Hägglund, 2018). It took into consideration the delay of stormwater in the different types of volumes as for example green roofs, macadam reservoirs and more. These coefficients are a measure of the percentage of the area that is contributing to the runoff. On hardened surfaces less water can be infiltrated in comparison to green surfaces such as grass where the water is infiltrated naturally. The coefficients vary between 0-1 for different types of surfaces (Svenskt Vatten, 2011).

The Rational method was applied to the project's all comprehensive concepts: Concept Draft 1 and Concept Draft 2 as well as The Final Concept. The goal was to study how applied solutions changed the stormwater capacity and therefore two scenarios were calculated for each concept; before and after applied solutions. To avoid unnecessary calculations for the concept drafts, unchanged areas were excluded from the scenarios. This however caused the before-scenarios of the two drafts to differ which made percentage comparisons appear misleading. Therefore, only absolute values of flow and flow decrease were calculated in the results. The Final Concept, on the other hand is presented with both absolute values and percentage differences to better visualise the capacity changes.

3.7.1.1 Equations and Parameters

To carry out the calculation method, equations and parameters from the book *Hydraulik för Samhällsbyggare* (Bondelid & Häggström, 2018) were used. To calculate the maximum rainfall equation 1 was used:

$$Q_{max} = i * \phi * A * k_f \qquad (1)$$

Q; flow [l/s]
i; rain intensity [l/s· ha]
ϕ; runoff coefficient [-]

A; surface area [m^2]
k_f = 1,25 (climate factor)

Due to expected climate change, rainfall is expected to increase and thus the climate factor was included. According to recommendations from Svenskt Vatten (2016) the factor was set to 1.25 regarding precipitation with a duration shorter than one hour.

To calculate the rain intensity equation 2 was used (Bondelid & Häggström, 2018):

$$i(tr) = 190 * \sqrt[3]{T} * \frac{ln(tr)}{t_r^{0.98}} + 2 \qquad (2)$$

i(tr); intensity [l/s· ha]
tr; is the duration of the rain [min]
T; is return time [month]

The calculations followed the recommendations from Svenskt Vatten (2016) which includes requirements for new stormwater facilities that have a return period of 30 years and duration of rapid stormwater diversion varying between 10 minutes to two hours. Rain intensity depends on the rain's duration and return time. In the calculations 100-year rain with a duration of 60 minutes was assumed.

t_r = 60 min
T = 360 months

To calculate the rain intensity, equation 2 and following parameters for duration, return time were used as well as runoff coefficients, see Table 2. Gravel type 1 represents the original gravel material on the site. Its runoff coefficient is an estimation based on the value of Gravel type 2 and the value 0.25 mirrors a slightly denser material with lower infiltration rate. The other values presented in Table 2 were taken from the book *Hydraulik för samhällsbyggare* (Bondelid & Häggström, 2018).

Table 2. Runoff coefficients for different surface types.

Surface type	**Runoff Coefficient ϕ [-]**
Grass	0.1
Normal roof	0.9
Green roof	0.5
Flowerbed	0.1
Hard surface	0.8
Sand/Gravel (type 1)	0.25
Sand/Gravel (type 2)	0.2

Rain garden	0.1
Permeable surface	0.3

3.7.2 Detention basin volume calculations

To handle the 100-year rains, detention basin storage solutions that can store stormwater were examined. These basins are incorporated to reduce the peak of stormwater runoff discharge. Stormwater storage was determined by calculating the volume of the magazine. The calculations determined how much water the basins can hold and thus how much the flooding can be reduced. Important to note is that the following calculations only take the basin volume capacity into consideration. Factors such as infiltration, purification and rain intensity were not included. To calculate the volume Equation 3 was used.

$$V = A * h \qquad (3)$$

V; Volume [m^3]
A; area [m^2]
h; height [m]

4. Case study Description

Following section describes conditions, facts and challenges relevant to understanding this specific campus area project. It covers descriptions of the project area, noticed stormwater issues on the site and established plans for future campus development.

4.1 Description of project area

The project site consists of areas with different properties and this following segment presents them with regard to its current uses and stormwater-related issues. It presents A-dammen and Geniknölen in detail and also the adjacent pathway with surrounding areas. The information is based on observations during visits on the site and personal communication with Chalmers staff.

4.1.1. A-dammen

A-dammen, shown in Figure 11, is a shallow pool located in the south-west part of the area under examination. It is notably flanked by a small, elevated green space to its west which acts as a barrier for rainwater from Sven Hultins gata. A line of trees lay on its eastern flank.

Figure 11. A-dammen on a sunny, late winter's day.

The pool itself is just 0.4m deep, about 13m wide and 42m long. It is made entirely out of stone slabs with a few fountains along its central axis. According to Sebastien Rauch (Professor at the Architecture and Civil Engineering Department, personal communication, April 20, 2023) it was constructed during the 60s to serve as a cooling mechanism for the university's new computers. Though by the time the construction finished, technology had advanced, rendering the primary function obsolete. Since then, the A-dammen has remained foremost as an aesthetic feature and does not hold any particular purpose regarding stormwater depository or treatment.

A few times a year A-dammen is used during student events, but mostly it sits as an under-utilised still pool. Between October and March the pool is empty, negating the aesthetic value the water would otherwise have during these months.

4.1.2. Geniknölen

Geniknölen, shown in Figure 12, is a green space where the campus community has an opportunity to rest and relax during their free time. The space consists of a few trees providing shadow atop a grassy hill surrounded by a concrete bank with a few benches. The space is particularly popular during warm and sunny days when wet soil isn't an issue as it is one of only a few green spaces on campus. During and after rainfall, parts of the space can get quite muddy, making the area harder to use.

Geniknölen isn't used for any special events during the year, but acts as an important landmark to help new students navigate themselves during their first weeks. It holds an important role in campus safety as it is used as an assembly point in case of fires or other emergencies.

Figure 12. Geniknölen.

4.1.3. Pathway and surrounding features

The largest part of the project area is made up of a cobblestone pathway going north to south, as well as a larger open cobblestone/asfalt space, see Figure 13. Its main purpose is to act as a transportation route for campus goers and visitors. The open nature of the pathway allows for large flows of pedestrian traffic, which is useful during high usage hours like lunch time, as well as during special occasions like freshmen orientation where large crowds often form. As well as benefiting pedestrian flows, the open space also allows for larger vehicles like campus security or emergency services to use the pathways.

Figure 13. Pathway in the area.

Apart from the previously mentioned A-dammen and Geniknölen, the area also features a few smaller points of interest and features. One such is Tågvagnen, often used as a venue for student events or gatherings, see Figure 14. The facade behind the train carriage is partly covered in vegetation and is the only feature of it within the project area. Also of note is the decorative artwork along the path commemorating patron saints of student sections.

Figure 14. Tågvagnen.

4.1.4. Current drainage system and stormwater issues

To get an understanding of the stormwater system in the area and how rainfall affects accessibility and comfort, the site was visited during both rainfall and dry weather. During the time limit no cloudburst appeared so instead the objective was to understand conditions during moderate rainfall.

Regarding the drainage system, the area was found to be equipped with several drainage wells, grate covered gutters and downspouts, illustrated in Figure 15. However, due to the uneven pavement many places have insufficient sloping and elevation levels which prevents the draining and leads to puddles or mild flooding even during normal rainfall. The stairs leading into the SB-house were also found to be troublesome, as the large puddles of water gathered on the steps. This is due to the fact that they are not flat but have a certain slope where the water flows to the middle.

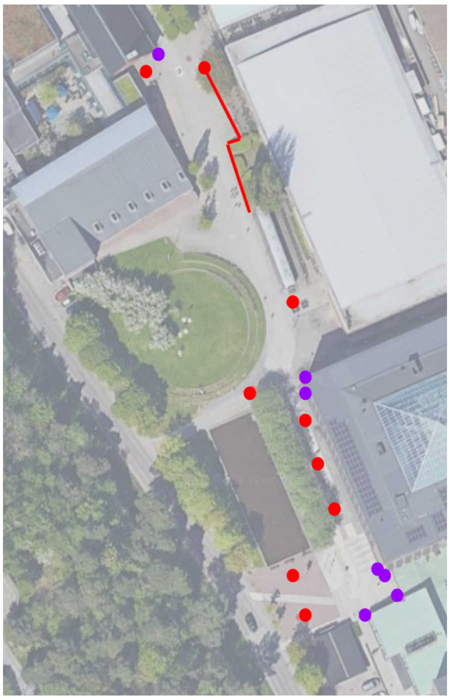

Figure 15. Map of stormwater drains and gutters. Red dots mark storm drains, red line mark a stormwater gutter and purple dots represent roof gutter downspouts.

Looking at flooding issues, the major area of concern is deemed to be in the northern part of the project site along the passage, where uneven terrain, insufficient drainage and sloping causes large gatherings of water, like in Figure 16. Pedestrians must either step through the puddles or make an effort to go around or over them which could cause inconvenience. In terms of accessibility, the puddles seem to risk causing difficulty and discomfort for disabled people walking with canes, crutches or using wheelchairs. They can also cause added hindrance for the visually impaired, as it becomes more difficult to use their canes. As it stands, the puddles do not however seem to be a hindrance for emergency vehicles.

The site has driving routes for emergency services vehicles (Siljedahl, 2004). These go from the Student Union Building to SB-building and are along the pathways. These routes must be unobstructed. Sven Hultins gata is the major transportation path but according to Göteborgs Stad (2019) it is not defined as a high priority road. However, as mentioned in chapter 2.1.3, the goal of 0.2m was still deemed appropriate for this area.

Figure 16. Passage during rain.

Another area of concern is “Lennart Rönnmarks plats” the gravel square just south of A-dammen. Here, water would not penetrate the surface but instead gather around the area’s two storm drains. The drains however seemingly do not work as intended, as they would not drain away the storm water gathered around them, even when the rain had stopped like in Figure 17. This can be due to sediment buildup in the drains, as the stormwater flows pick up gravel along the square’s surface. Another issue is that although this is a newly constructed surface it has become uneven, this again likely due to erosion or ground heave. This prevents the runoff even more and along with the uneven passage pavement gives the area a quite unkempt appearance.

Figure 17. Lennart Rönnmarks plats post rainfall.

The stairs leading up to the SB-building are constructed with an inclination towards the inner area. This prevents runoff which results in water gathering in the centre of each step. The amount of water is small and most runs off, but it can cause inconvenience to pedestrians using them to enter the SB-building.

In regard to copper pollution, there is a significant potential source in the copper roofing found in the southern part of the area around the SB Entrance. This roof covers a large part of the SB House, but since the majority is tilted towards the inner yard only a lesser amount of polluted water seems to divert onto the project site. A summarising picture of all the noticed problem areas is presented in Figure 18.

Figure 18. Overview of areas for stormwater problems on the site. Blue markings show visible floodings during normal rain and orange circles show where the significant copper sources (roofs) can be found in the area.

4.2 Overall development plans for Chalmers campus

Chalmers University is divided into three campuses Johanneberg, Lindholmen and Onsala. The report only covers the Campus Johanneberg which is situated in the southern part of central Gothenburg. Johanneberg. As with much of Gothenburg, the ground largely consists of deep layers of clay, which in itself requires special requirements when building on the site (Jendeby. L, 2020). Because of this, the city's geology is well known and the Gothenburg clay is often described as a hindrance, but with the right knowledge it is possible to build on. The school is home to 8 500 students and around 3 000 employees (Chalmers, 2021). It covers a large area with study facilities covering 420 000m^2 and is tied together by walkways and green spaces (Akademiska Hus, 2019).

Together with the Chalmers Student Union, *Chalmersfastigheter* and *Akademiska Hus*, Chalmers University of Technology has set a vision to develop a more sustainable and environmentally friendly campus with better usage of the already existing spaces as well as expanding the campus (Akademiska Hus, 2019). According to the Chalmers' Campus Plan 2019-2050, the university's plan for Johanneberg campus by 2050 is to build around 300 000m^2 facilities both aimed for study spaces, housing etc and 55 000m^2 are old buildings that are to be reconstructed.

The plan covers issues with stormwater on campus. As Johanneberg is surrounded by higher grounds and passageways with large slopes, it results in restricted accessibility and unwanted water flows (Akademiska Hus, 2019). To combat the problem, the campus plan envisions creative solutions to stormwater management, by creating an inviting environment that not only keeps people safe from the flooding water, but also acts as an attractive place for recreation.

4.3 Planned developments of the project area

The following section discusses the current and future plans regarding the campus, both in regards to student facilities and outdoor spacing. Main focus lay on the area outside SB House but will also touch plans that will affect directly or indirectly the project site.

4.3.1 Detailed development plan

The current detailed development plan which includes the area around A-dammen, does not contain any relevant arrangements regarding the project site (Göteborgs Stad, 1998). It is dated 1998 and only describes the until then planned development of the new Student Union Building, completed in 2001. Even though the plan was amended in 2016, the readjustments did not affect that specific area (Göteborgs Stad, 2016).

A detailed development plan that will affect Campus Johanneberg is *Gibraltarvallen,* which includes a new bus stop by the southern entrance shown in Figure 19, (Göteborgs Stad, 2020a), which may lead to increased pedestrian traffic on the pathways. The plan also discusses stormwater issues, concluding that when simulating 100-year rainfall, problems will arise at Sven Hultins plats which represents the red dot in Figure 19.

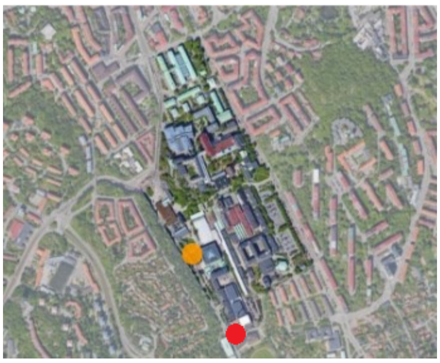

Figure 19. Southern entrance marked in red.

4.3.2 Chalmers Campus plan 2019 - 2050

As mentioned in chapter 4.2, Chalmers Campus Plan is an overarching strategy of development in part dedicated to Campus Johanneberg (Akademiska Hus, 2019). It holds preliminary proposals by the property owners and have not been ratified by the authorities as part of any legally binding zoning plan. As the plan serves as a long term strategic vision, this gives a good idea of what Chalmers wants the area to be in the future.

This project's specific area is mentioned in the plans for 2050, as development areas "2M" and "2L" and the main focus lies on densification (Akademiska Hus, 2019). 2M marks a new construction replacing Tågvagnen to work as a gathering point or stage of some sort. At marking 2L, the bordering SSPA-building is suggested to be replaced by a totally new building. This will hold an integrated park area which in turn will connect with the open space by Geniknölen. Notably, neither of the plans discuss stormwater management in any capacity, which could be interpreted as being a non-priority.

5. Result

Since this project is based on different phases where one lays the foundation for the next, the results presented in following sections are divided into two parts. First the results from the prestudy where information from interviews, surveys and stormwater modelling are gathered. Thereafter follows the concept synthesis starting with the list of requirements and requests. In this part, all the gathered information and conditions are boiled down into relevant demands for upcoming concepts. Finally, a summarised version of the solution development process is presented. It describes how different solutions have emerged, been combined, evaluated and sorted out to form one remaining Final Concept, which also is fully displayed.

5.1. Results of prestudy

This section presents data which was collected by interviews, survey and stormwater modelling to complement the literature study and provide a better foundation for thought through solution proposals.

5.1.1. Output from interviews

The interviews clarified how Campus Johanneberg is co-owned by two companies, Akademiska Hus and Chalmersfastigheter. The first one is a state-owned real-estate company which operates all over the country while the second one is a subsidiary company to the non-profit institution Chalmers University of Technology Foundation [Stiftelsen Chalmers Tekniska Högskola]. Development of areas depend on the responsibility distribution and usually include cooperation between the different owners. For this specific project area, Akademiska Hus is the land owner and thereby a major actor.

According to Sara Karlsson at Akademiska Hus, the company wants to create a park area south of the project site. It will function as a large “bowl” to detain large amounts of stormwater and stretch up all the way to the case study site along Sven Hultins gata. The area is planned to contain several objects of value for sustainability, for instance carpools and urban food production. When it comes to the project area, they had plans of moving Tågvagnen to implement an open stormwater solution working as a volleyball court, but paused it due to current finances and prioritisation of other areas, for instance *Kopparbunken*.

The interview with Anna Zahlbruckner and Freja Frenberg at Chalmersfastigheter, did not yield any concrete plan relating to our area. It did however include some opinions of what they would like to see more of. It was mentioned in a discussion among fellow colleagues that more outdoor roofing would be appreciated. Since it rains a lot in Gothenburg, some protection would be appropriate. Not complete rain coverage but rather smaller spots to escape sudden rainfalls. She explained how fuller weather protection came with other challenges such as ventilation and people using them as living settlements. New concepts that fit these requirements had been discussed with architects but only at an early stage.

Jens Thoms Ivarsson, from Kretslopp och Vatten at the Municipality of Gothenburg, had a slightly different approach to this project. With a background as Creative Director in project Rain Gothenburg, he provided an interesting change of perspective and inspiration to ways of thinking that engineers often leave out. He used the question of “How does one experience a place when it rains?” to defy the problem and claim, from a technical standpoint, that solutions are not complete if the people affected will not be there to use them. To provide this understanding, he promoted interdisciplinary group work and input from different perspectives as well as dialogue with actual users. For the case study itself, he also lifted the idea of a creative solution where stormwater treatment could be combined with an architecture to highlight the work at Chalmers and the ACE institution.

5.1.2 Output from survey

This section contains information gathered by the survey and the results are displayed in full in Appendix A. A total of 57 people participated and the survey was available during a month.

5.1.2.1 Profile of respondent

All participants in the survey were students. As shown in Figure 20, the majority of the respondents belonged to ACE, representing 46 of the total 57 participants, or 80.7%. The second largest group were people in the field of mechanical engineering, mechatronics and technical design, holding three people which mirrored 5.3%. Two people answered “Other”, making up 3.5%.

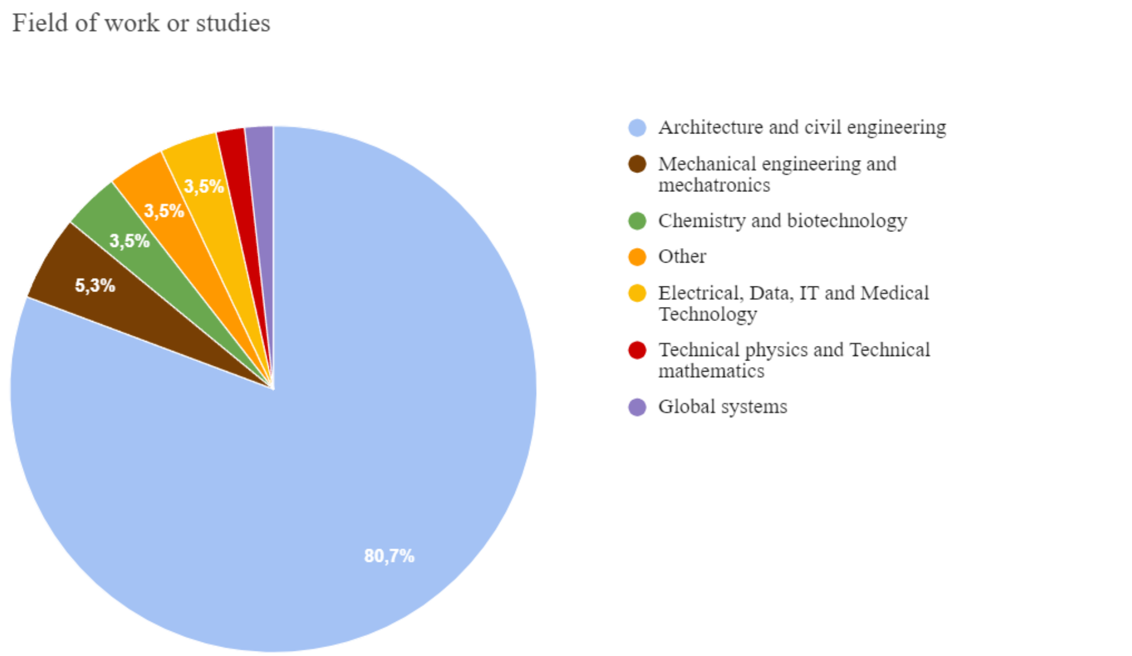

Figure 20. Pie chart of field of studies or work for participants of the survey.

Out of the discussed participants, a total of 41 people, or 71%, estimated that they visit the site every day or several times a week, see Figure 21. Eleven people, 19%, said they visit at least once a week. This concludes that about 90% of the participants of the survey cross the area on a weekly basis.

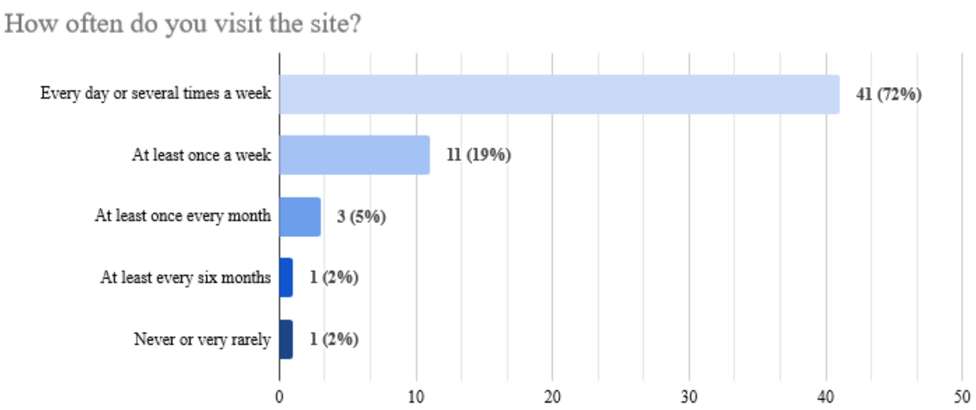

Figure 21. Bar chart of visit frequency.

