Designing the Green Bridge of Copenhagen

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In Cooperation with

MILJØPUNKT AMAGER

Designing the Green Bridge of Copenhagen

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In Cooperation with

Director Claus Knudsen

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Abstract

Air pollution is currently a problem for Copenhagen and, in a broader scale, has contributed to climate change. Langebro (Long Bridge) and the roads leading to it, are experiencing the worst of the city's pollution due to the heavy volume of traffic this area endures daily. To combat this problem, environmental organizations, including our sponsor Miljøpunkt Amager, have conceptualized a greater potential green strip for Copenhagen in the hopes of reducing traffic and naturally absorbing air pollutants from vehicles. Through the use of interviews and street surveys, this project explored the balance between the city's political and public preferences for green spaces in order to create a surface design for, and web page to promote, the potential Langebro section of the larger green strip.

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Executive Summary

Designing the Green Bridge of Copenhagen

Introduction

Copenhagen has been struggling with problems related to traffic congestion since the city's expansion following its industrialization. As cars became more popular, subsequent air and noise pollution increased and grew problematic for the health and well-being of the city's inhabitants. Pollution is still a problem today, and current traffic congestion is contributing to global climate change via the amount of greenhouse gases entering the atmosphere. Climate change is a global phenomenon associated with changes in the frequency and severity of weather conditions such as drought and flooding. In 2009, the Copenhagen government launched the Carbon Neutral Initiative- a comprehensive plan to reduce greenhouse emissions and make Copenhagen the first carbon neutral capital in the world. The importance of this initiative was emphasized when, in 2011, Copenhagen experienced a historic cloudburst which flooded the city causing an estimated 6 Billion DKK (about 1 Billion USD) in damages. To reach carbon neutrality and adapt to the recent changes in weather severity, the city is actively focusing on decreasing car usage, finding greener ways to handle stormwater, and increasing their quantity of green spaces, all while maintaining or improving the city's livability.

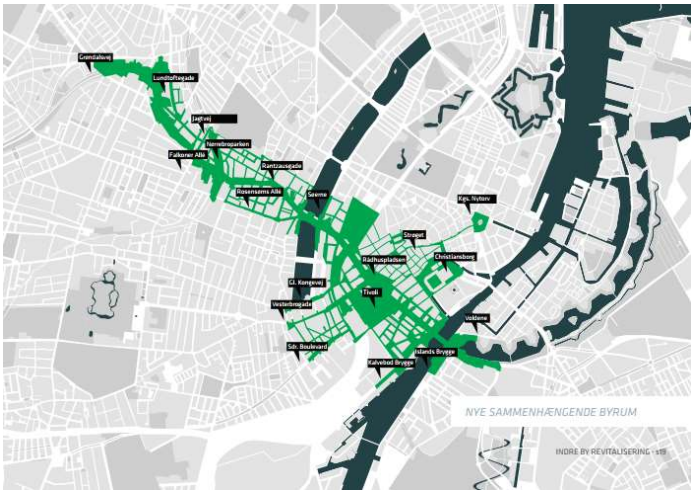

Figure 1: Conceptualization of a Greater Green Strip Through Copenhagen

Jensen, A. & Tredje Natur (2014). Indre by Revitalisering. Københavns Hjerte Fra Bispeengen Til Amager

Our sponsor, Miljøpunkt Amager, is an environmental non-profit organization dedicated to increasing awareness for environmental concerns and promoting greener living. One of their initiatives is to encourage traffic reduction in favor of alternative forms of transportation, such as biking or public transit. Currently in the city there are many proposals for traffic reduction including creating tunnels underneath the city, congestion pricing, and ways to increase public transit abilities. These options are being discussed by city officials, however there is a great deal of controversy about the costs and benefits of each option. Our sponsor is working, in cooperation

with other local Miljøpunkt organizations, to create a large green strip proposal, as shown in Figure 1, which runs from the northern area of Nørrebro, down the busy H.C. Andersens Boulevard, across Langebro (Long Bridge), and down Amager Boulevard. This green strip is designed under the assumption that there will be reduced traffic through the area. Once complete, this large scale conceptualization will be used to incentivize politicians and locals to reduce both the amount of traffic and the space designated to it.

Greening Langebro

This project focused on assisting Miljøpunkt Amager by analyzing the public opinion and preferences of green spaces in order to create a design proposal for the greening of Langebro. To accomplish this goal we completed the following objectives:

1. Understand the impacts and challenges of implementing green spaces in Copenhagen
2. Assess public opinion and preferences of green spaces on Langebro
3. Create green space surface designs for Langebro based on local and municipality preferences while integrating with the design for Amager Boulevard
4. Assist Miljøpunkt Amager in promoting a green strip through Copenhagen by creating a webpage with design renderings and information about the project

The first two objectives, were completed through interviews and surveys with political figures, experts in relevant fields, and locals around the site location. The purpose of speaking with city officials and employees of the municipality was to understand the political opinions and current plans for reducing traffic and greening Copenhagen. Experts in architecture, civil engineering, botany, and green space design were interviewed to better understand logistical and technical intricacies of designing for a bridge. Finally, it was vital to talk with members of the community to better understand what aspects and features of green spaces would be preferred for a green space on Langebro. After analyzing this information, design proposals were created for consultation with Simone Hochreiter, an architect working with Miljøpunkt Nørrebro. From here surface designs were finalized and created using the computer program Revit.

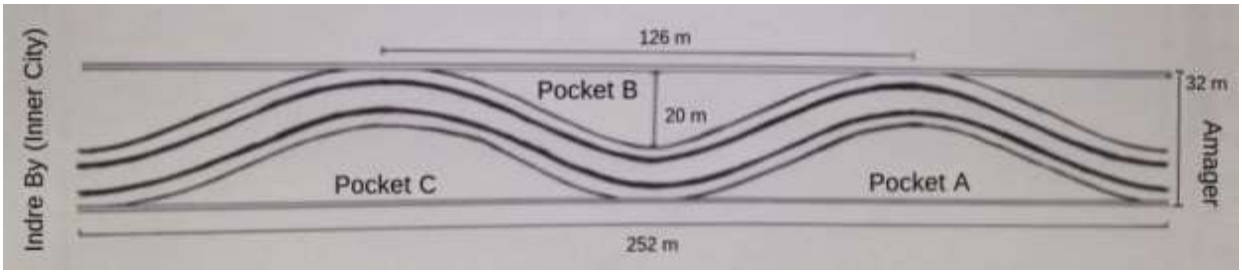

Figure 2: Aerial Dimensions & Layout of Langebro design

Langebro Final Design Proposal

The final design utilized a winding road, as shown in Figure 2, which allows for the creation of three distinct pocket parks and two side parks. The street will consist of two car lanes (one in each direction), two bike lanes, and two pedestrian lanes, as shown in Figure 3.

This design integrates a barrier of bushes and trees between