5.1.2.2 Noted inconvenience, experienced values and requests for development

The first three area questions focus on the walkway between the Student Union hall and SB House. When asked about the following statement: "I have noticed pools of water on the walkway during heavy rain", the majority of the respondents, 40 people, answered that they agree and further 15 answered with "somewhat agree". Answers regarding "If the water collected on the walkway during rain is troublesome " were more indecisive. Result shows that 25 people noticed puddles on the walkway during heavy rain. The same number of people answered "somewhat agree" to the same statement, see Figure 22. For a majority of participants, the priority for solving the problem was ranked as medium, see Appendix A, Figure 2.

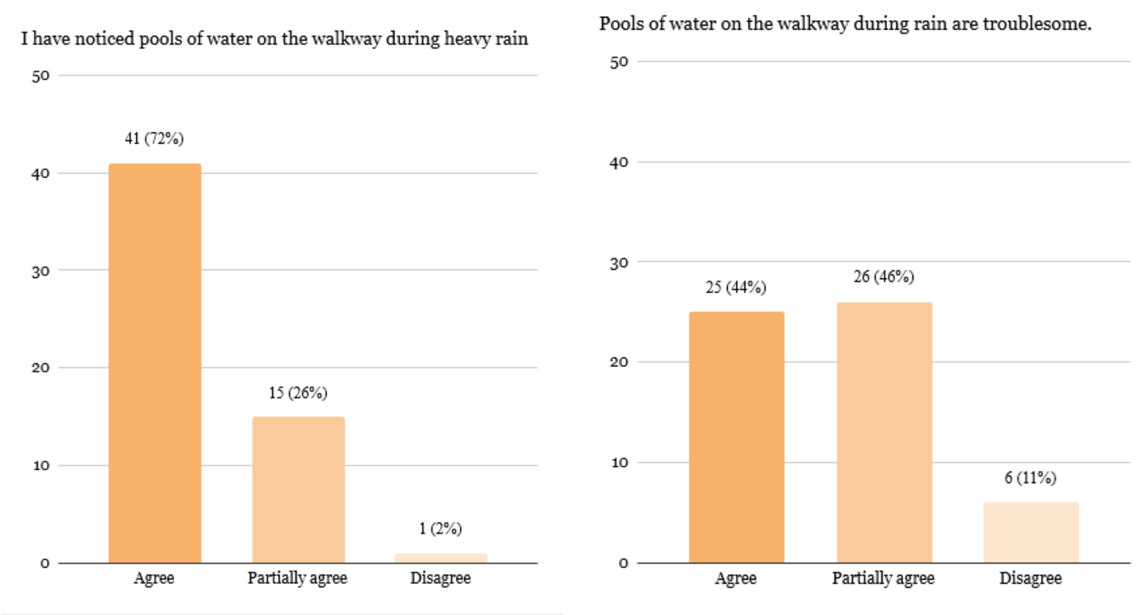

Figure 22. Bar chart of results of the participants agreement to the following statements.

One question was intended to provide information on what cultural and other significant values the space of A-dammen holds. The results can be seen in Appendix A, Figure 3 and indicates that respondents believed A-dammen has a high cultural value. Other answers state that possibilities for recreational activities are valued relatively highly with a majority gradings stating a four on the scale from one to five. 41 out of 57 participants answered a one on a scale from one to five, meaning that they thought the pond had a low value regarding opportunities for bathing. One respondent stated that the reason was the possibility that the water was presumed unhygienic. When asked about Geniknölen, 96% of respondents whole-heartedly or partly agreed that Geniknölen is a good space for relaxation during lunch hours and 71% agreed that they use the space for recreational purposes.

The survey ended with an open question where participants could write a short text of what they would like to see change in the area. The answers are displayed in full in Appendix A but can be summarised as requests of more and seating areas and green spaces. People frequently asked for benches and tables to provide better opportunities to sit outside during lunch breaks. Both the amount and quality of the seatings were deemed important. They also requested larger open spaces with greenery.

5.1.2.3 Summarised analysis

The large majority of participants were students in the field architecture and civil engineering, which could be largely part of the survey being spread across the SB-building. The participants consisted of frequent visitors of the area, which argues that their views are credible. Next to all participants have noticed rain accumulation on the pavement during and after rainy weather and most of them expressed it being troublesome. Although when asked about how high the priority to solve the problem, a majority answered that it was a medium priority. The pond A-dammen was seen by the participants as having a high cultural value with relatively high possibilities for recreation already but participants were open to remodelling it if needed. A large request for more seating areas with higher capacity and quality was noted.

5.1.3 Results from digital flooding simulations

The following segment describes results and measurements given by the digital modelling tool SCALGO and the municipality of Gothenburg´s simulation tool Vatten i Staden. It presents the amount of flooding both in volume and depth, watersheds, runoff and accumulations. Special notice has been taken in the amount of flooding, runoff directions during heavy rainfall and where troublesome areas can be located.

5.1.3.1 SCALGO output

Figure 23 shows the digital flooding simulation caused by all four weather events with data about the amount of water relevant to the south west reagan of Sweden (Svenskt Vatten, 2020). Coloured areas represent flooding with a gradient showing the severity of the water depth. A conclusion that can be made when studying figure 23 is that the passage seems to be the biggest problem area at the site. Vast water masses gathering at *Teknologgården* have no escape routes except for the under dimensioned sewage system and therefore creates a risk for adjacent buildings. Another area which was shown to be troublesome is the stairwell at the Student Union Building, where heavy flooding was indicated. Already at 18mm of rainfall, it showed flooding occurring in the area. Flooding caused by both 10- and 100-year rain will create a water depth greater than 20cm (see figure 23), which is considered to be high enough to risk restricting accessibility for emergency vehicles.

A-dammen seem to manage its volume without overflow, which is expected due to its high edges. There also seem to be large accumulations at Geniknölen, but as mentioned before, SCALGO do not consider the infiltration rate. Therefore results in for instance green areas with high infiltration rate can become exaggerated. However, if the ground consists of mostly clay, the infiltration will still be low and since Geniknölen lacks other drainage there is a risk of it being flooded anyway.

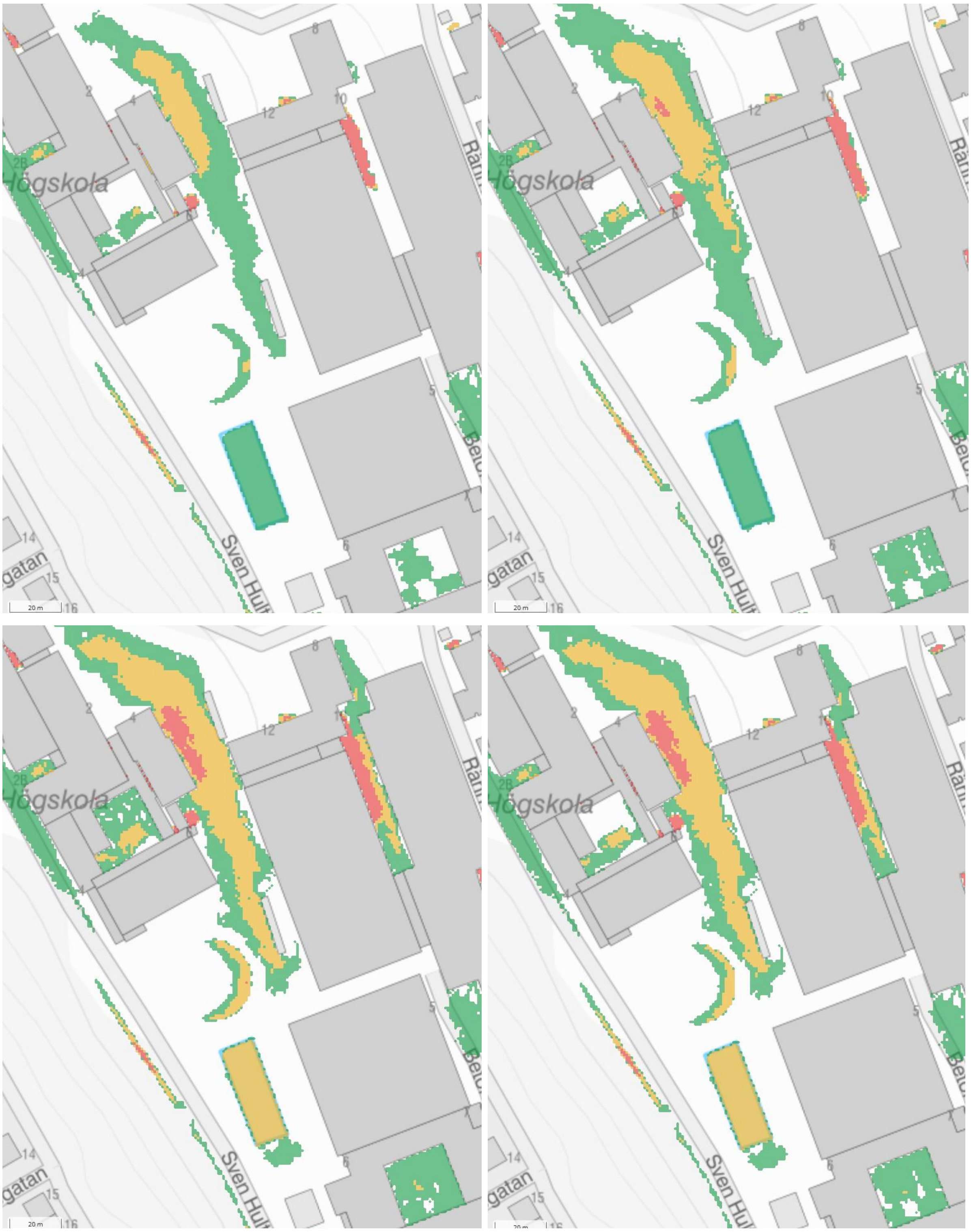

Figure 23. Illustrations of flooding as a result of four scenarios of heavy rainfall. The gradient shows 0-20sm (green), 20-40cm (yellow), 40cm-above (red). The images show the results of simulations for 15 minute 10-year rain (top left), 60 minute 10-year rain (top right), 15 minute 100-year rain (bottom left) and 60 minute 100-year rain (bottom right), using the SCALGO flooding simulation tool.

Catchment areas

The program produced a representation of precipitation catchment areas, shown in Figure 24 with different colours marking catchment fields and black lines defying the watersheds. Worth noting is the turquoise field indicating large additional flows to the passage and at Teknologgården. Another interesting element is the influx of water to A-dammen, represented in pink. The small size indicates how little rainfall will flow to A-dammen even if its edges were to be lowered, which could lessen the opportunity to use it as a detention basin during cloudbursts.

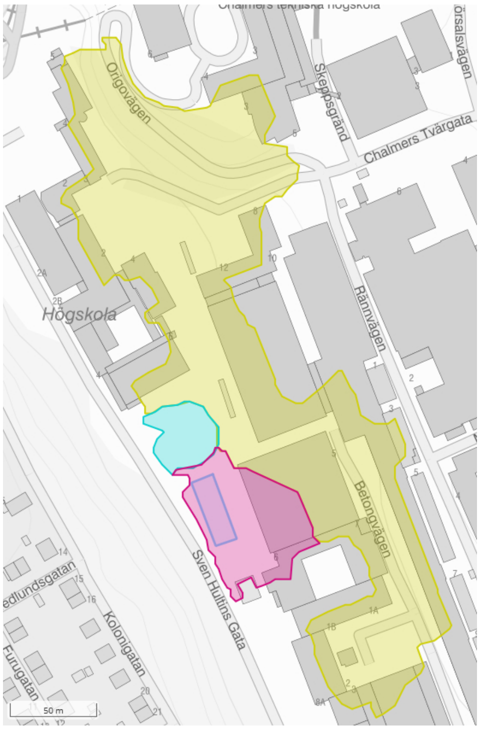

Figure 24. Map from SCALGO of the project area's watersheds, simulated with a rainfall of 18mm.

Volumes of flooding

The digital simulation also calculated the water volume that floods the area for all four chosen weather events. The amount of water that will collect on the passage beside Tågvagnen can be seen in Table 3. It shows that 286m^3 of water will collect on the pathway including the flooding on Teknologgården already after 15 minutes of a 10-year rain. After 60 minutes of 100-year rain the volume reaches over 450m^3.

Table 3. The table shows simulated water volumes for each catchment area of concern.

	15 min, 10-year rain [m^3]	**60 min, 10-year rain [m^3]**	**15 min, 100-year rain [m^3]**	**60 min, 100-year rain [m^3]**
Tågvagnen	286.18	442.60	453.57	453.57
A-dammen	72.59	100.82	127.85	127.85

5.1.3.2 MIKE output

The MIKE simulation outcome of six hours 100-year rain was consistent with the SCALGO results on several points. First, flooding occurs on the passage between SB-building and student union building, as well as at A-dammen and Geniknölen. It also points out another stairwell along the Student Union Building as a danger zone which SCALGO did not. The simulation shows that during the most extreme weather the water levels would become 0.2-0.5m which would decrease accessibility. The MIKE output also visualises more clearly than SCALGO how A-dammen would reach its capacity during the most extreme rains and predicts large floodings on Sven hultins gata.

The water flow rate can be seen in Figure 25. On the nearby street, Sven Hultins gata is the water stream flowing in the direction north with a high velocity. Meanwhile the water streams on the study site have a low flow rate. This indicates that there are no large streams and stormwater should thereby be treated locally since it does not travel in great length.

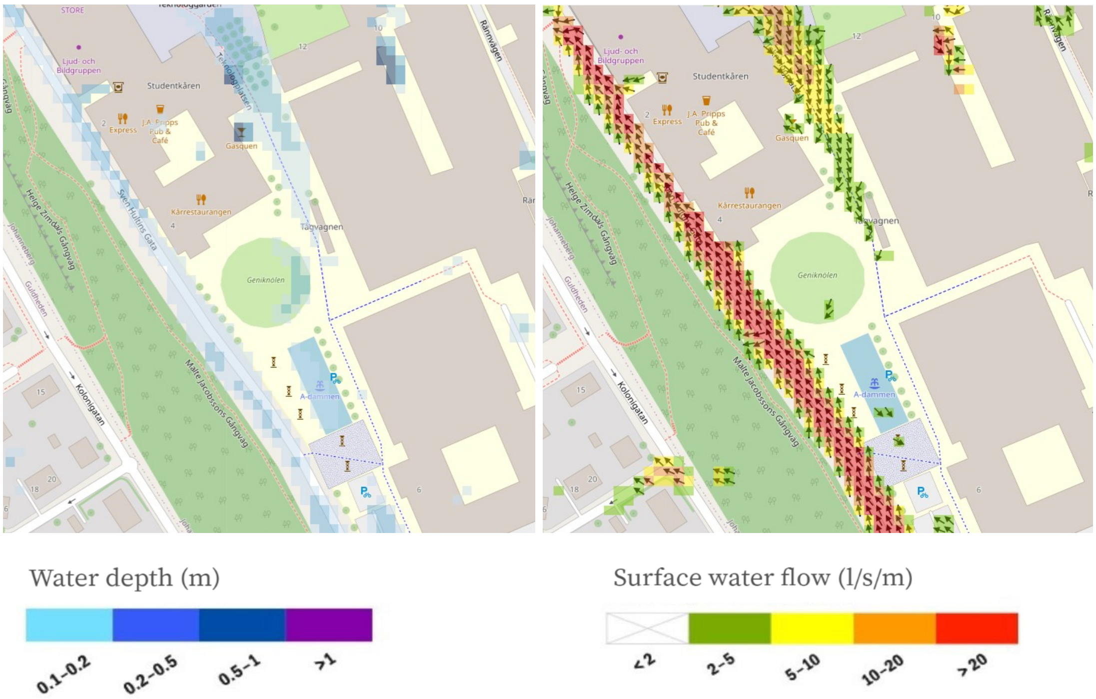

Figure 25. Water depths, surface water flow rates and directions. Map of simulated flooding caused by 6 hours of 100 year rain. Left presents maximum water depth in metres, right is the surface water flow with the arrows demonstrating the direction of flow.

5.1.3.3 Concluded output analysis

The flooding simulation concluded that a risk of flooding during heavy rainfall exists in the area. The most problematic at the site is located on the passage between the Student Union Building and SB House. Problematic zones include the stairwells at the Student union building. During a 10- and 100-year rain the water levels are high enough to decrease accessibility to a degree of not being acceptable for emergency vehicles. The worst flooding scenario predicts water volumes up to 454m^3 on the walkway between the Student Union Building and SB House. A-dammen has a current storage volume of 128m^3 but during a

100-year rain it would risk overflowing. Regarding water flow in the area, the velocity is low and no problematic streams can be detected.

5.2. Results from Concept Synthesis

This section consists of the results from the concept synthesis. First it presents the Case study's LoRR, then summarises the discoveries made during the development processes and at last presents The Final Concept.

5.2.1 Case Study's List of Requirements and Requests

In Table 4, 5 and 6 this section presents the LoRR for the case study which summarises relevant recommendations and demands based on information from prestudy.

Table 4. List of Requirements and Requests - STORMWATER MANAGEMENT

	Requirements	Requests
Always	Facilitated accessibility of surfaces dedicated for transportation: - Passages between union building, the SB-house and Sven Hultins gata for service vehicles, pedestrians and cyclists. - Route from Sven hultins gata along buildings for emergency vehicles. - Route from Sven Hultins gata to entrance of SB building for transports of heavy and bulky goods.	Enabled collecting and storing of stormwater for anthropogenic usage. Rain generated feature (s) contributing to some experience(s) listed below: - Cultural / campus spirit incarnating. - Aesthetically pleasing / mood lifting. - Recreational. - Technologically inspiring.
Cloudburst	Enabled water quantity management with capacity of water volumes caused by 100 year rains during 60 minutes duration time.	None
Normal Rain	Enabled water quality management: Copper treatment of water from downpipes on the lower part on the SB-house. Decrease water gatherings perceived to hinder accessibility or cause inconvenience. Provided water diversion from areas sensitive to prolonged water contact.	Pollution treatment of water from Sven Hultins gata. Accessibility of rain protection somewhere along the passage.
Dry Periods	None	None

Table 5. List of Requirements and Requests - SAFETY

	Requirements	**Requests**
Always	Enabled safety regards concerning - tripping - slipping - drowning - experienced insecurity - crime prevention	None
Cloudburst	None	None
Normal Rain	None	None
Dry Periods	None	None

Table 6. List of Requirements and Requests- RECREATION, SOCIAL INTERACTIONS & CAMPUS SPIRIT

	Requirements	**Requests**
Always	None	Memorial plaque for the creation of A-dammen Prideful visualisation and promoting of Chalmers and the ACE Department.
Cloudburst	None	None
Normal Rain	None	Facilitated interaction areas protected from rain and wind. Facilitated waiting areas on passage, protected from rain and wind. Enabled withholding of important student activities and traditions.
Dry Periods	Facilitation of increased seatings. Accessibility to green areas.	Enabled withholding of important student traditions Facilitation of study environment Facilitated seating in shadow. Enabled view of open water mirror

5.2.2 Summary of potential solutions from the concept development process

During the sessions of tailoring solutions for the project site it became clear that there were many alternatives and possibilities. Most construction options showed for example both functional and aesthetic potential if they were designed in a mindful way. However, due to the group members' competence areas and limited timeframe, the primary focus became directed at technical flooding and pollution management. Other external anthropogenic usages such as water collection and reuse were down prioritised.

Recurring elements for management of normal rain were channels or gutters which combine diversion with detention. Tilting of pavement for water diversion on the pathways and ways to substitute impervious areas in favour of green or permeable surfaces were also discussed. Since the current state of the passage pavement prevents existing drainage to work sufficiently, a future reconstruction was seen as an opportunity to adjust that at the same time.

Compared to normal rain, cloudbursts had fewer options when it came to providing large storage capacity. Mainly four different alternatives were discussed which mostly focused on providing controlled diversion and storage of the large masses gathering at Teknologgården. One was usage of the A-dammen by providing stormwater intake and drainage plus increased volume. Next was utilisation of Geniknölen, which would need an inlet through the concrete walls and could improve filtration at the bottom. Another was to construct a totally new water pit in a more sufficient position by the area's natural lowpoint. Finally, to avoid transport of large water masses from the start, large wells with underground storage and detention were mentioned. The last one would be placed as close to Teknologgården as possible.

When it came to copper treatment, rain gardens and green roofs were the preferred solutions. Due to the few copper sources in the project site's catchment areas, these options could handle the issue locally, meanwhile contributing other functions such as detention and ecological services.

The topics of recreation, inspiration and social interaction made way for more multifunctional and unique ideas. Many involved ways to use construction edges as both water barriers and informal seatings. Others let gutters and channels detain meanwhile creating artistic features by patterns in pavement or temporary waterfalls. Some of the most prominent ones were roofing over the passage with integrated storage capacity and hydraulic artwork on walls but also channels on the ground forming a so-called "rainclock" that should detain runoff while illustrating rain as an important climate phenomenon.

5.2.3 Summarised results of the Concept Draft 1 and Concept Draft 2

The concept drafts resulted in two slightly different approaches, which both focused on A-dammen and the passage. In both cases, the pond was reformed where it would allow a stormwater inlet and with edges constructed as informal seating. They also used rain sheds formed as large mushrooms with integrated seatings for additional water storage and social spots. Different features of the drafts are described in more detail in Appendix D, while following paragraphs summarises them.

Draft 1 shrank the A-dammen in favour of new green space and held a wetland stretching along the SSPA-building. The mushroom sheds were spread out on different positions along the passage and on the new green area. The idea was to use the natural low point near Teknologgården for cloudburst storage while making the A-dammen area more accessible.

When it came to the mushrooms, the main purpose was to add more water storage, social spots and being a visually interesting common denominator at the same time. To improve the accessibility of Geniknölen it proposed better use of edges and added gravel at the pit's bottom to avoid creation of mud, see figure 29 for an illustration. Another change included the gravel at Lennart Rönnmarks plats to avoid erosion and facilitate better infiltration.

Draft 2 planned to move Tågvagnen and instead replace it with a gathering of mushroom sheds, where there would be four smaller mushrooms and three bigger ones. It primarily used the A-dammen for water storage. The concept also explored the solution of a so-called rainclock by the SSPA-building, i.e. a partly covered channel construction visualising different rain types. The idea was to divert and detain stormwater into a pit with different overflow levels with inspiration drawn from a sundial. It should be dimensioned to match the catchment areas' stormwaterflow so that a new part of the clock is filled during for instance 1-month- 1-year- and 10-year rains. An illustration of that design as well as one on a wall can be seen in Figure 26 & 27. Total overflow would be diverted to A-dammen, Geniknölen or the ordinary drainage system. To handle the copper pollution an extended green roof was proposed for the cyclist shed outside the SB entrance along with a rain garden collecting roof runoff by a channel in the staircase, see Figure 28.

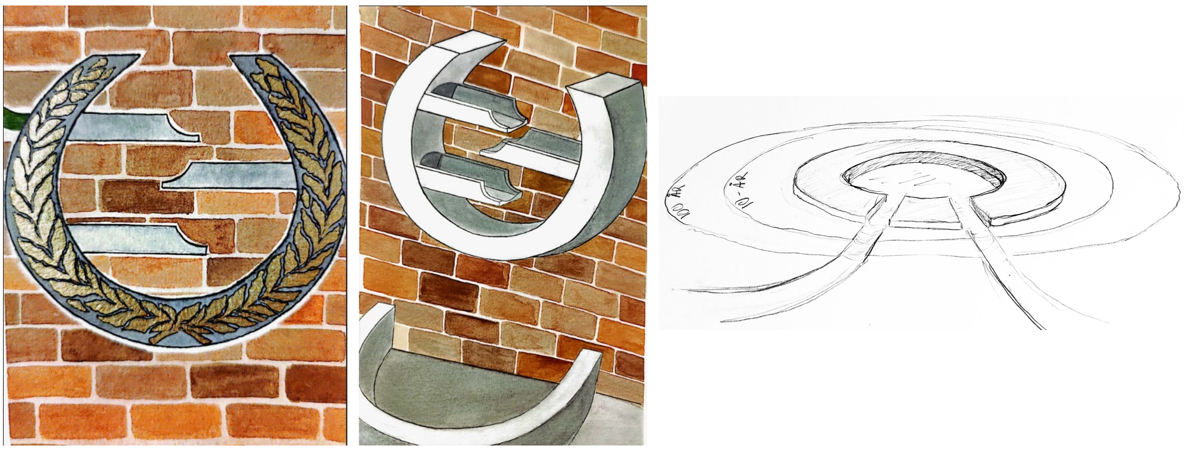

Figure 26 & 27. Illustrations of different ideas of the Rain-clock. The first two figures: placed on the ground and wall. The third figure: placed on the ground.

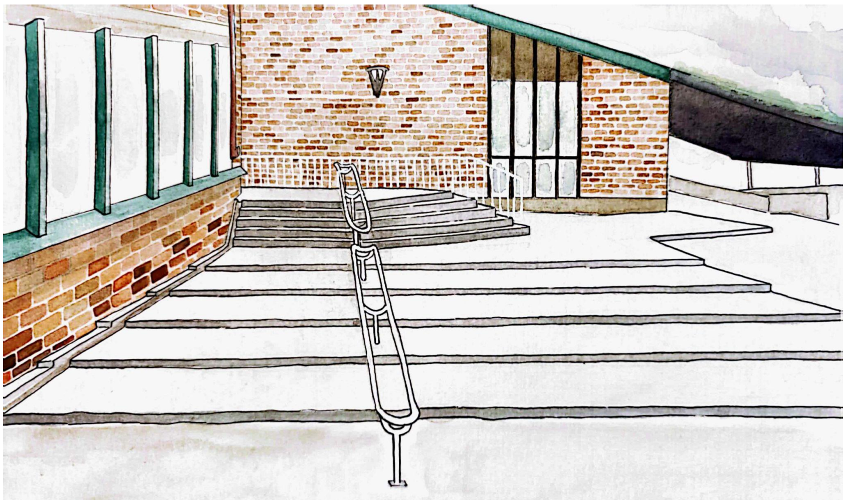

Figure 28. Illustration of the entrance of SB-building with green roof and channel in the staircase from Concept Draft 2.

Figure 29. Illustration of the fixed seating at Geniknölen as well as the new green space north of A-dammen.

5.2.3.1 Calculation results for Concept Draft 1 and Concept Draft 2

To better judge the effect of applied solutions, calculations of runoff flow and storage capacity were made. Following tables 7-12 present both concept's capacity in regard to stormwater runoff and storage before and after applied solutions. The results show that Concept Draft 1 reduces its flow with 36 136l/s while providing 435m^3 storage compared to SCALGO's approximation of about 450m^3. Concept Draft 2 showed lower capacity with a runoff decrease of 16 936l/s and a storage capacity of 201m^3. Important to note when reading the results for concept 1 is that the infiltration area will be increased for the passage north of A-dammen due to the new green space, which results in a higher flow after the solutions are applied. Because of this, a direct translation of the efficiency regarding infiltration for the solution can not be made for this specific solution.

Table 7. Concept Draft 1: Runoff flows before applied solutions.

Area	Surface type	Runoff Coefficient [-]	Area size [m^2]	Flow [l/s]
Gravel east of A-dammen	Gravel Type 1	0.25	118	4119
Passage By SSPA building	Hard surface	0.8	355	39 655
Lennart Rönnmarks Plats	Gravel type 1	0.25	210	7330
Maximum Flow				**51 104**

Table 8: Concept Draft 1: Runoff flows after applied solutions.

Area	Surface type	Runoff Coefficient [-]	Area size [m^2]	Flow [l/s]
Green area by A-dammen	Green area	0.1	297	4147
Passage by SSPA building	Rain garden	0.1	355	4957
Lennart Rönnmarks Plats	Gravel type 2	0.2	210	5864
Maximum Flow				**14 968**

Table 9. Concept Draft 1: Water storage capacity after applied solutions.

Solution	Volume [m^3]
A-dammen	185
Wetland	250
Total	**435**

Table 10. Concept Draft 2: Runoff flows before applied solutions.

Area	Surface type	Runoff Coefficient [-]	Area size [m^2]	Flow [l/s]
Alongside the SB house	Hard surface	0.8	64	7149
Roof for biker shed	Hard surface	0.8	162	18 095
Passage next to biker shed	Hard surface	0.8	93	10 389
Maximum Flow				**35 632**

Table 11. Concept Draft 2: Runoff flows after applied solutions.

Area	Solution type	Runoff Coefficient [-]	Area [m^2]	Flow [l/s]
Alongside the SB house	Rain garden	0.1	64	894
Passage and biker shed	Green roof	0.5	255	17 802
Maximum Flow				**18 696**

Table 12. Concept Draft 2: Water storage capacity after applied solutions.

Solution	Volume [m^3]
A-dammen	187
Single large mushroom	1.6
Single small mushroom	0.85
Total mushrooms	14
Total storage	**201**

5.2.4 The Final Concept

To improve storage capacity and runoff flows as well as other social and visual features the Final Concept emerged as an improved combination of both Concept Draft 1 and Concept Draft 2. Its major functions are listed below and Figure 30 illustrates the layout and different features. Illustrations as to what it might look like can be seen in Figure 31-33, mainly showing proportions to real space but include ideas on how the aesthetics can be formed.

5.2.4.1 Layout, features and functions

Figure 30. Map of The Final Concept. The map shows us a list of numbers 1-10 that indicate the placement of each solution with the corresponding descriptions below.

1. A large infiltration ditch working as a rain garden stretching along the SSPA-building. This is the site's natural lowpoint and therefore deemed as a more efficient place to retain water masses. Some periods the space would be almost dry but during rain it would get filled with drainage from adjacent gutters. To avoid damaging the adjacent SSPA-building, that side should be reinforced and water would be drained slowly through pipes instead of only relying on infiltration through the ground. To enable more accessibility of the space, the edges would have integrated stair steps and an elevated wooden promenade to allow for movement across the area as well as seating to allow for recreation. Approximate dimensions are $40x9x0.7m^3$.

2. Readjusted stone pavement on the passage and surrounding the basement stairwells at the Student Union house. Thresholds around the stairwells would avoid cellar flooding and restoring of sufficient slopes and elevation differences on the passage would ensure the sufficiency of the existing drainage system and diversion to the wetland.

3. Move Tågvagnen to another part of campus and replace it with six mushroom sheds. The sheds work as decorative rain- and sun protection as well as stormwater collectors with trunks as detention basins. They would be drained at the bottom but with repressed outflow and be either hollow to provide water storage or filled with porous material to fill the same purpose while avoiding gathering debris. The sheds come in two different sizes with different amounts of storage volume and seatings.

The larger one with trunk diameter of 1m and height of 4.2m and the smaller one with diameter of 0.8 m and height 3.6m.

4. Shrinked and redesigned the A-damm. By deepening the pool and reconstructing the walls as stairsteps starting at ground level the pool would allow inflow of stormwater and provide cloudburst storage as well as informal seatings during dryer periods. Since the pool would need to be active all year around, current fountains would need to be removed or changed to allow freezing. To keep a requested water level the pool would be drained but with a small outlet to not overload the sewage system. The northern wall would also have a damming outlet leading to a new constructed green surface which during cloudburst would expand the volume even more.

   The bottom level would be permanently covered by water, with a depth of around 0.95m to ground level but the part used for storage capacity would start from the second tier and be around 0.55m deep with a total area of approximately 338m^2.

5. The removed part of A-dammen is replaced by a depressed green area to gather floodings from adjacent roads and also work as extended pond volume. The dip is covered with grass apart from a few gravel trails and holds a number of infiltration pits to allow slow but continuous drainage. To facilitate runoff road curbsides are placed at grass level.

6. Green roof on the old cyclist shed with extension over to the SBII-building's copper roof. Since the area's major copper source is located at the SB-entrance this gives an opportunity to provide local treatment meanwhile providing water detention as well as weather protection without preventing accessibility.

7. Replacing the current flowerbed along SBI with a rain garden. An additional way to handle the copper issue but mainly meant to provide water detention and aesthetics.

8. Reconstruct the stairs at the SB entrance. By correcting the slope and constructing a waterfall gutter into the adjacent rain garden the space would improve its stormwater quality, avoid inconvenience and create a more convincing entrance to a department for high class water infrastructure.

9. Small adjustments on Geniknölen for added and more convenient seatings. Stonecovers on the top of the walls and gravel or some kind of feet laverage at the bottom of the pit to make the space more available during wet and muddy periods.

10. Reconstruction of gravel surface *Lennart Rönnmarks plats*. To avoid current erosion and increase permeability the new surface would consist of gravel type 2 with larger grain size, with a hard made pathway for more convenient crossing. The area would also be given a slight slope towards the reconstructed A-dammen so that stormwater would flow toward it in case of flooding.

11. Hydraulic Rainclock on SSPA wall. The idea is an engineering artwork which gathers runoff from the SSPA roof and utilises the water and potential energy to activate different functions. Depending on rain intensity and duration different volumes would gather in hanging basins and run water wheels. The energy would drive a clockwork, configured to translate the volume and duration time with certain rain types, for example “10-year rain”, and display the result on a visible scale. Used water on the way down could be led in scenic streams or gathered in pools to create waterfalls before ending up in the wetland below. It would thereby be detained while at the same time being a visible example of water engineering and illustrate the approaching climate challenges.

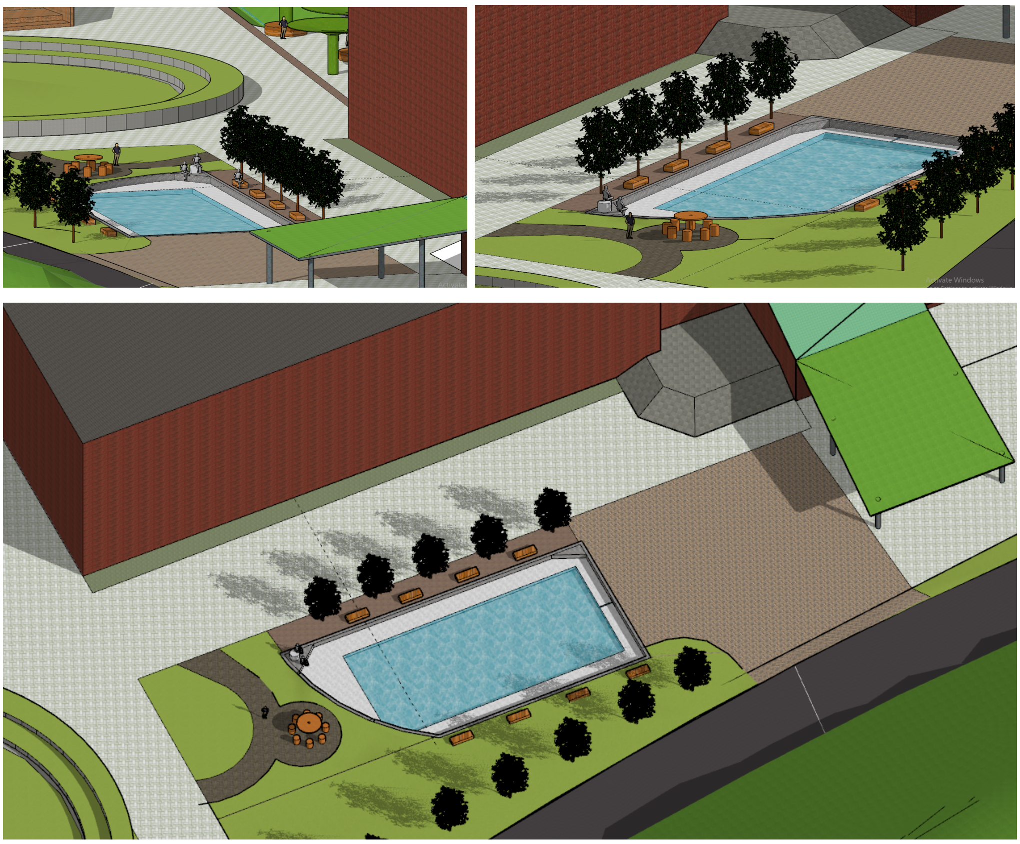

Figure 31. Sketchup model with a view of the south part of The Final Concept, including proportions which can be compared to adult sized mannequins. Note that the different green textures on the roofing illustrate the transition between copper and green roofing.

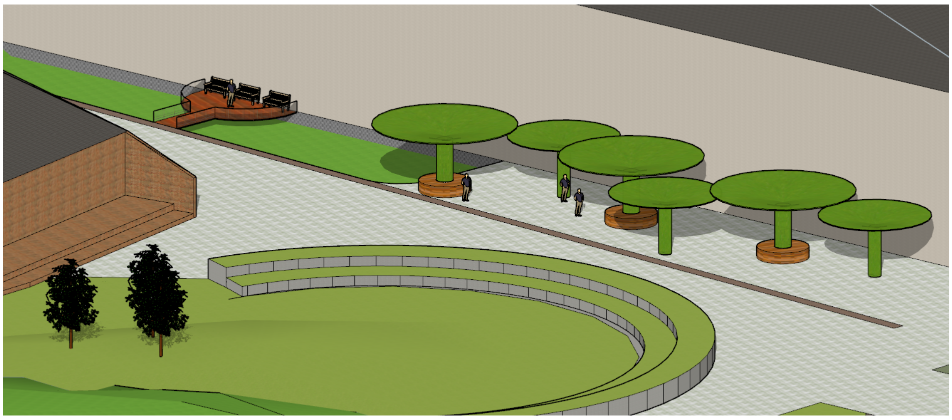

Figure 32. Sketchup model with a view of most of the northern part of The Final Concept. Pictured are Geniknölen, the “mushroom” area with people for scale, and the infiltration ditch.

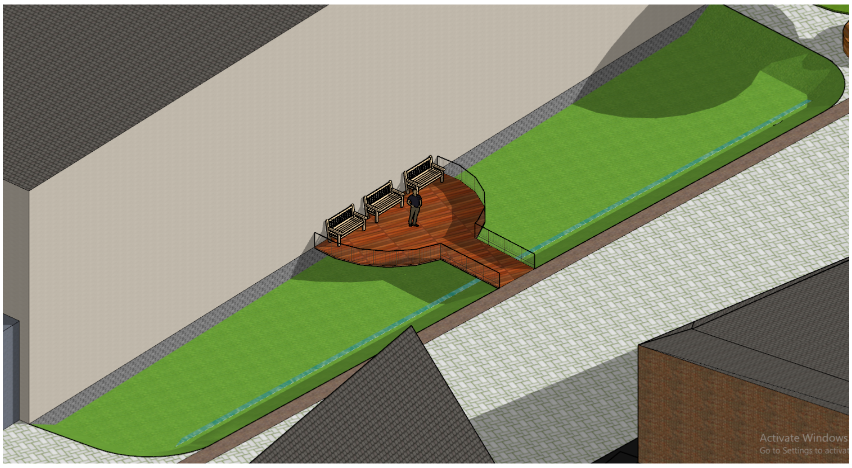

Figure 33. Sketchup model with a view of the infiltration ditch, including how a deck could look like. Note that the illustration is missing the vegetation which would exist in the ditch.

5.2.4.2. Calculation results for The Final Concept

Calculations for The Final Concept were made in the same way as for the drafts and are visible in Table 13 and Table 14. Everything resulted in a storage volume of 448m^3 and a runoff flow of 33 664 l/s.

According to these approximative calculations, the total flow is reduced by 53 073l/s, which represents 38% of the original flow at the site. Table 15 shows the storage capacity for each applied sub-solution and the total volume capacity of about 448m^3. Used dimensions for the calculations of different solutions are the same as for the drafts 1 and 2 and can be found in Appendix D.

Table 13. The Final Concept: Runoff flows before applied solutions.

Area	Surface type	Runoff Coefficient [-]	Area size [m^2]	Flow [l/s]
Passage north of A-dammen	Gravel type 1	0.25	118	4119
Lennart Rönnmarks plats	Gravel type 1	0.25	210	7330
Along the SB house, beside plant bed	Hard surface	0.8	64	7149
Passage next to biker shed	Hard surface	0.8	255	28 484
Passage by SSPA building	Hard surface	0.8	355	39 655
Total Flow				**86 737**

Table 14. The Final Concept: Runoff flows after applied solutions.

Area	Surface type	Runoff Coefficient [-]	Area size [m^2]	Flow [l/s]
Passage along SSPA building	Rain Garden	0.1	355	4957
Lennart Rönnmarks plats	Gravel (type 2)	0.2	210	5864
Along the SB house, beside plant bed	Rain garden	0.1	64	894
Passage next to biker shed	Green Roof	0.5	255	17 802
Passage north of A-dammen	Green space	0.1	297	4147
Total Flow				**33 664**

Table 15. The Final Concept: Water storage capacity after applied solutions.

Solution	**Volume [m^3]**
Rain Garden	250
The A-dammen	185
Mushrooms	15
Total Volume	**450**

5.3.4.3 Evaluation of The Final Concept against LoRR

Tables 16-18 presents how The Final Concept answers against its LoRR. Notations represent Y : Yes, N : No, P : Partly, I : Impossible to evaluate at this state of development, - : Nothing to comment.

Table 16. Evaluated List of Requirements and Requests - STORMWATER MANAGEMENT

	Requirements		**Requests**	
Always	Facilitated accessibility of surfaces dedicated for transportation: - Passages between union building, the SB-house and Sven Hultins gata for service vehicles, pedestrians and cyclists. - Route from Sven hultins gata along buildings for emergency vehicles. - Route from Sven Hultins gata to entrance of SB building for transports of heavy and bulky goods.	 Y Y Y	Enabled collecting and storing of stormwater for anthropogenic usage. Rain generated feature (s) contributing to some experience(s) listed below: - Cultural / campus spirit incarnating. - Aesthetically pleasing / mood lifting. - Recreational - Technologically inspiring	 Y Y Y Y
Cloudburst	Enabled water quantity management with capacity of water volumes caused by 100 year rains during 60 minutes duration time.	P	None	-
Normal Rain	Enabled water quality management: Copper treatment of water from downpipes on the lower part on the SB-house. Decrease water gatherings perceived to hinder accessibility or cause inconvenience. Provided water diversion from areas sensitive to prolonged water contact.	Y Y Y	Pollution treatment of water from Sven Hultins gata. Accessibility of rain protection somewhere along the passage.	N Y
Dry Periods	None	-	None	-

Table 17. Evaluated List of Requirements and Requests - SAFETY

	Requirements		Requests	
Always	Enabled safety regards concerning - tripping - slipping - drowning - experienced insecurity - crime prevention	 I I P I P	None	-
Cloudburst	None	-	None	-
Normal Rain	None	-	None	-
Dry Periods	None	-	None	-

Table 18. Evaluated List of Requirements and Requests- RECREATION, SOCIAL INTERACTIONS & CAMPUS SPIRIT

	Requirements		Requests	
Always	None	-	Memorial plaque for the creation of A-dammen Prideful visualisation and promoting of Chalmers and the ACE Department.	N Y
Cloudburst	None	-	None	-
Normal Rain	None	-	Facilitated interaction areas protected from rain and wind. Facilitated waiting areas on passage, protected from rain and wind. Enabled withholding of important student activities and traditions.	P Y Y
Dry Periods	Facilitation of increased seatings. Accessibility to green areas.	Y Y	Enabled withholding of important student traditions Facilitation of study environment Facilitated seating in shadow. Enabled view of open water mirror	P N Y Y

6. Discussion

The following chapter covers an evaluation of The Final Concept, analyses the work method and highlights areas that could further be studied. Sources of errors are discussed and addressed as well as areas where information is lacking or where the project would benefit from further development.

6.1 Strengths, drawbacks and comments on The Final Concept

The Final Concept was designed and formed according to the information gathered from the various steps made in the report. It was designed according to the list of requirements and requests, and polished through a handful of iterations. However, even if the concept covers the biggest problems at the site it still has its drawbacks.

When evaluating the solutions, the strength of the final concept is based mostly on the capacity of the solutions in regard to infiltration and storage. With the calculations made of the stormwater before and after the new solutions, the current flow at the site could almost be reduced by 70%. Together with the volume capacity, that means almost all stormwater predicted on site has a chance of being managed. Solutions were strategically placed to utilise the site's natural low points as guidance for the water flow to end up in desired places.

However, the solutions ended up being very extensive. Reshaping A-dammen or constructing laying new paving on the footpath are major projects that may be difficult to execute on site as it will affect the activity that prevails now. To counteract that, each sub-solution was designed so that they could be applied independently of each other, even though full effect requires the entire concept.

In the limitations chapter it was mentioned that the calculations of the expenses were not a limiting factor while designing the area. However it is important to note that the various solutions would be costly and therefore possibly difficult to justify from the financial point of view. When forming the concept, great emphasis was placed on social and ecological sustainability, i.e focusing on creating social spaces with seating or green areas with better environment for biodiversity.

The term sustainability does however include the economical aspect, which leads to room for improvement to achieve the goal. Having said that, due to the main focus on social sustainability many of the wishes from the survey could be met, mostly regarding the seating places. With inspiration from the interview held with Akademiska Hus regarding social areas, many of the designed features managed to benefit the campus in multifunctional ways.

Due to these dilemmas prioritisation of measures seemed appropriate. Solutions that solve the major problems on the site or cover more points on the LoRR would be considered of higher priority. These would include for instance the rain garden, which is essential for the cloudburst management and pavement adjustments since they were a lesser investment which still could solve many of the problems caused by normal rain. On the flip side, solutions with lower priority became those with properties which were already somewhat accommodated, as adjustments at Geniknölen. The rainclock was harder to place, due to its still uncertain construction and design. If designed properly it could become an inspiring highlight worthy of a world class campus. However it is important to note that since all artworks can be perceived differently, the idea would need more development before becoming fully convincing.

As mentioned above, some solutions would be considered of lower priority, but to strive for the goal of becoming the world's best campus they are still considered important to implement. For instance the mushrooms, which do not contribute as much to the site with water management. However, as they contribute to social, visual and convenience aspects they were chosen to remain in The Final Concept.

A potential drawback is that unique solutions, such as the rain clock and mushrooms, with unstandardised constructions can require more maintenance and scattered opinions around them. A campus area is at first hand made for its community members, so if a solution is perceived as unmotivated or distasteful, there can be a risk of creating irritation or making people feel uncomfortable. The solutions in the concept however have the potential to develop into a pleasant and safe environment that benefits its users and improves the campus experience. They are tailored to the site to highlight the area's potential and since several original area features remain, old values and traditions can be preserved while still providing space for new ones.

Also worth mentioning is that due to limited time and resources The Final Concept was settled, even though ideas on how to improve it were constantly discussed. Some topics were location of the solutions, possibilities to upkeep campus traditions and accessibility, how to divert water from mushrooms to the rain gardens etc. Others focused on the wanted rain experience, for example by letting water in the mushrooms stream over coloured glass or partly drop over the shed edges to create a rain tunnel. Such developments had surely improved some problems that remained, but needed to be evaluated further and were therefore considered more suitable for future studies.

6.2 Project methodology

While creating The Final Concept, a broad set of methods was used to find suitable solutions in an effective way. This resulted in an approach where many different skills could be highlighted. Through creative methods such as sketching or digital visualisation complemented with more technical tools such as calculations, digital simulations and literature studies, the group gained a broad understanding of the project.

The literature study was appreciated as it laid a good foundation to the design of the concept. When a number of different solutions are presented together with an investigation of the site, it is easier to select solutions that could be applied to the studied area. When the whole group had accessible information it was easier to conduct workshops and discussions for the concept forming.

Research on how to conduct processes regarding stormwater management was not made prior to the project start. With the right knowledge on how to carry out studies such as these would have made all steps in the process more efficient and led to better problem solving approaches. The decision however to not look at similar projects was intentional, as the group wanted to create a unique concept. Because of this, new methods could be implemented that could lead to new results and solutions to the problems.

In the initial information gathering, the interviews, survey and literature study provided a strong foundation to the report. With inputs from relevant stakeholders and people who use the space together with scientific studies that describe the problem and requirements placed on these, the requirements could be easily met. To make this even more efficient, more limitations should have been made as well as they should have been carried out earlier in the project process. Due to the survey being sent out in later stages, this led to it not being reached to a larger group of people. In total it was out for a month, but with a longer period of time more people had accessed it and thus a larger amount of data could be collected.

A large majority of respondents came from the ACE institution, which gives a skewed picture in the answers and a certain bias. As well as a longer timeframe, the survey was not promoted correctly when it was mainly sent out to students at the ACE department. In order to get a more representative result, more target groups should have been included, partly other institutions at the university but also including the faculty. Since the project area mostly concerns the ACE institution, the answers in the survey were considered to be important, as the most affected were able to express themselves and were therefore chosen to remain in the report.

Stormwater modelling and calculations are relatively easy methods that give a good input for the report. With programs like SCALGO and MIKE the problem areas could be easily investigated and gave a broader understanding of the site and when being complemented with calculations regarding the flow and volume capacity one could easily understand the effectiveness of the solutions. It is also important to note that both methods were very simplistic and may result in an unrealistic representation of reality. The calculations were rough estimates and the simulations gave exaggerated results. To prevent this, better guidance of the simulation programs should have been sought out and better understanding on how to carry them out. As this was the first time using both MIKE and SCALGO the programs may not have been used to their full potential as there was a lack of understanding on how to use them.

The project's design inspired approach was partly new to the group members and proved to be mostly beneficial but also tedious. It helped break down the task in manageable pieces and provided good inspiration and structure for the creative processes. The new strategies, however, were proven to be time-consuming because many parts needed rework or were interpreted differently. Still, for someone not used to architecture- and design work the method was an eye opener on several points. One example was the strengths of using sketches to convey ideas and difficulties of unbiased comparisons of the same when drawing levels or medium differs. Another example was the LoRR, with the interesting idea of keeping creativeness inside the frame of demands but outside the box of solutions. The first part worked quite well as the list made it easy to for instance check concept performance. The second one appeared harder to motivate since it forced the group to spend time on investigating new ideas even when there already existed good ones in the repertoire.

6.3 Future studies

As mentioned previously, the project included limitations to keep the focus on the topics of greatest relevance. However, this meant interesting areas were purposely excluded. If future studies were to be conducted, several issues could be further investigated and reflected upon.

When evaluating the work methods it was concluded that a broader set of competence within the subject would be beneficial. Influences of architecture or design could probably have added a valuable perspective and been of help during the creative processes. It would also be interesting to see used methods such as LoRR developed further, perhaps with added weighting of requests.

Another interesting aspect that should be evaluated is a follow up on the concept, where new surveys or interviews were to be held to evaluate how appreciated The Final Concept would be. When forming the site, the main target group are the people who use the area everyday. If the solution does not fit the target group The Final Concept will not be viewed as a success and needs further development.

When the various problem areas were investigated, different factors were built on assumptions, such as the amount of copper at the site. To optimise the concept further investigations on the problem areas should have been conducted. Measurements of pollution and identification of affected recipients would be relevant to determine the needed extent of solutions. Also a geotechnical investigation would be interesting to understand important factors as actual soil properties and ground water levels Information about these was insufficient and in the case of future studies, there should be contact with experts in the field to get a more accurate picture of the problems on the site.

The plans discussed in the report should also not hinder future plans for the area. As described earlier, stakeholders have already made plans to develop the campus. These were to some extent kept in mind when the design of the concept was done, but in some places they clashed. Due to this it would be interesting to further develop the concept in more detail to see how it can maintain the same level of services but without hinder future plans of the site.

Together with stakeholders' plans and solutions from other universities and campuses, it would have been possible to create a better campus. Something interesting and rewarding though, would have been to examine other campuses around the world to see how they tackle the same issues. By looking at real life examples, it would give a better picture of how the solutions are perceived by the people around and also how effective they are. This would give inspiration on other creative solutions that are not found in reports or textbooks.

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Appendix A - Survey questions and results

Enkätfrågor

Världens bästa campus när det regnar

Kandidatarbete inom samhällsbyggnadsteknik

Framöver kommer nederböden öka, vilket ställer högre krav på dagvattenhantering. Därför vill vi undersöka möjligheterna kring ombyggnation i området runt A-dammen. Följande enkät har som syfte att undersöka den upplevda miljön för studenter och personal i området mellan kårhuset och SB-huset. Området inkluderar Geniknölen, A-dammen och passagen som går igenom. Resultatet kommer att bidra till en grund för att skapa ett koncept som kan förbättra dagvattenhantering och den sociala miljön i området.

Enkäten tar ca 5 min att svara på.

Deltagarinformation

Vad är din sysselsättning på Chalmers?

- ☐ *Student*
- ☐ *Personal*

Inom vilket fält studerar, forskar eller utbildar du inom?

Kemi- och bioteknik
Teknisk fysik och Teknisk matematik
Arkitektur och samhällsbyggnadsteknik
Maskinteknik /mekatronik
Elektro, Data, IT och Medicinteknik
Globala system.
Industriell ekonomi och Ekonomi och produktionsteknik
Övrigt

Hur ofta besöker du området kring geniknölen och A-dammen

- ☐ *Varje dag /flera gånger i veckan*
- ☐ *En gång i veckan*
- ☐ *En gång i månaden*
- ☐ *En gång i halvåret*
- ☐ *Aldrig eller väldigt sällan*
- ☐ *Vet ej*

Passagen mellan kårhuset och SB-huset:
Hur bra stämmer följande påstående?

	Instämmer helt	Instämmer delvis	Instämmer inte alls	Vet ej/vill inte svara
Det är märkbart stora vattensamlingar på vägbanan vid nederbörd.	○	○	○	○
Det är besvärande med vattensamlingar på vägbanan vid regn.	○	○	○	○

Hur hög prioritering bör sättas för åtgärd?

- ○ Hög (inom 1 år)
- ○ Medel (inom 5 år)
- ○ Låg (inom 20 år)
- ○ Ingen åtgärd behöves
- ○ Vet inte/ vill inte svara

A-dammen

Svara från 1-5 på hur mycket du värderar A-dammen inom följande kategorier:

	1	2	3	4	5	Övrigt/vill inte svara
Kulturellt värde för dig som Chalmerist:	○	○	○	○	○	○
Sentimentalt värde:	○	○	○	○	○	○
Möjlighet till rekreation:	○	○	○	○	○	○
Möjlighet till bad	○	○	○	○	○	○

Vid en ombyggnation av A-dammen
Ett hypotetiskt scenario där A-dammen rivs, demoleras, skrotas och byts ut.

Hur mycket instämmer du med följande påståenden?

	Instämmer	Instämmer inte	Vet ej/ vill inte svara
Jag finner bevaring av A-dammen viktig.	○	○	○
Jag är öppen för ombyggnation om möjlighet till rekreation ökar.	○	○	○
Jag är öppen för ombyggnation om dagvattenhanteringen blir bättre.	○	○	○
Jag är öppen för ombyggnation även om det INTE möjliggör samma årliga event (brobyggartävling/wakeboard).	○	○	○

Grönområde vid Geniknölen

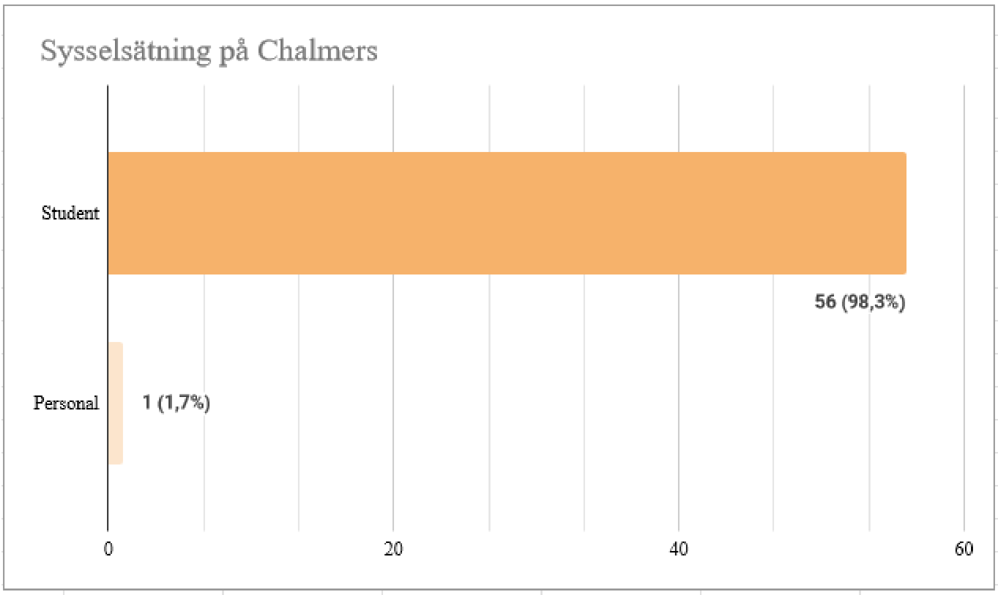
Hur mycket instämmer du på följande påstående?

	Instämmer helt	Instämmer delvist	Instämmer inte alls	Vet ej/ vill inte svara
Det finns goda möjligheter för avkoppling vid lunchraster.	○	○	○	○
Jag använder mig av området för rekreation.	○	○	○	○

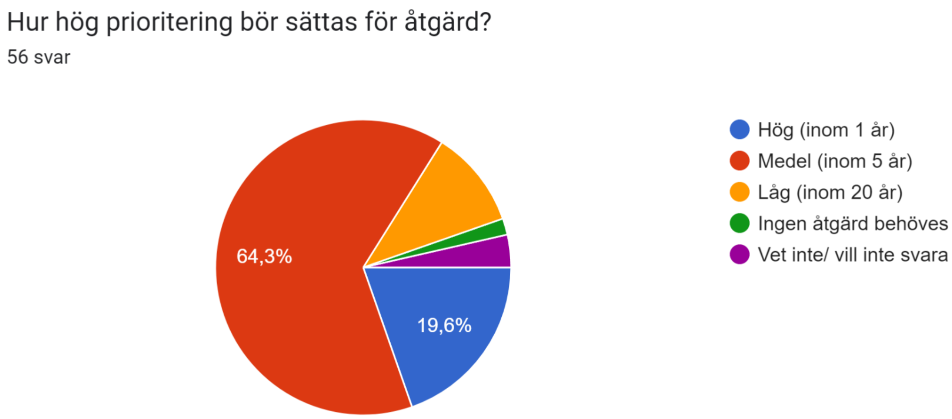
Övrig förändring som ni skulle vilja se i vid Geniknölen:

____

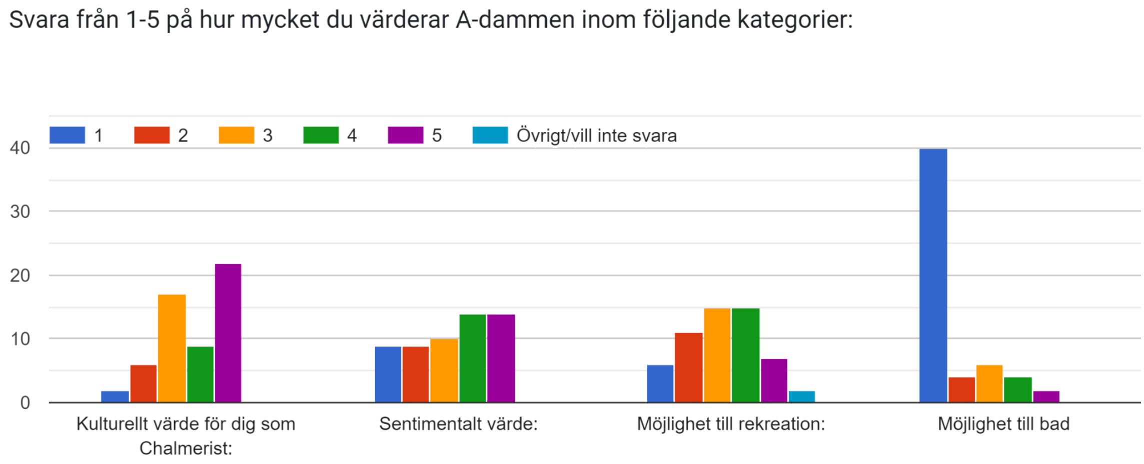
Enkätresultat



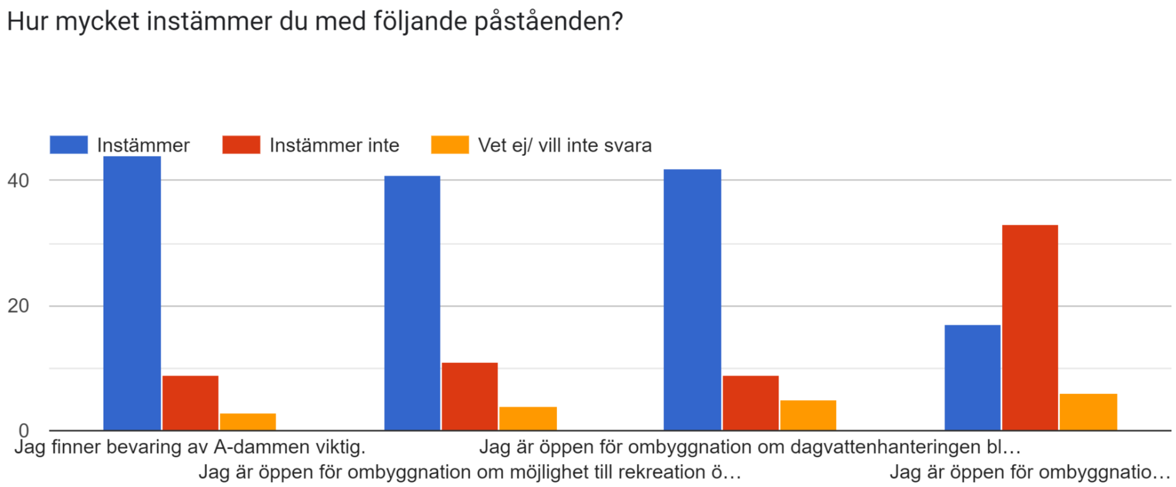
Figur 1. Graf över antalet deltagare i studien samt deras sysselsättning.



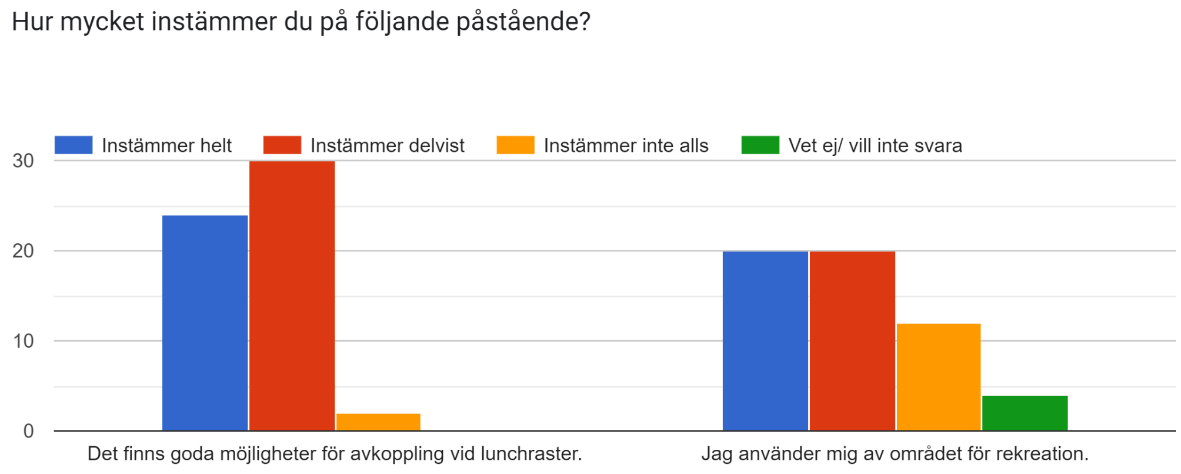
Figur 2. Diagram över hur deltagarna prioriterar hanteringen av dagvattenproblematiken i området.



Figur 3. Diagram över hur högt deltagarna värderar A-dammen med hänsyn till kulturellt -, sentimentalt - och rekreationellt värde samt möjligheter till bad.



Figur 4. Deltagarnas öppenhet för rekonstruktion av A-dammen.



Figur 5. Diagram över deltagarnas åsikter rörande avkoppling och rekreation på projektplatsen.

Utförliga svar om förändring som deltagarna skulle vilja se i vid Geniknölen:

- Mer platser sitta/mer säten
- Mer sittplatser som exempelvis bänkar osv för att äta lunch/plugga mm
- Möjliggöra för för fler sittplatser
- Fler sittplatser
- Mer bänkar/bord på andra sidan vattnet hade varit något samt generellt mer bänkar där man faktiskt kan sitta. Det finns ju ingen riktig plats att sitta runt geniknölen om man inte vill sitta på stenarna eller tegelväggen vid kårhuset
- Säkerställa att grönområdet bibehålls och att det finns större öppna ytor, inga större förändringar
- En tillplattad yta för kubb
- Bänkar med bord
- Kanske mer bord för man kan sitta och äta och inte bara bänkar
- Sittplatser med bord i mitten så man kan käka eller hänga med kompisar
- Fler bänkar i söderläge
- Mer bänkplatser!
- En lång bänk längs fönstren in till kårrestaurangen.
- Skönare sittplatser

Appendix B - Interview questions and transcriptions

Akademiska Hus - Intervjumall

Intervjuperson(er): Sara Karlsson
Intervjuare: Ella, Johanna
Datum: 23/2 - 2023

Introduktion:

- Presentation av oss, arbetet och intervjuns syfte.
  (Syfte: få inblick i hur man kan jobba med dagvatten i urbana miljöer och framförallt hur man kan integrera lösningar med sociala ytor)
- Är det okej att vi spelar in?
- Du jobbar som vi förstått det på Akademiska Hus. Vill du berätta lite kort om vad du arbetar med?

Frågor:

1. Vad har du personligen och Akademiska hus som organisation för ansvar gällande området kring Campus, och specifikt kring A-dammen och geniknölen?
    - Hur ser ansvarsfördelningen ut vid projekteringar?
    - Hur ser samarbetet ut med Chalmersfastigheter och Studentkåren?

2. Hur arbetar ni [Akademiska hus/Chalmersfastigheter] med dagvattenhantering i sina projekt?
    - Vad har ni upplevt varit den största problematiken med dagvatten på Campus?
    - Vad är dina erfarenheter av multifunktionella dagvattenlösningar?

3. Vad har ni för framtidsplaner för området och känner du till några specifika planer för dagvattenhanteringen?
    - Finns det någonting som projekteras nu eller i närtid?
    - Finns det några specifika prioriteringar ett sånt här projekt bör ta hänsyn till?

Om tid finns:

4. I vårt arbete vill vi integrera dagvattenhanteringen med den sociala miljön. Hur brukar ni hantera olika sociala aspekter, exempelvis säkerhet, tillgänglighet, utformning (materialval).

5. Finns det några specifika problem som upptäckts i projekt runt omkring som kan vara viktiga lärdomar om/när det här området byggs om?
    - Främst gällande dagvattenhantering
    - Andra förhållanden som kan göra byggnation problematiskt, tex markförhållanden/skyddsvärda objekt osv.

Akademiska Hus - Transkribering

[Utanför inspelning]
Vatten rör sig alltid till lägsta punkt, som man ej får glömma. Få bort vatten snabbt är ganska lätt, men växter nära fasad och lagra vatten är en utmaning för fastighetsägare, hur kan man trygga hur man ska säkra att vattnet ej ska skada huset.

[Inspelat]
Vad är din bakgrund?

- Jag pluggade nere på Alnarp som Landskaps ingenjör och arkitekt och efter studierna började jag jobba på akademiska hus där jag har jobbat i nu 6 år. Då har jag framför allt jobbat i syd från Karlstad ner till Lund. Jag jobbar med bolagsövergripande 20% av hållbarhetsfrågor framför allt ekologisk hållbarhet och biodiversitet, hur vi i branschen och på akademiska hus uppnår målen gällande biodiversitet.

Vad är ditt ansvarsområde?

- Min titel är Strategisk Fastighets Utvecklare Utemiljö, förkortatt SFUU. Då är jag med mycket i de tidiga skeden och särskilt gällande utemiljön där man jobbar med extremväder blir det mycket lättare om får vara med i tidigt skede än att komma in senare då det blir svårare att fixa.

Om vi skalar ner det lite, är det att du bestämmer vad som behövs vara vart?

- Ja, min uppgift är ju att jobba med våra utemiljöer som vi har. Vi äger ganska mycket mark runt om, och det är skillnaden jämfört med många andra fastighetsbolag som kanske bara äger en meter utanför fastigheten och sen äger kommunen marken. Då får kommunen snarare ansvaret att ta hand om extremvädret, men vi äger campus och där med marken mellan byggnader vilket är unikt att man äger så mycket mark och därmed det extra ansvaret som kommer med det.

Vad har Akademiska hus för ansvarsområden gällande Johanneberg campus och hur ser ansvarsfördelningen ut mellan er och exempelvis Göteborgs stad och chalmersfastigheter i olika projekt?

- På just Chalmers är det lite speciellt, då på många universitet kan det bara vara akademiska hus som är fastighetsägare. Eftersom att vi är statliga och Chalmers är en stiftelse och då har Akademiska Hus sålt ca hälften av marken till Chalmersfastigheter och resterande äger Akademiska hus. Tidigare ägde vi en större del och nu tillhör de stiftelsen som fungerar som ett fastighetsbolag. Vi äger och förvaltar våra hus och bygger hus men också marken. Så sammanfattningsvis äger vi, bygger vi och förvaltar. Nu med de pågående mark projekten som är igång, bland annat vid Chalmers Tvärgata och vid Sven Hultins, är min uppgift att svara på frågorna; Här har vi behov, allt från underhållsbehov eller att rusta upp område. Då initierar jag projekten och sen så kan jag driva projekten som jag sedan lämnar över till förvaltning. Jag har varit med i hela projektet för Sven Hultins Gata på campus, där det långsiktiga målet är att ta fram en park där vi nu behöver ta bort hela parkeringen.

Ska ni ta bort all parkering där?

- Ja det är den långsiktiga tanken. Hela tanken är att skapa parken som en “skål” som ska kunna ta hand om mycket vatten. Bäddarna som är utanför byggnaden (skriv in vilken byggnad det är) är gjorda som regnbäddar som ska kunna ta hand om vatten. Vi försöker leda vattnet så att de åker genom bäddarna. Hela tanken här är då att ta hand om vatten.

Har ni planer på att utöka parken bort till A-dammen?Vad är era framtidsplaner för området? Specifikt för dagvattenshantering.

- Tanken är att vi ska få till det hela vägen bort. Vi hade lite större planer runt tågvagnen med att göra en dagvattenlösning. Dock blev det bort prioriterat då det skulle kosta mycket så tanken där är just nu pausad och istället ligger fokuset lite längre upp på campus kring kopparbunken. Dagvattenlösningar vid tågvagnen finns med i campusplanen och jag jobbar på att få det genomfört. I planen beskrivs det bara som ett grönstråk och där har jag tagit fram ett förslag kring hur det skulle kunna se ut. Det planeringen som vi redan har gjort försöker vi baka in så mycket olika värden som vi kan och får. I planen finns det bilpool och en mobilitetshubb som svarar på frågorna hur vi kan få ett mer hållbart resande till och på campus. Studenter är duktiga på att resa tills fots, men vad vi har identifierat här är att ofta är det besökare som parkerar här och då ställs frågan behöver vi förse parkering till besökare eller ska vi tillgodose andra kvaliteter? Vi bygger även sven trädgård, vid kullarna. Den ska dels kunna ta hand om vatten, men ett stort fokus på att kunna skapa matproduktion inne i staden på ett hållbart sätt. Enligt FN klimatmål finns det med att lösa hållbar matproduktion och detta är ett försöker på att lösa matproduktionen. Nästan allt som vi kommer att odla där kommer att vara ätbart och perent, i en offentlig miljö där man kan skapa matproduktion. Den spelar även stor roll ur den sociala aspekten där vi vet att man mår bra i en grön miljö och en god utsikt. När kolonilotterna kom till då vi hade stora problem kring just detta i Sverige och nu har vi fått en uppsving med matproduktion för att kunna nå upp till våra klimatmål. Detta ökar även den biologiska mångfalden och en hobby för många.

Många studenter på campus hade önskat för mer sittplatser på campus och de bänkar som finns uppskattas av många under sommaren. Vi är många personer på skolan och önskar att det skulle finnas mer platser för alla.

- Detta är ett stort önskemål som vi har märkt från skolan och vi jobbar konstant på att uppfylla dessa. Det är dock alltid en balansgång mellan att folk vill ha mycket sittplatser men till större delar av året står de helt tomma. Lösningen är då inte alltid att trycka in så många platser som möjligt, utan istället jobba med informella eller tillfälliga sittplatser.Sen är det även viktigt att möblerna är producerade på ett hållbart sätt så att mycket resurser används till dess potential. Exempelvis i Karlstad har man jobbat med möbler som använde “plock virke” som inte har bidragit till skövling av skogar. Livslängden måste också tas till hänsyn i utformningen tillsamman med många fler.

Vad har ni för prioriteringar när ni påbörjar dessa projekt?

- Mycket handlar om att man ska “känna platsen” och prioritera vart folk rör sig mest. Exempelvis entreer eller huvudstråken. Då allt kostar pengar måste allt prioriteras och då ligger huvudfokuset just de mest folkrika platserna så att man kan hjälpa så många personer som möjligt på en gång. Det är även viktigt att ställa sig frågan hur många värden kan vi få in i projektet.

Är dagvatten inte ett av de första prioriteringarna?

- Det ligger som ett lager där vi har gjort en riskbedömning på alla våra fastigheter gällande extremväder. Nu har vi krav på oss att jobba med extremväder från lagstiftning vilket gör att vi måste ta hand om dagvatten.

Vad är er största problematik när det gäller dagvatten?

- Något som jag hade velat jobba vidare med hur man lagrar vatten från perioder med mycket nederbörd till perioder med torka. Hur kan man lagra detta så det kan sedan användas. Historiskt sett har vi jobbat med att få bort stora mängder vatten fort men i framtiden vill vi snarare se vatten som en tillgång. Att föra bort vattnet snabbt är en ganska enkel process men att bevara och ta vara på dess värde kan hjälpa oss nå klimatmålen. Att skapa regn speglar är jätteviktigt för biodiversiteten, vilket är ett av våra största miljöproblem i dagsläget, men även för att skapa rekreationsvärde för människor. Vad vi behöver gör är att börja tänka om och inse att vatten inte är ett problem utan att se det som en förutsättning för liv och ta vara på den.

Vi vill försöka integrera vår lösning på dagvattenproblem med den sociala miljön, hur hanterar ni de olika sociala aspekterna, exempelvis utformning eller säkerhet?

- I Sverige är vi väldigt rädda för djupa vattenspeglar då man anser att många kan skada sig i dem, speciellt yngre barn. Men om vi jämför med andra ställen exempelvis Holland där man har kanaler som är mycket djupare har man inte sett att skaderisken ökar. Då får vi också inom denna aspekten börja tänka om att vi inte behöver vara så rädda för att lagra vattnet och ha det lite djupare. Då kan man kanske börja jobba med släntning istället, då man skulle kunna hinna rädda barnen innan det blir för djupt. När vi kollar på A-dammen, som användes för kylning av datorer, är mycket djupare än vad vi ser. Då hade det varit intressant att se om vi hade kunnat göra den djupare och inte behöva tomma på vintern och istället använda den som ec skridskobana. Nu är vi lite för rädda att ha kvar vattnet i A-dammen året runt men något som jag gärna hade jobbat vidare med. I projektet nu med parken kommer det mesta i grönområdet bli ätbart. Det handlar mycket också mycket om att gå tillbaka till “skogsträdgården” och mycket om återhämtning, något som jag har forskat om då miljöpsykologi fokuserar på de hälsoeffekter som finns och vad för faktorer som vi människor får återhämtning från och vad vi känner oss trygga i. Detta har vi då försökt ha med i planen för Campus. Kullarna och ängsmarken ska skilja visuellt av från biltrafiken så att man ska få en känsla av att det är grönt och bidrar med den biologiska mångfalden. Genom att gömma bilvägen visuellt bidrar det till att fler pollinerare kan vistas på platsen som är en stor del till den biologiska mångfalden och klippt gräs för samvaron där man ska kunna nyttja parken. Tanken kring tågvagnen för en öppen dagvattenlösning har pausats för ekonomiska skäl, men där tanken var att ha en volleybollplan. Istället diskuteras en billigare lösning där man genom att måla streck man skapa en basketbollplan.

Hur ni haft ett liknande projekt med att integrera matproduktion tidigare?

- Det här är vårt första projekt. Tidigare har vi haft odling platser där ett team jobbar och sköter jorden mycket. I projektet nu vill man inte ha en odlingsgrupp utan alla ska kunna ta del av odlingen. VI akademiska Hus ska kunna förvalta och växterna är perenna och jobbar mycket med växter som vi kanske inte vet att man kan äta, exempelvis olika ätbara blommor.

Kommer ni ha något samarbete då med studentkåren?

- Nej, då många odling grupper ofta har väldigt engagerade medlemmar men när dessa lämnar skolan kan det finnas risk att engagemanget minskar. Det är inte lätt att få kontinuiteten av skötsel och då faller det tillbaka på oss. Om det börjar se ovårdat ut börjar folk klaga. Så detta är ett försök på hur vi kan förvalta dessa projekt.

Hur ni några tips för oss för vårt område?

- Det som är klurigt där är att dels de hamlade träden där är kulturmärkta och får då ej flyttas eller huggas ner. Den andra problematiken är att det är ett väldigt stort flöde med folk där. Hur ska ni kunna säkerställa trafiken? Ni kan ej göra allt grönt utan fokusera på tillgängligheten. Till sist är hur ni ska få till sittplatser, där det är fullt under fina dagar men står tomt till större delen av året, då kan ni kanske fokusera på de informella sittplatserna istället. Det kan också vara intressant att ni inte försöker få bort vattnet snabbt utan att diskutera hur det kan återanvändas, något som vi fastighetsägare inte idag är så kunniga i. Ställer er frågan, hur kan vi trygga oss att er fastighet ej skadas när vi lagrar vattnet här.

Chalmersfastigheter - Intervjumall

Intervjuperson(er): Anna Zahlbruckner & Freja Frenberg
Intervjuare: Robin Fox, Ella Blomquist, Hugo Malmqvist
Datum: 21/3 - 2023

Introduktion:

- Presentation av oss, arbetet och intervjuns syfte.
  (Syfte: få inblick i hur man kan jobba med dagvatten i urbana miljöer och framförallt hur man kan integrera lösningar med sociala ytor, Visa BILDER)

- Är det okej att vi spelar in?

- Du jobbar som vi förstått det på Akademiska Hus. Vill du berätta lite kort om din roll/ansvarsområde?

Frågor:

1. Organisationen Chalmersfastigheter:
    - Vad är Chalmersfastigheters affärsidé?
    - Vilka äger Chalmersfastigheter och vad är ert syfte?
    - Vad är Chalmersfastigheters roll i förvaltandet av Chalmers Campus Johanneberg?
    - Hur stor del/vilka delar äger ni?
    - Hur fungerar sammarbetet med Akademiska hus, andra intressenter?

2. Vårt projektområde och dagvattenhantieing generellt:
    - Vårt område: vem äger fastigheten? Vad har Chalmersfastigheter för ansvar?
    - Hur måste ni tänka kring förvaltandet av fastigheten då det är en allmän plats som är tillgänglig för alla?
    - Hur hanterar ni frågor kring dagvatten i allmänt?
    - Hur hanterar ni dagvatten i området specifikt?
    - Har ni några planer på att förnya dagvattensystemet?

3. Övrigt:
    - Har ni någon säga i vad som bygg på ytorna ni använder men inte äger?
    - Finns det någon fördel med att äga ytorna istället för att hyra?
    - Hur stort ansvar har ni för projekt som huvudsakligen byggs för studenterna? tex sociala ytor.

Chalmersfastigheter - Transkribering

[Inspelat]

Vårt projekt kommer att innefatta området utanför SB-huset, vid A-dammen, där vi ska optimera utrymmet med hänsyn på dagvatten och de sociala ytorna.

- Som vi har diskuterat så är det inte vi på Chalmersfastigheter som äger just den marken, utan akademiska hus äger den. Vi är två fastighetsägare och kåren som äger kårhuset. Frågorna som ni har ska vi försöka svara på så mycket som möjligt men kommer nog bli mer generella svar än för just er plats då det inte är vår mark.

Ni kan ju börja med att presentera er själva och vad det är som ni jobbar med.

- Jag heter Freja Frenberg och jag har jobbat här i 2 månader och har samma roll som anna, nämligen campus och lokal utvecklare. I grunden är jag arkitekt, så att jag känner väl till området som ni kommer att jobba med. Jag har jobbat i ungefär 10 år som arkitekt, så detta är en ny roll för mig.
- Jag heter Anna Zahlbruckner och jag jobbar då också som campus och lokal utvecklare. Jag kom hit för snart 2 år sedan. Jag pluggade också på Chalmers för 10 år sedan då jag läste Affärsutveckling och Entreprenörskap (AE-programmet).
- Vi jobbar med utredning i tidiga skeden på campus. Vi kan sitta och planera allt från den "gröna världen" på campus till att vi stöttar viss form av fastighetsutveckling. Men främst handlar mycket av det vi gör om campus och då utemiljön på området.

Vad är Chalmersfastighets affärside? Vad är ert syfte, eller vad är det ni gör?

- vi ska tillhandahålla lokaler till chalmers tekniska högskola. Primära syftet är att se till att det är tillräckligt och att det är bra. Vi har vårt största vision där vi ska bidra och skapa hållbara campus i världsklass. Detta är det vi jobbar mot, men rent praktiskt ingår vi i samma stiftelse concern som högskolan och vi är den part som till viss del äger och till viss del hyr in de ytor som skolan behöver för att driva sin verksamhet. Vi finns på Johanneberg, Lindholmen och Onsala.

När det handlar främst om Johanneberg, vad håller ni på med mer specifikt på platsen?

- Det beror på vem som slutligen är den faktiska fastighetsägaren kan man säga. I byggnaderna som vi äger själva, där driver vi allt från tidig tanke till projektering till förvaltning, hela fastighetens livscykel. När det kommer till SB-huset där ni jobbar, är skolan vår hyresgäst där vi är dialog med skolan om vad som behövs och komma fram med ideer, men måste vi gå till fastighetsägaren som är akademiska hus för att skapa projektet och sedan blir det just dem som driver projektet rent genomförande mässigt. Liknande fungerar det med marken utanför, där vi har ett tätt samarbete med Akademiska Hus.

Om vi förstår det rätt, om chalmers vill ändra något på campus oavsett om det är ni som äger marken eller inte, går de igenom mer ändå?

- Oftas är det så. Sen är vi ofta i samma forum som akademiska hus, men i stort sätt är vi nästan alltid involverade på något sätt.

Ert samarbete med Akademiska hus, hur fungerar det? Äger ni något tillsammans?

- Det finns väldigt tydliga gränser. Man behöver vara tydlig så vi har inga fastigheter med akademiska hus i dagsläget. Sen har vi väldigt mycket som är angränsande.

Påverkar detta fördelandet av ägarskapen? Blir det större skillnader på platser där det ägs av olika fastigheter?

- Vi två är väldigt olika organisationer, där akademiska hus är mycket större i jämförelse med chalmersfastigheter. Bara detta gör att vi har väldigt olika sätt att ta oss tillväga och olika snabba på olika frågor. Vi har olika budgetar och olika processer, men vi försöker att tillsammans jobba efter campusplanen som gjordes 2019 där vi har en gemensam vision. Vi jobbar dock tillsammans för att få samma känsla över campus, men då blir det kanske att de tar fram en plan för deras projekt och vi tar fram ett för vårt men vi kan använda samma arkitekt, så att känslan blir den samma. Vi har jobbat med långsiktiga planer, men hur ser den ut över hela campus, hur ska vi knyta ihop det. Vi lägger resurser på rätt ställe och hur vi ska samarbeta. Gör vi något, går vi igenom på hur vi har tänkt och håller oss involverade på chalmers. Vi har karaktärer på campus och pratat om hur vi ska definiera och hur det ska se ut. Det blir något som vi alla måste förhålla oss till. Det finns en hel del gemensamma styrdokument. Framtagna tankar som skapades tillsammans.

Är dessa framtagna för att beslya att ni äger olika delar av campus eller för att belysa att chalmers är en hyresgäst?

- Det är lite blandat. Det är alltid en förutsättning att så här finns det en ägarstruktur. Men vi alla ska jobba för en samma känsla. Exempelvis utifrån ett brukarperspektiv eller miljöperspektiv, det här ska vi lyfta. Sen finns det nog mer dokument som vi har jobbat med som är mer styrda där ägare av marken definieras tydligt. Men i slutändan gör att ändå med Chalmers i huvudfokus eller som syfte. Jag skulle nog ändå säga att vi har ett ganska starkt perspektiv att det vi gör är för verksamheten som pågår.

Ni pratade innan om att ni är olika snabba på olika frågor, vad skulle detta kunna vara?

- Just att vi är olika snabba på hantera olika saker handlar om att vi har olika processer, där generellt har vi lite mindre kedjor för att fatta belsut vilket gör att vi ofta kan snabba på processen. När det gäller dagvattenhantering, så vet jag inte om vi är olika på att hantera dessa då vi har olika förutsättningar nom marken som vi äger. Akademiska hus har väldigt mycket mer tuffa områden med dagvatten. Detta kan då har blivit mer aktuellt för dem att hantera.

På tal om Göteborgs stad, hur fungerar ert samarbete emellan. Hur mycket jobbar ni tillsammans?

- De brukar ej vara med och planera eller lägger sig i specifika projekt. De är en part i alla möjliga processer som till exempel detaljplaner. Det finns olika forum där vi möts och diskuterar olika frågor. Sen ska man komma ihåg att Göteborgs Stad är en väldigt stor verksamhet där man träffar olika perspektiv i olika delar av staden.

Är de intresserade att veta hur många studieplatser det finns?

- Nej, de kan nog vara inne mer på grundskolor och påverka. Men som vi precis var inne på så samarbetar vi med staden när det handlar om bygglov eller när vi ska göra till exempel nya pendelstråk utanför. Annars är det väldigt tydliga markägarförhållanden. Inne på campus äger staden inte något. Om de skulle till exempel utveckla Sven Hultins gata skulle vi vara väldigt intresserade av att vara med i den diskussionen. Vi är intresserade av att se vad det är som de ska göra och hur det skulle påverka oss.

Gäller även det kåren, har de ingen säg i era planer och hur utvecklingen ska ske?

- De är en del av att ta fram campus planen och en del i att ha tagit fram styrgruppen för campuset. De är absolut med och tidigare förslag som har kommit fram exempelvis gällande geniknölen eller tågvagnen har kåren varit med som en part. Men varje år byts kårledningen ut så det kräver lite. I vårt styrelse sitter sittande kårordförande. Vi har struktur som gör att de kan vara involverade och arbetsgrupper där de är en part. Allt vi gör är för studenter och hur de ska kunna nyttja campus.

Ni nämnde kort att ni ville utveckla ett campus i världsklass. Vad betyder det för er?

- Det kommer från att man vill konkurrera med de bästa universiteten i världen. Alla ska känna till chalmers, och det handlar både om verksamheten chalmers och campuset där man vill komma hit för att det upplevs så bra.

Hur uppnår man detta? är det genom vackra byggnader? Utemiljöer? m.m

- Begreppet världsklass beror väldigt mycket på vem man frågar. Men mycket av det vi kollar på kommer från campus visionen och där campus handlar främst om utemöblerna. Byggnaderna är lite mer svåra att hantera. Byggnader ingår också, men när vi pratar mer om utemiljön handlar det mer om biltrafik. Vem är den viktiga parten på campus och samtidigt på hållbart världsklass, hur ekologiska värdena ser ut. Vi vill ha en miljö som tar hand om klimatförändringarna och bibehålla den biologiska mångfald. Vi har haft denna visionen länge, men chalmers tog sig an denna när vi gjorde campusplanen.

Gällande campus planen för år 2050, hur realistisk är den?

- Den är mer av en vision eller visa vad som skulle kunna vara möjligt. Driver man en detaljplan är visar vi på vad som skulle kunnas göras.

Vill ni i den arkitekturstilen bygga mer "speciellt" så att ni skapar ett campus som utmärker sig?

- det beror på situation, men vi är inte ett byggande fastighetsbolag heller så det är inte många nybyggnationer som vi på chalmersfastigheter har gjort. För campusplanen beror det på vilken plats vi pratar om och rollen på campus, där kanske inte allt ska bara ha en hög arkitektonisk stil, så det finns en nyansering där. När vi tittar på hållbara aspekten har vi sociala hållbarheten men även ekonomin. Vad vill man betala? Vi har suttit och kollat på jättefina lösningar men för varje kvm blir det dyrare. Sen måste vi även kolla på den ekologiska hållbarheten och ställa oss frågan, vill vi bygga nytt? Hur kan vi nyttja våra lokaler till fullo innan vi gör nytt. Vi jobbar även mycket med att möjliggöra olika saker, vi genomför inte det.

När vi har kollat på vårt projekt har vi hittat viss problematik om föroreningar kopplat till koppar från koppartaken och vi har svårt att lösa hur vattnet alltid ska rinna till lägsta punkten utan att skapa en massa pölar på området. När ni jobbar med dagvatten, hur gör ni det?

- När det gäller koppar tak, har ni varit uppe och kollat? Det finns många tak som ser ut som koppar men är inte det utan målat för att se ut som koppar. Det har varit koppartak och det ska vara en känsla av det. Vi har tagit upp koppartak gällande våra fastigheter där vi har bytt ut kopparteåken till annat material men målat om det så att vi får samma känsla. Sen har vi visa k-märkta hus där vi ej kan ändra.

Lägger ni mycket fokus på just vattenpölar på campus?

- Där vi ser det jobbar vi med det. Sen finns nog ställen som vi inte ser med pölar som vi inte jobbat med. Det är problematiskt där vi inte äger marken och vi kan ej gå in och påverka.
- Vi kunde ej ge ett tydligt svar på vad campus i världsklass är, men vi har campus index varje år. Det handlar om att vi försöker lyssna på folk på varför de vill vara här, vilka behov är det och vara lite framåt tänkande på vad som håller fram i tiden och inte bara här och nu. 2029 firar 200 årsjubileum, vad skapar vi för förutsättningar 2229? Ett campus i världsklass ska man också kunna ta hand om, inte bara super flödiga tekniska lösningar som är praktiskt jobbiga.

Vårt tes är "Världens bästa campus när det regnar". Vad gör Chalmersfastigehter för att förbättra upplevelsen på campus medan det regnar?

- Vi tycker att de kan bli bättre, om man återgår till det där med "Campus i världsklass i Göteborg". Kanske inte att man måste kunna gå torrskodd från Kapellplatsen och upp, men att det finns något ställe att gömma sig vid ett plötsligt skyfall. Vi har titta med en arktitekt lite hur man skulle kunna skapa något sådant.

Ni hade inte velat ha platser där man även kan utföra aktiviteter när det regnar?

- Jo, vi tittar på det men oftsast inte väderskyddat. Där kommer saker som ventilation på fråga, samt att man inte vill att folk bosätter sig i offentliga utrymmen. Det finns väldigt många aspekter att förhålla sig till. Vi har ett tag funderat på möjligheten att skapa något trevligt, där man inte kanske kan gå under tak konstant, men "hoppa sig " torr. Tankar pågor, men tid ska bara finnas för att skapa ett färdigt koncept.

Göteborgs Stad - Intervjumall

Intervjuperson(er): Jens Thoms Ivarsson, Göteborgs Stad, Kretslopp och vatten
Intervjuare: Anja, Ella
Datum: 14/3 - 2023

Introduktion:

- Är det okej att vi spelar in?
- Presentation av oss, arbetet och intervjuns syfte.
  (Syfte: få inblick i hur man kan jobba med dagvatten i urbana miljöer och framförallt hur man kan integrera lösningar med sociala ytor)

- Ni jobbar som vi förstått det på Kretslopp och vatten i Göteborgs stad, och har även varit involverade i ett dagvattensprojekt RainGothenburg. Hur ser er roll ut där?
- För något år sedan höll du en inspirationsföreläsning om projektet RainGothenburg och vi kände att vårt projekt säkert kan ha mycket att hämta därifrån. Skulle ni vilja berätta lite om det? (Vi är särskilt intresserade av idén med multifunktionella ytor och att nyttja vattnet som resurs och bygga bort problem men samtidigt skapa mervärde.)

Frågor:

Angående socialt integrerade dagvattenprojekt som exempelvis de i RainGothenburg:

1. Sociala Aspekter:
   - Vilka aspekter bör tas hänsyn till?
   - Vad behöver ni veta/ta reda på för att kunna ta hänsyn till detta?
   - Hur gör ni rent praktiskt för att få tag i informationen?
   - När ni samlat in datan, hur jobbar ni vidare med den?
     (Hur vägs olika aspekter mot varandra osv)?

2. Ekonomiska aspekter:
   - Hur ser ni på dagvattenlösningar som kräver regelbundet underhåll?
     (ex växtbäddar som ska rensas eller filter som slammar igen. Vad gör sådana lösningar försvarbara?)
   - Angående livslängder, hur länge kan man förvänta sig att en dagvattenlösning ska hålla och fungera?

3. Utformningsprocessen:
   - Hur går ni tillväga när ni utvecklar en lösning?

Angående vårt projekt, har du några tips på hur vi kan ta oss an designdelen?

- Har ni några spontana förslag på lösningar att undersöka?
- Är det några extra viktiga aspekter i konceptutformningen som är lätt att glömma?
- Har ni några förslag på liknande projekt som vi kan titta på för mer inspiration.

Göteborgs Stad - Transkribering

[Inspelat]

Du jobbar på kretslopp vatten, Göteborg och har varit involverad i Rain Gothenburg. Vi undrar om vad din roll är inom projekten rörande dessa.

- Jag blev först anställd av Business Göteborg för sex år sedan och ett tag efter detta så blev jag även anställd på kretslopp och vatten som konstnärlig ledare eller så kallad Creative Director. Kretslopp och vatten blev en projektägare till det som då hette "Världens bästa stad när det regnar" där projektet hade funnits ett tag men mer i formatet i ett word-dokument bara. Då fick jag uppdraget att skapa det, hur kunde vi skapa världens bästa stad när det regnar? Då påbörjade jag arbetet. Min bakgrund är som designer och konstnär samt varumärkesstrateg, så innan hade jag aldrig jobbat med regn eller denna typen av projekt tidigare, vilket jag tycker är väldigt bra. Rain Gothenburg går ut på detta då de försöker hitta nya sätt i hur vi ska utveckla våra städer. När vi tittar på hur en stad ser ut och vad som utgör en stad så handlar det i första hand om människor, allt i staden som byggnader, vägarna, parkerna m.m. finns inte till för något annat än för människors bruk. Och vi människor har ju trots allt våra sinnen kvar, även om vi lever i en digital värld idag, så är sinnena kvar då vi upplever att saker händer och uppfattas på olika sätt såsom syn, lukt eller känsel. Denna aspekt glöms dock ofta bort när man jobbar med stadsutveckling och samhällsutveckling,vilket är något som jag tycker är synd. Därför så är en av tankarna att försöka förmå staden att jobba mer med bredare team i en början i de olika projekten. Så om man till exempel har en utpekad plats som är en lågpunkt där mycket vatten ansamlas, istället för tidigare sätt då man bara ger uppdraget till personer som enbart jobbar med regn, där kompetensen inom gruppen är lika viktig men kan kombineras i team där man tillsammans sitter ner. Och vad skulle hända om från staden och sa att det är lika viktigt att det blir en positiv upplevelse för människan som att vi ska hantera en viss mängd vatten på platsen. Om vi likställer dessa då tvingas projektet till att utförandet sker på ett annat sätt än tidigare, vilket jag tror skulle vara bra. Dock inte i alla fall, utan i vissa projekt kan man göra en lösning som man vet fungerar bra.

Precis som du säger när man får in den andra aspekten redan från början så kan man ofta anpassa de olika lösningarna så att de fortfarande blir en positiv upplevelse av dem

- Den stora skillnaden är att; dels det som skiljer tänket från Rain Gothenburg jämfört med de flesta andra är att de ställer frågan "Hur är det att vara på en sådan här plats när det regnar?", det räcker ej med att säga att det ska vara till exempel att vara en rain garden utan denna ska också ha en praktisk lösning som kan vara fin att titta på. Om jag står i regnet kommer jag inte att titta på regnbäddar eller vilja vara där. Just denna tanke är viktig att ta med sig. Göteborgs stad är ganska långsam vilket leder till att vi inte har platser som löser detta. Just nu håller vi på att bygga Seminarieparken som ska vara färdigställt senare under året.

Vi i vårt projekt så har vi delat upp de olika faktorerna till en kravspecifikation, där det är uppdelat i; Vad behöver vi & Vad skulle vi vilja ha när det regnar och när det inte regnar. På detta sätt blir det att få in en slags multifunktionalitet, då vi vill uppfylla kraven som finns när det kommer mycket regnvatten men också andra funktioner i samma lösning som bidrar inom andra aspekter.
I liknande projekt i Rain Gothenburg, när ni jobbar i liknande projekt, finns det några speciella sociala aspekter som ni lägger extra vikt vid i utformningen av era projekt?

- Korta svaret är; nej, det finns ingen som väger viktigare än det andra. När vi ska kolla på detta behöver vi definiera orden ibland. Vissa ord behöver lite mer förklaring. Vi kan fråga oss vad innebär de sociala aspekterna. En social aspekt skulle kunna vara hemlöshet eller en annan skulle kunna vara möjlighet för lekplatser för barn. Man får börja med att definiera utefter behov. Beroende på var man är i staden så behöver man fundera hur staden ser ut här och vilka sociala förutsättningar det finns på platsen. Man behöver definiera vad en social aktivitet är.

Just för vårt projekt har det varit ganska lösa ramar kring de olika sociala aspekterna. Det som vi kom fram till var att vi vill skapa en yta som dels tillgodoser alla tekniska behov men även att främja den sociala kulturen på campus, men vi kan uppleva att vi bidrar mest till den ingenjörsmässiga biten av lösningen. I den sociala delen har vi främst fokuserat på mötesplatser, men insåg ganska snabbt att det inte finns platser där man vill samlas när det regnar. Då har vi frågat oss om detta kanske inte är relevant att försöka få ut folk när det regnar, utan den delen av campus som vi behandlar i rapporten är en transportled med lite grönområde. Istället fokuserade vi på att under tiden det regnar kan man försöka göra transportleden så visuellt och funktionellt sätt bidrar till en bättre plats som hanterar regnvattenproblem, men att lösningen ska vara trevlig och inbjudande även när det inte regnar.

- Precis så som ni har beskrivit, folk går inte ut när det regnar utan istället ställer man frågan vad är det man kan göra som gör att folk skulle överväga att faktiskt gå ut när det regnar. Detta är väldigt svårt, då de flesta av oss kanske inte gillar att gå ut när det regnar. Dock en sak som vi kan konstatera är att om man i alla fall väljer att fortfarande vara torr och inte behöva stå i regnar, så är det en bra grej att tänka på. Ni i ert projekt behöver begränsa er. Var på campus ska ni hitta lösning, är det längst hela stråket eller bara välja en plats och på den valda platsen hittar vi något som gör att varje gång det regnar då sker något just här. Detta kan vara att, om vi tittar på regnvatten i fallande form som samlas på ytor och tak. Då kan man teoretiskt sett räkna på hur mycket vatten som kommer på ytan vid 10- 20- 50- 100 års regn osv. Då kan ni fundera på, på hur många olika sätt kan vi visualisera så att folk går förbi även när det inte regnar och är sol, så kan man se på något sätt olika grejer som aktiveras just när de olika regnperioderna uppnås, men inte förens dess då det krävs x antal liter vatten för att den ska orka väga över osv. Med hjälp av konst kan man skapa mer intresse och identitet till platsen vilket gör att människor vill dit och kolla. Jag tror att fördelen med detta kan också vara att man drar fokus till något är ganska viktigt. Det vill säga hur vi hanterar regn i vårt samhälle. Funktionen ni väljer kan ni välja just detta att man kan uppmärksamma regn, men sen kan ni också välja om ni vill ha fördröjning eller rena vattnet.

Det var väldigt intressanta tankar och nytt sätt att tänka på för oss. Gällande vårt projekt, finns det några viktiga aspekter som man ofta glömmer?

- I ert fall handlar det mycket om just mötesplatser utomhus, men en annan aspekt som är ganska relevant gällande klimatförändringar är att behovet av skugga ökar i sommartid. Det kan bli en bonus-effekt om man skulle ha ett tak. Ni pratade om utmaningar, där jag tycker att utmaningar när man ska bygga i det offentliga rummet, som exempelvis campus, så ska man göra något som blir tillräckligt fint samtidigt som det är intressant och spännande. Förhoppningen är att man ska gå förbi detta och väcka intresse. Den dagen det regnar och man kan stå under ett tak som även har något roligt händer, hade många accepterat att den fanns där just under den dagen, men som sagt, den tidigare utmaningen är då att hitta en lösning som funkar alla dagar även då det inte regnar. Hur man ej gör kommer dock det alltid finnas de som tycker om det och de som inte gör det. Så som jag hoppas är att ni som gör dessa projekt i skolan ska göra det ihop med hh-valand??, där ni sitter ner tillsammans med olika kompetenser såsom konstnärer tillsammans med kunskaper som ni på programmet har och tillsammans hitta en lösning. Det borde vara ett projekt där ni ska lära er att jobba ihop med andra. Detta är framtiden, där städer utveckling måste använda alla olika kompetenser och jag tycker därför att det vore bra att få med i er utbildning.

När ni utformar era projekt, är det mer de estetiska delarna?

- nej, man tror det då jag är designer och konstnär. Jag sitter ej med just de tekniska delarna, men många av de grejer jag har gjort och projekt som jag har varit med i handlar bara om att diskutera tekniska lösningar. Där använder jag mig av designmetodiken hela tiden. Det handlar knappt något om färg och form, utan jag vill förtydliga att något som vi behöver förstå är att man i framtiden måste jobba i team redan från början i projekten, som inte nödvändigtvis måste resultera i en rätt lösning i början.

Om man gör en stor installation för att skapa en upplevelse i samband med vattenhantering, hur ska man vikta de ekonomiska aspekterna? Hur brukar ni resonera på större stadsprojekt när det kommer till de ekonomiska bitarna?

- Detta är en väldigt intressant fråga, där kommunen använder sig av gamla metoder. Man kan ställa sig frågan; vad är det värt? Som exempelvis om man ska skapa ett konstverk som skulle kosta 15 miljoner skulle det inte ses som ekonomiskt värde, men om detta konstverk skapar en världsattraktion som drar dit mycket folk och kultur. Man kan sänka ribban där det inte måste vara på världsnivå men för de som bor lokalt och vilket värde som det bidrar till folket runt om. Det kan vara väldigt olika dock. Ibland kan man få en budget, där det kan sträcka sig väldigt mycket. Då handlar det ofta inte om att man får göra vad man vill, man ska samla in så mycket information som möjligt och sen börja konstruera en lösning. Det handlar också en del med att synka mellan de olika grupperna så att man utnyttjar resurser på bästa sätt. Dock, om vi går tillbaka till frågan som du ställde så finns det inget tydligt svar. Vi har hur mycket pengar som helst, allt annat är en ren lögn, men dock i vår del av världen så kanaliseras de pengarna på ett väldigt konstigt sätt. Det finns ingen brist på pengar men det finns brist på hur vi fördelar pengarna. I staden finns det en sak som kallas för “1% regeln” vilket handlar om att om vi gör ett nytt projekt, ska 1% av den totala budgeten av projektet gå till konst. Det behöver vara väldigt stora projekt om detta ska ge någon effekt dock.

Men om vi då har bakat in de kreativa bitarna redan från början så att det blir en del av helhetslösningen så borde man komma dit.
Men den kan väl också bli lite problematisk om man använder det tekniska och konsten.

- kan bli men inte i alla fall. Regeln kan vara en väldigt komplicerad process. Tyvärr har det blivit att många förvaltningar i staden undviker att kalla det för konst bara för att slippa den regeln. Den styr på ett sätt så man kan inte vara med att påverka vilken konstnär det blir utan det blir en omständig process. Dock är det väldigt bra och bra att den finns för att den tvingar samhället att satsa på konst, vilket är otroligt viktigt.

Du har pratat med tidigare grupper vid liknande projekt, har du några spontana förslag på saker som du tyckte var extra bra från de tidigare åren?

- Jag tänker mycket på exemplet som jag sa innan om hur man kan skapa någon slags konst vid olika sorters regn. Att visa det och uppmärksamma detta. Dock har Chalmers missat en enorm möjlighet, där man har all form av samhällsbyggnad och arkitektur men man har inget på campus som visar att man ligger i framkant när det gäller hantering av regnvatten. Chalmers hade vunnit på att visa att man dels befinner sig i Göteborg som är en regnig stad.

Det finns en solkalender på campus som visar olika beroende på vilken tid av året som solen lyser på. På samma sätt tycker vi att man hade kunnat ha en regnkalender

- exakt. Det är beroende på budgeten, men ni har ju mer fiktiv idee som bara presenterar ett koncept. Det ordet som du sa med regnkalender som i sig kanske inte behöver en stor investering och tillför ett värde, visar att chalmers är en skola som tänker på just vår stad och hur vi tar hänsyns till våra förutsättningar. En sista grej som jag vill säga om budget är att man säger att man ska ta hänsyn till drift och underhåll, men detta tycker jag är en myt då det finns en massa exempel på hur man har löst drift och underhåll på kreativa sätt på andra ställen i världen där man har använt sig av olika samarbeten som kan underhålla på ett kostnadseffektivt sätt. Istället för att säga att det blir dyrt att underhålla detta, så kan man istället fråga sig på hur många olika sätt skulle man kunna lösa det ekonomiskt så att vi får en fin plats?

Appendix C - Concept workshop results

Detta är en sammanställning av skisser på dagvattenlösningar som tagits fram under en workshop den 30 mars. Lösningarna är sorterade under tre kategorier normalregn, skyfall och övrigt. Det sistnämnda syftar på lösningar vars främsta kvalité är något annat än vattenkapacitet. För alla lösningar utvärdering gjorts av positiva, negativa och intressanta aspekter. Grova skisser av lösningarna finns längst ner i dokumentet.

Normalregn

Här presenteras lösningar vars främsta syfte är att hantera normalregn

Omgjord Stenläggning med en kanal över gångvägen
Tabell 1. Representerar lösning 1 i Figur 1.

Positivt	- Visuellt snygg - Enhetlig design med resten av campus - Bra fördröjning	- Vattenavledning - Har större kapacitet än vanliga rännor
Negativt	- Påverkar framkomligheten negativt - Kan ta mycket plats	- Kan vara känsliga för sättningar
Intressant		

Vinklad plattläggning till under mark-rännor som leder vidare till A-dammen
Tabell 2. Dagvattenlösning som hanterar normalregn, kan ses i Figur 18.

Positivt	- Har en bra framkomlighet - Motverkar vattensamling på samlingsplatser - En lättare lösning som ej kräver mycket resurser - Finns utrymme att kombinera lösningen med kreativa aspekter - Påverkar inte nuvarande funktioner som finns på platsen
Negativt	- Ingen fördröjning eller rening av vattnet - Det är en lägre elevation att arbeta med
Intressant	

Ombyggda kanter på A-dammen med sittplatser samt ta bort fontänerna
Tabell 3. Ombyggnation av A-dammen för att hantera normalregn, kan ses i Figur 15.

Positivt	- Skyfallsfördröjning - Stor magasinering - Öppen för kreativa lösningar	- Inte lika känsligt för olika väderförhållanden utan fontänerna - Mer sittplatser
Negativt	- Tar bort intressepunkt med inga fontäner - Påverkar omliggande natur	- Tar mycket plats - Ett omfattande projekt
Intressant		

Ränna genom vallen till Geniknölen

Tabell 4. Dagvattenhantering som hanterar normalregn, skiss kan ses på Figur 9 & 10.

Positivt	- Tar hand om vattnet från teknologgården - Bra fördröjning av vattnet - Stor kapacitet
Negativt	- Kräver viss underhåll
Intressant	

Undermarks ledning med brunnar mot A-dammen

Tabell 5. Skiss finns i Figur 13.

Positivt	- Ger god framkomlighet på platsen
Negativt	- Ingen fördröjning - kräver underhåll - Anses vara en tråkig lösning då den ej framhäver kreativitet eller estetik
Intressant	- Begränsar Kapaciteten

Sänk A-dammen till 2 nivåer; första nivån hålls på en konstant vattennivå + andra nivån fylls vid skyfall. Sittplatser runt om på sidan

Tabell 6. Skiss finns i Figur 13

Positivt	- Mer kapacitet - Ökad rekreation - Mer sittplatser	- Finns potential för kreativitet - Minskar ej framkomligheten
Negativt	- Kräver underhåll av vattnet - Omfattande projekt	- Tar mycket plats i anspråk till säkerhetsaspekter
Intressant		

Gröna Tak på ställen där det finns koppartak

Tabell 7. Generell lösning kan appliceras på taken vid den studerade platsen.

Positivt	- Anses vara en fin lösning - Förbättrar ljudkvaliteten på platsen - Ökar den biologiska mångfalden	- Mer grönytor - Viss rening av vattnet - Fördröjning av vattnet från taken
Negativt	- Kräver underhållning och kan bidra negativt estetiskt sätt om det ej görs korrekt	
Intressant		

Mindre Rain Garden vid Huvudentren till SB-huset

Tabell 8. Lösning som hanterar normalregn, illustration på lösning finns i Figur 2.

Positivt	- Anses vara en fin lösning - Bidrar med en fördröjning och rening av vattnet
Negativt	- Kräver underhåll - Påverkar framkomlighet
Intressant	- Kapaciteten på trädgården beror på dess utformning och position

Minska A-dammen och öka grönytan med mer sittplatser

Tabell 9. Skiss finns i Figur 14

Positivt	- Bättre utnyttjande av nuvarande yta - Mer gröna ytor - Mer plats för rekreation	- Påverkar ej framkomligheten - Stor efterfrågan från enkäten - Öka biodiversiteten - Mer sittplatser
Negativt	- Kan påverka nuvarande aktiviteter på platsen. - Kräver visst underhåll	
Intressant		

Permeabel gångsten som komplement till de hårdgjorda ytorna på platsen

Tabell 10. Skiss finns i Figur 14

Positivt	- Anses som en fin lösning - relativt enkel lösning - Påverkar ej framkomligheten för räddningstjänst - Minskar påfrestningen på nuvarande dagvattensystem
Negativt	- Kan ge hinder för framkomligheten - Kräver underhåll
Intressant	- Kan användas som ett element som ger en enhetlig känsla på hela campus

Avrinningsränna vid tapporna vid ingånen till SB-Huset som leds vidare till en närliggande rabatt

Tabell 11. Illustration finns i Figur 4

Positivt	- Relativt lätt lösning - Förhindrar vattensamling på trapporna - Bättre framkomlighet
Negativt	- Kan anses vara en dyr lösning för dess effekt
Intressant	

Utöka det gröna taket på hela cykelförrådet söder om rampen vid entren

Tabell 12. Illustration på lösning finns i Figur 4

Positivt	- Relativt lätt lösning - Bidrar med grönyta - Ökar den biologiska mångfalden - Bidrar med rening av vattnet
Negativt	- Finns redan grönt tak på platsen så kan vara onödigt att utöka
Intressant	- Kan vara en onödig investering om det redan är relativt rent på platsen

Grusyta söder om A-dammen

Tabell 13. Skiss finns i Figur 14

Positivt	- Ger god framkomlighet - Resurseffektiv
Negativt	- Inte lika hög prioritet då det enbart ska fungera som en förstärkning för redan existerande lösning
Intressant	

Skyfall

Här presenteras lösningar som ska främst fungera vid skyfall

Regnsvamp av glas med sittytor vid nuvarande tågvagnen

Tabell 14. Skiss på konstruktionen kan ses i Figur 16.

Positivt	- Ger en fördröjning av vattnet - Magasinerings effekt - Ger regnskydd - Unik lösning som kan ge en identitet till platsen - Påverkar ej framkomligheten
Negativt	- Kan ta mycket plats - kan bli väldigt dyr - Svår att underhålla - Vandalisering av svampar
Intressant	

Djupt infiltrationsområde vid tågvagnen

Tabell 15. Dagvattenlösning som hanterar skyfall, skiss kan ses i Figur 11 & 12.

Positivt	- Ökad brukningsgrad - Ger en fördröjning av vattnet - Påverkar ej framkomligheten
Negativt	- Risk med att ha mycket vatten intill byggnad
Intressant	- Kan kontrollera grundvattennivån på platsen

Djupa rännor som är galler täckta till ett magasin vid A-dammen och kyrkan

Tabell 16. Översiktsbild kan ses i Figur 17.

Positivt	- Har en hög kapacitet - Bibehåller framkomligheten - Finns utrymme att göra den fin med galler
Negativt	- Kan leda till synliga råttor på platsen - måste ta hänsyn till lutningen
Intressant	- Har en stor kreativ frihet i utformningen

Våtmark vid Kyrkan

Tabell 17; Större våtmark med magasinerad effekt som ligger vid det största problemområdet vid den studerade platsen.

Positivt	- Hanterar vattnet vid det största problemområdet - Anses vara en fin lösning - Ökar biodiversiteten
Negativt	- Platsbegränsad - Omfattande projekt - Området har begränsad med solljus, kan bli ett mörk område - Tågvagnen behöver flyttas - Kan ge en oönskad lukt om den ej underhålls
Intressant	- Hur man ska flytta på tågvagnen

Barriärer för att leda vattnet till A-dammen och Geniknölen

Tabell 18. Skiss kan ses i Figur 17.

Positivt	- Kan utformas med intressanta former - Kan vara nödvändig för att leda skyfall till geniknölen
Negativt	- Ger negativ framkomlighet för fordon och gångtraffikanter - Behövs göra stor för att den ska bli effektiv
Intressant	

Ränna genom nuvarande kullar till A-dammen

Tabell 19. Lösning som hanterar skyfall, illustration på lösning finns i Figur 2.

Positivt	- Underlättat vid 100-års regn - Fyller A-dammen - Okomplicerad lösning
Negativt	- Kan ta kapacitet som annars skulle gå till campus - Förstoppning i rännan kan ske
Intressant	- Kan behöva samtal med kommunen då det är dem som äger marken vid intresse

Sänka A-dammen med olika nivåer. Asymmetriska sittytor där de kan täckas med vatten vid regnperioder

Tabell 20. Lösning som hanterar skyfall, illustration på lösning finns i Figur 2.

Positivt	- Visuellt rolig lösning - Ökar kapaciteten - Ger mer informella sittplatser
Negativt	- Kan påverka nuvarande aktiviteter på platsen - Omständig lösning
Intressant	- Kan leda vattnet från Svens Hultins Gata

Speciallösningar

Här presenteras speciallösningar vars främsta syfte är inte att hantera vatten mängder utan att bidra med andra funktioner på platsen.

Regnklocka tillsammans med magasin mellan tågvagnen och kyrkan

Tabell 21. Extra feature som kan ses i Figur 6 & 7.

Positivt	- Anses bli en fin lösning - Magasinerar vattnet - Lutningen gör det lättare att leda vattnet till A-dammen - Unik lösning som framhäver verksamheten
Negativt	- Kan vara en otydlig lösning - Kan ta mycket plats - Används ej när det är soligt - Behöver hög underhållning
Intressant	- Skapar ett tekniskt intresse - Kopplas till Väg och Vatten

Sittplatser runt Geniknölen och grusytan

Tabell 22. Skiss finns i Figur 22.

Positivt	- främjar den sociala miljön - Skapar bättre arbetsmiljö
Negativt	- Beroende på årstiden - Kan ta mycket plats - Kan förhindra plats för transporter och evenemang - Hanterar ej vattenflöden
Intressant	

Regnpassage med Svampar

Tabell 23. En passage med svampkonstruktioner som fungerar som en extra feature, se Figur 5.

Positivt	- Anses som en fin lösning - Kan göras som ett konstverk - Landmärke - Kan uppskattas även då det ej regnar - Ger mer skugga på platsen - Unik lösning
Negativt	- Svår att underhålla - Ingen rening av vattnet - Kan ta mycket plats - Finns risk att den ej uppskattas av alla som använder platsen
Intressant	- Kan kombineras med andra lösningar

Hydrauliskt Konstverk

Tabell 24. En extra feature som fungerar som konstverk, illustration finns i Figur 3.

Positivt	- Anses som en fin lösning - Ingenjörsmässigt spännande - Väcker intresse på platsen - Ger en fördröjning av vattnet - Unik lösning
Negativt	- Kan vara svårt att få fram budskapet - Inte lätt att åstadkomma
Intressant	- Stark koppling till ACE - Gör regn till något positivt - Bör utformas som ett konstverk så att den tillför till platsen även om det ej regnar

Fördröjningsmagasin som markerar när ett visst regn är uppfyllt

Tabell 25. Extra feature som presenteras i Figur 1.

Positivt	- Anses som en fin lösning - Ger en fördröjning på vattnet - Visualiserar regn som en “happening” - unik lösning
Negativt	- Ger ingen förbättring på vattenkvaliteten - Låg effekt med avseende på placering
Intressant	

Övrigt

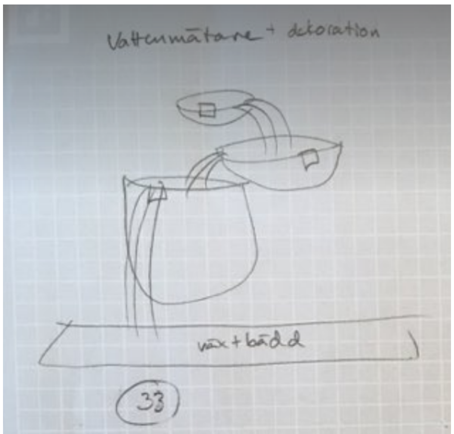
Här presenteras övriga lösningar som kan tillämpas på platsen.

Sättning säkra under nya markanläggningar

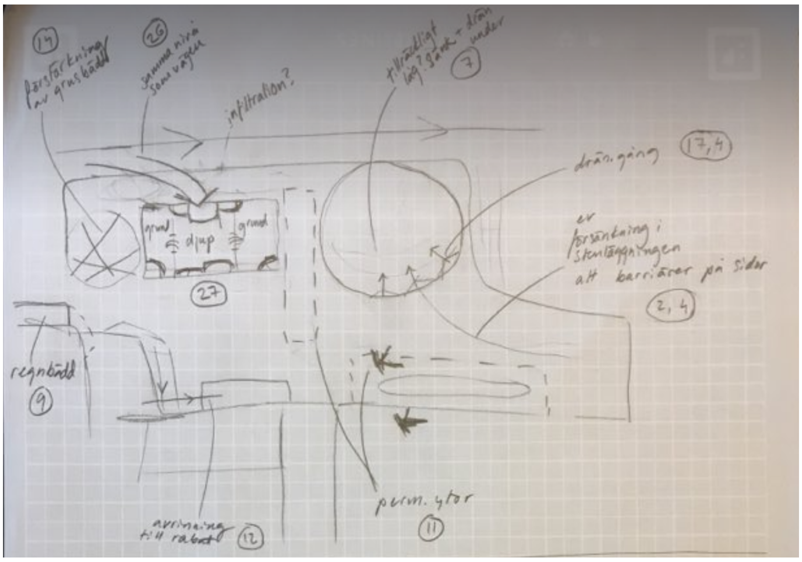
Tabell 25. Kan appliceras på platser där det anses finnas risk med sättningar.

Positivt	- Minskar risk för ojämna ytor - Ökar framkomligheten - Minskar risken för pölar på platser längst gångstråket
Negativt	- Tidskrävande lösning som påverkar framkomligheten under bebyggelse - Kan anses vara dyr för dess påverkan
Intressant	- Borde undersöka möjligheten för detta vid alla nya beläggningar

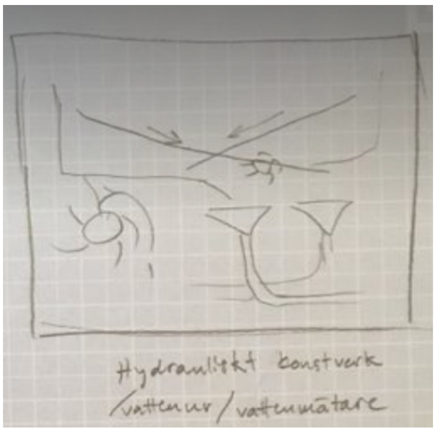
Figurer



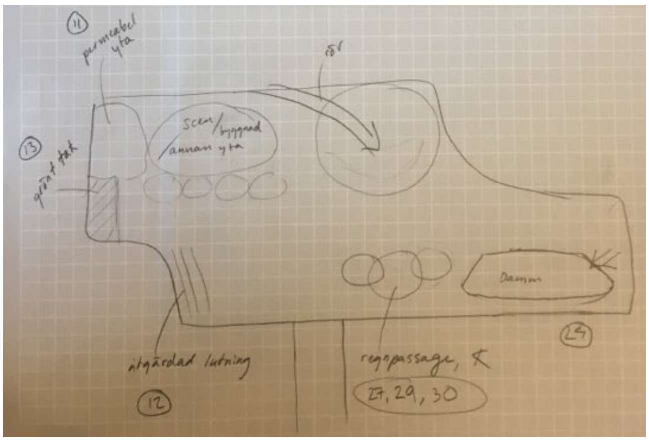
Figur 1. Illustrerad lösning på ett fördröjningsmagasin som markerar när ett visst regn är uppfyllt.



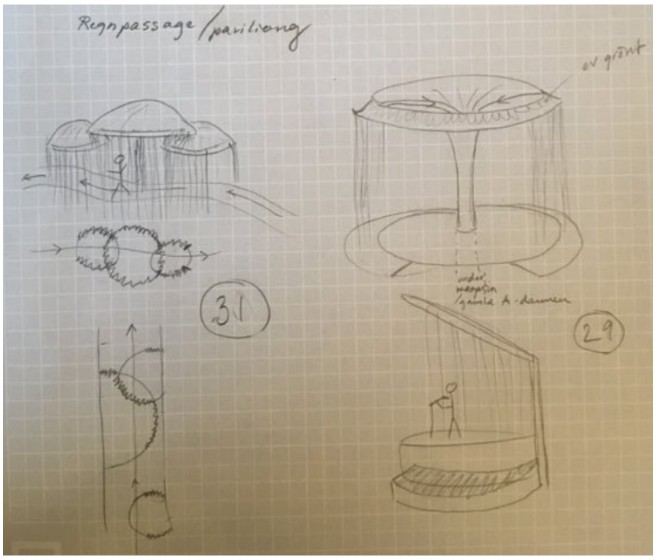
Figur 2. Helhets lösning på den studerade platsen med olika funktioner. Dessa funktioner diskuteras enskilt i tabeller ovan.

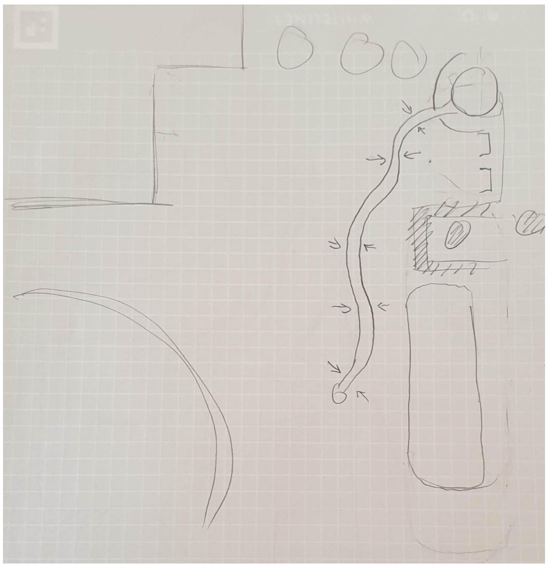


Figur 3: Illustration på ett hydrauliskt konstverk.



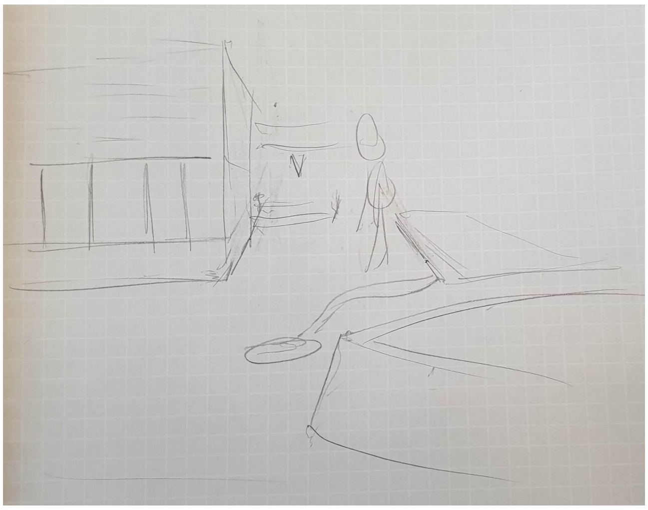
Figur 4: Helhets lösning på den studerade platsen med olika funktioner.



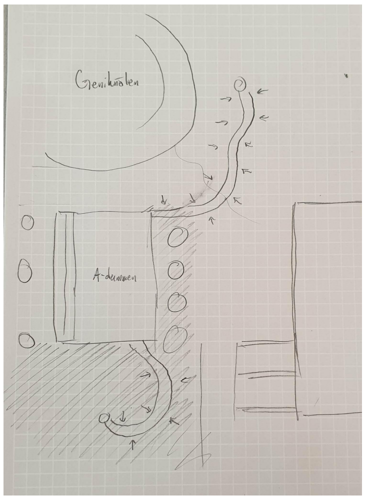


Figur 5. Illustration på en regnpassage med svampkonstruktioner som fungerar som ett regnskydd.

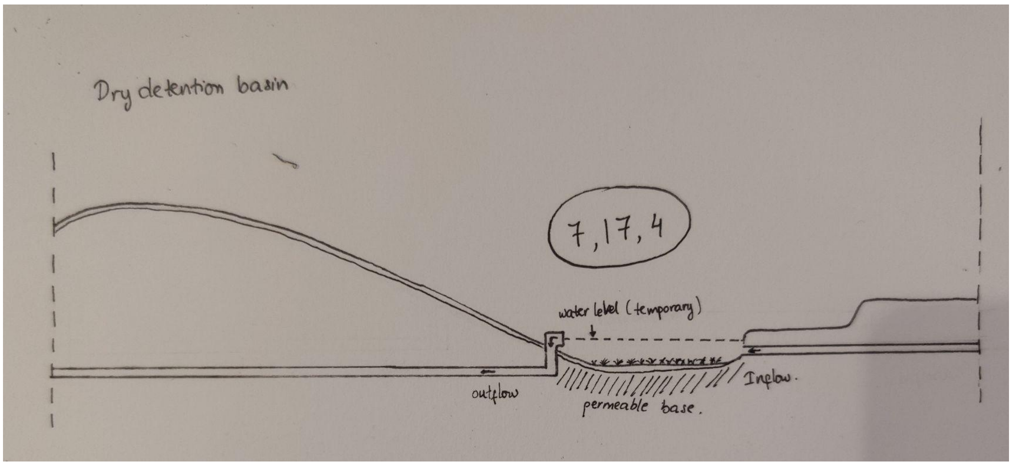
Figur 6. Skiss på en regnklocka (uppe till höger på bilden) i kombination med ett magasin.



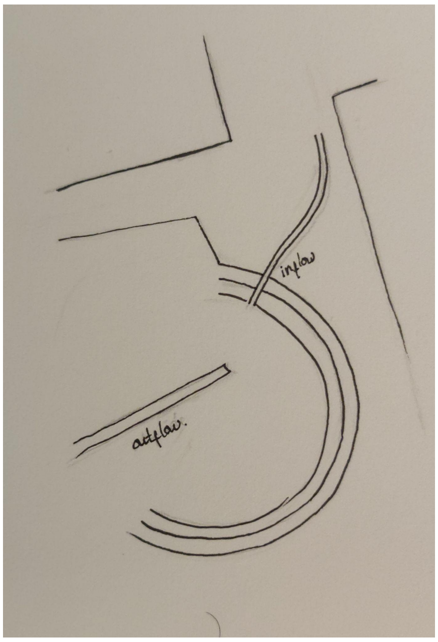
Figur 7. T.v. Fortsättning på figur 6 med ledning till magasinet.



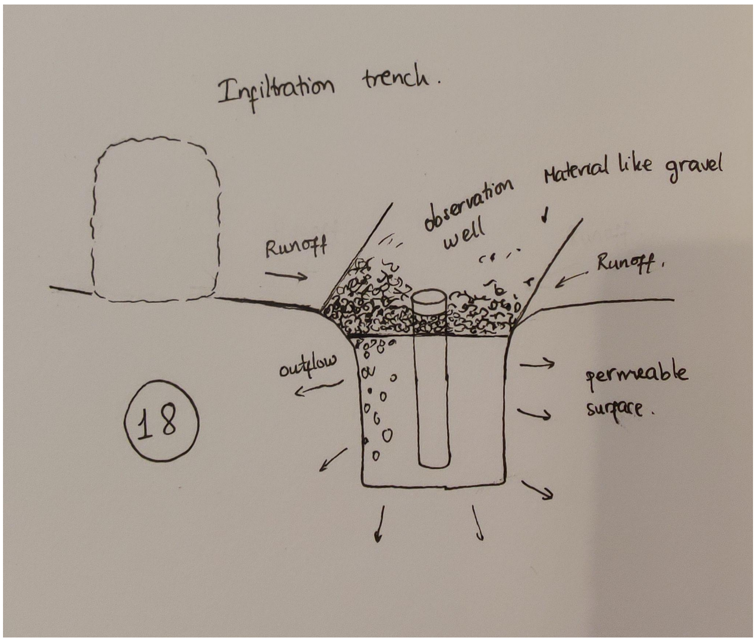
Figur 8. T.h. Skiss på Kanal över gångväg som hanterar normalregn.



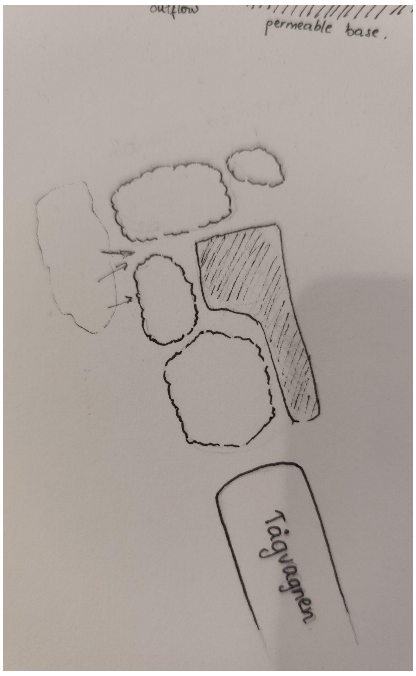
Figur 9. T.h. Tvärsnitts Sektion av ränna som leds till Geniknölen.



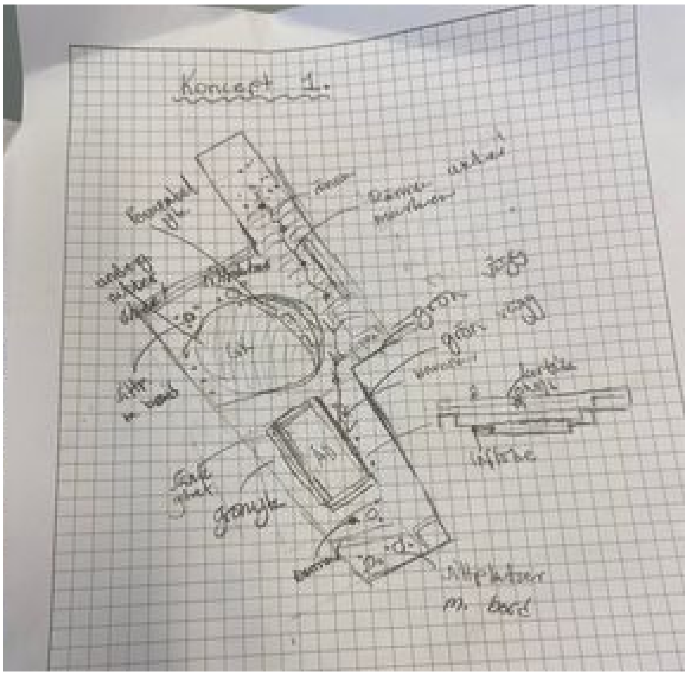
Figur 10. Översiktsbild på rännor till geniknölen.



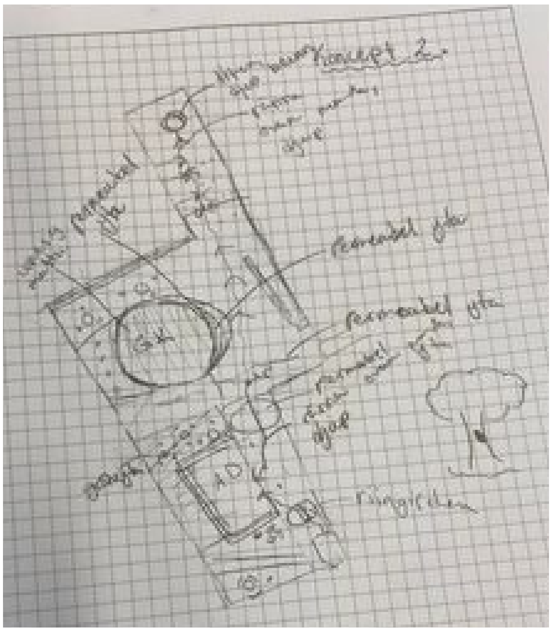
Figur 11; Dagvattenhantering som ger ett djupt infiltrationsområde vid tågvagnen.

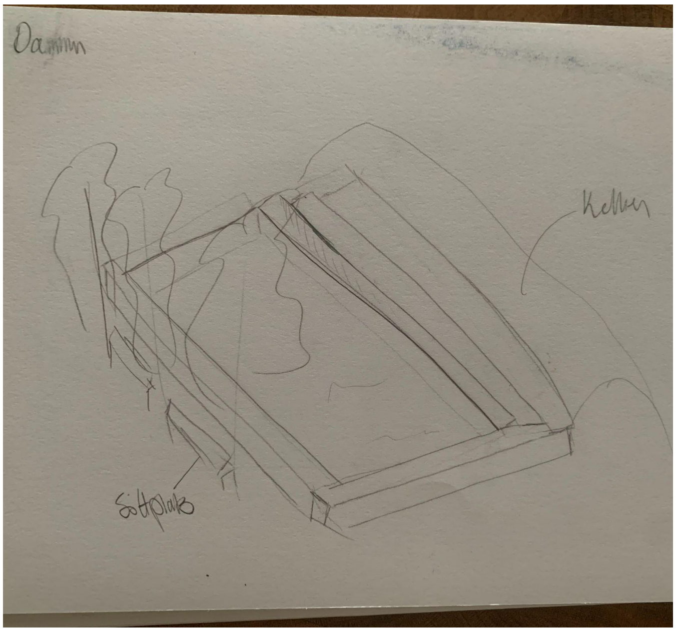


Figur 12; T.v. Översiktsbild som visar djupinfiltration området befinner sig på campus.



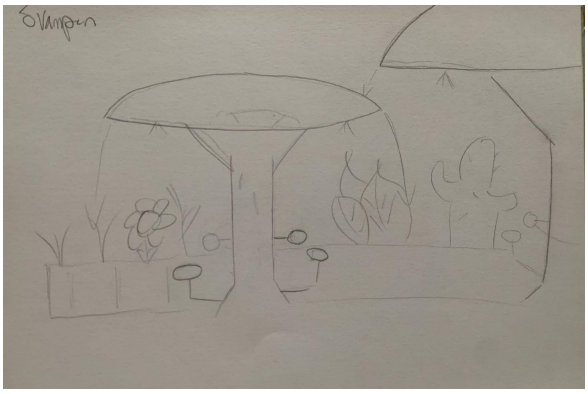
Figur 13; T. h. Översiktsbild på olika dellösningar på var platsen.



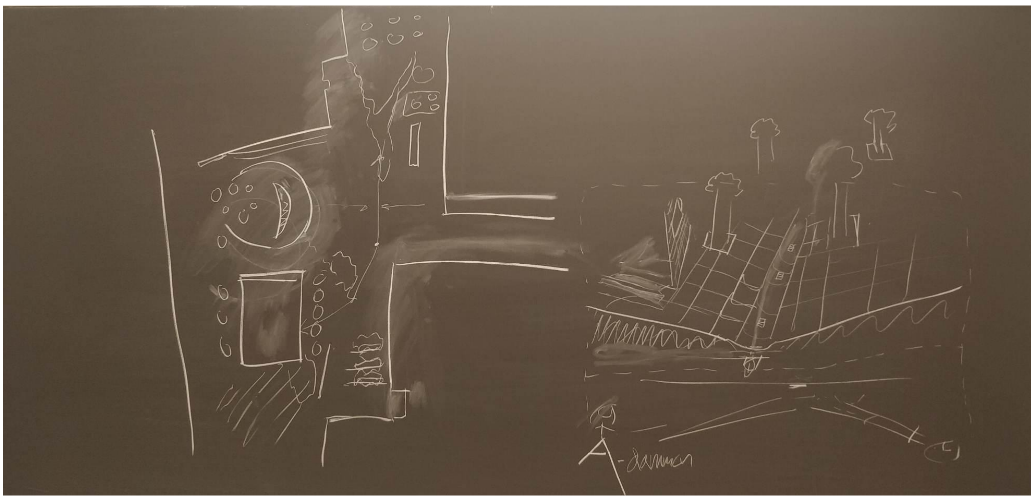


Figur 14; T.v. Översiktsbild på olika dellösningar på platsen.

Figur 15; Skiss på ny design av A-dammen.



Figur 16; Illustrerad bild på Svamp Konstruktion gjort av glas med sittplatser .



Figur 17; Översiktsbild på vinklade rännor och hur de leds på platsen till A-dammen och Kyrkan.

Appendix D - Comprehensive Concept Drafts

This is a description of the two comprehensive concept drafts which were produced during the concept synthesis. Approximated dimensions for the solutions are also noted in following tables and some are clarified in text.

General changes

The drafts have two slightly different approaches which both focus on A-dammen and the passage and involve following two features nr 1 and 2.

1. Mushroom formed sheds, working as decorative rain- and sun protection as well as stormwater collectors with trunks as detention basins. Some of them should also have integrated seatings to better work as social spots. The trunks should be drained at the bottom but with slow outflow and they should be either hollow or filled with some porous material to provide good storage capacity. The sheds come in two different sizes with different amounts of storage volume and seatings. Maximum storage volume is 1.6m^3 and 0.85 m^3 for the large respectively the small ones.

2. Redesign of A-dammen. By deepening the pool and reconstructing the walls as irregular stairsteps with added stormwater inlets provide large storage volume for cloudbursts and informal seatings during dryer periods. For Draft 1, the pool itself has a reduced area but increased depth for a concurrent water level in addition to extra storage capacity. A-dammen would be redesigned to be used more effectively by adding tiers/steps for seating.The bottom level would be permanently covered by water, with a depth of around 0.95m to ground level but the part used for storage capacity would start from the second tier and be around 0.55m deep with a total area of approximately 338m^2.giving a total stormwater retention volume of 185m^3. Draft 2, deepens the pool in the same way but without the area decreasing, meaning the retention volume would be even larger.

Concept Draft 1

Draft 1, see Figure 1, shrinks the A-damm in favour of a more accessible green space and spread out mushroom sheds over the project area as a visually interesting common denominator. It also adds small changes of Geniknölen, Lennart Rönnmarks plats and the most dominating feature was a new infiltration area or wetland, see descriptions number 3-6 below.

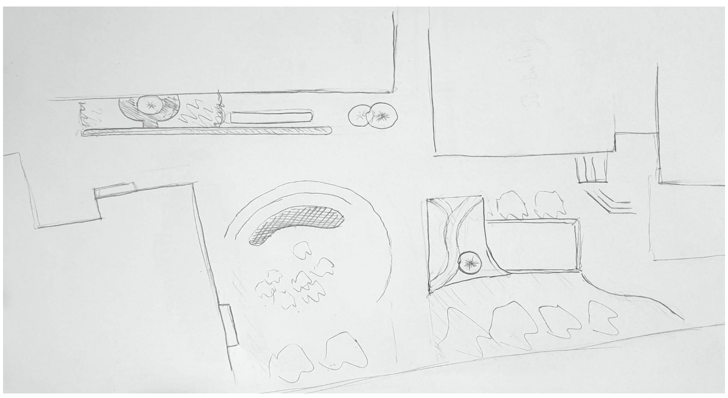


Figure 1: Layout sketch of Concept Draft 1. The round markings with stars inside represent the mushroom formed sheds. Grid markings at Geniknölen represent gravel.

3. A large infiltration ditch working as a rain garden and stretching along the SSPA-building. This is the site's natural lowpoint and therefore deemed as a more efficient place to detain water masses. Some periods the space would be almost dry but during rain it would get filled with drainage from adjacent gutters. To avoid damaging the adjacent SSPAbuilding, that side should be reinforced and the water would be drained slowly through pipes instead of only relying on infiltration through the ground. To enable more accessibility of the space and avoid large falling heights the edges would have integrated stair steps and an elevated wooden promenade to allow moving across it. With an average width of 9m, length of 40m and an average depth of circa 0.7m, the wetland would cover an area of 355 m^2 and allow a total of 250 m^3 of water retention without accounting for ground penetration.

4. The removed part of A-dammen is replaced by a depressed green area to gather floodings from adjacent roads and also work as extended pond volume. The dip is covered with grass apart from a few streaks of gravel trails and holds a number of infiltration pits to allow slow but continuous drainage. To facilitate runoff the road curbsides are placed at grass level. The area would be approximately 297 m^2. The surface would lie lower than the surrounding pathway and lower than the maximum level of A-dammen, allowing for some water deposit capacity in case of overflow in A-dammen.

5. To improve the accessibility of Geniknölen it proposed stone covers on the edges to provide better seatings and added gravel at the pit's bottom to avoid creation of mud.

6. Reconstruct gravel surface Lennart Rönnmarks plats. To avoid current erosion and increase permeability the new surface would consist of gravel with higher grain size, with a hard made pathway for more convenient crossing. The area would also be given a slight slope towards the reconstructed A-dammen so that stormwater would flow toward it in case of flooding.

Calculated stormwater capacity

The following tables present the stormwater capacity for Concept Draft 1.

Table 1: *Concept Draft 1: Water storage capacity after applied solutions.*

Area	**Volume [m^3]**
The A-dammen	185
Wetland	250
Total	**435**

Table 2: *Concept Draft 1: Runoff flows before applied solutions*

Area	**Surface type**	**Runoff Coefficient [-]**	**Area size [m^2]**	**Flow [l/s]**
Graveled area east of A-dammen	Gravel type 1	0.25	118	4119
Passage By SSPA building	Hard surface	0.8	355	39 655
Lennart Rönnmarks Plats	Gravel type 1	0.25	210	7330
Maximum Flow				**51 104**

Table 3: *Concept Draft 1: Runoff flows after applied solutions.*

Area	**Surface type**	**Runoff coefficient [-]**	**Area size [m^2]**	**Flow [l/s]**
Green area by A-dammen	Green area	0.1	297	4147
Passage by SSPA building	Wetland	0.1	355	4957
Lennart Rönnmarks Plats	Gravel type 2	0.2	210	5864
Maximum Flow				**14 968**

Concept Draft 2

Draft 2, see Figure 3, removed *Tågvagnen* entirely to replace it with a gathering of mushroom sheds and primarily used the A-damm for water storage. It also held a green green roof and a rain garden for copper treatment and a so called rainclock, see nr 7-10 below.

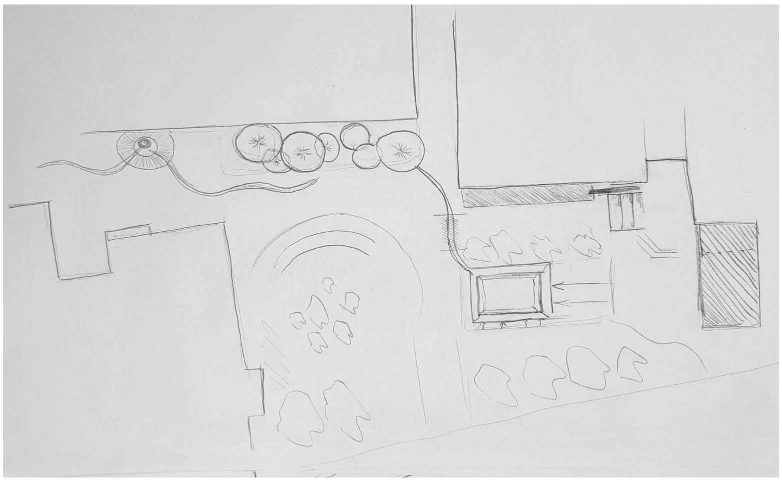


Figure 3: Layout of Concept Draft 2. The round markings with stars inside represent the mushroom formed sheds.

7. A "rainclock" by the SSPA-building, i.e. a gutter construction visualising different rain types, see Figure 4. The idea is to divert and detain stormwater into a pit with different overflow levels. The volume should be dimensioned to match the catchment areas' stormwaterflow so that a new part of the clock is filled during for instance 1-year-, 10-year- and 100-year rains. Total overflow should preferably divert through pavement channels/pipes to A-dammen or Geniknölen or if necessary, to the ordinary drainage system. To avoid limited accessibility parts of the channels would be covered with grids.

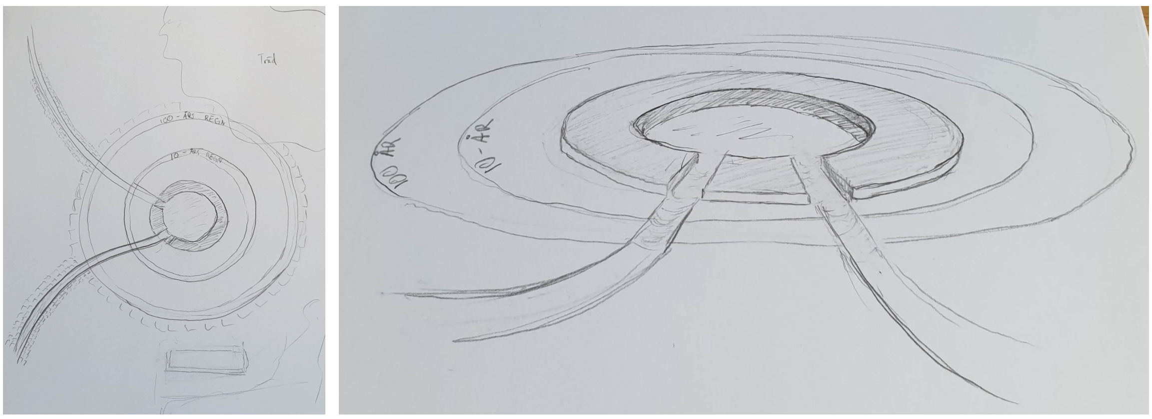


Figure 4: Two sketches of the rainclock as a gutter construction.

8. Green roof on the old biker shed and extended to the SBII-building's copper roof. Since the major copper source in the project's catchment area is located at the SB-entrance it seemed reasonable to handle the issue locally. Beside copper treatment this solution also provides water detention and weather protection.

9. Replacing the current flower bed along SBI with a larger rain garden. Another way to handle the copper issue while also providing water detention and aesthetics.

10. Reconstruct the stairs at the SB entrance. By correcting the slope and constructing a waterfall gutter into the adjacent rain garden the space would improve its stormwater quality, avoid inconvenience and create a more convincing entrance to a department for high class water infrastructure.

Calculated stormwater capacity

The following tables present the stormwater capacity for Concept Draft 2.

Table 4: *Concept Draft 2: Water storage capacity after applied solutions.*

Storage space	**Volume [m^3]**
A-dammen	187
Single small mushroom small	1.6
Single large mushroom	0.85
Total mushrooms	14
Total storage	**201**

Table 5: *Concept Draft 2: Runoff flows before applied solutions.*

Area	**Surface type**	**Runoff Coefficient [-]**	**Area size [m^2]**	**Flow [l/s]**
Alongside the SB house	Hard surface	0.8	64	7149
Roof for biker shed	Hard surface	0.8	162	18 095
Passage next to biker shed	Hard surface	0.8	93	10 389
Maximum Flow				**35 632**

Table 6: *Concept Draft 2: Runoff flows after applied solutions.*

Area	**Solution type**	**Runoff Coefficient [-]**	**Area [m^2]**	**Flow [l/s]**
Alongside the SB house	Rain garden	0.1	64	894
Passage and biker shed	Green roof	0.5	255	17 802
Maximum Flow				18 696

Comparison and Evaluation of Concept Drafts against LoR

When evaluating the drafts against the LoR, only a few requirements are left unfulfilled. Draft 1 does not fulfil the copper treatment and safety requirement where the first is totally left out while the other needs more detailed design to be evaluated. Its cloudburst capacity however is promising and handles more than 70 % of SCALGO's worst 100-year rain scenario of about 450 m3 water volume. The position of the wetland also seems more sufficient in regard to ground levels.

Draft 2 fulfils all requirements except for the cloudburst capacity, which only holds about 40 % of the worst case scenario. Also the decrease of runoff flows is smaller than for Draft 1. This draft however still held many visually and socially interesting ideas.

Table 7: Changed capacity compared to original layout.

Concept Draft	**Reduced runoff flow [l/s]**	**Provided storage capacity [m3]**
Draft 1	36 136	435
Draft 2	16 936	201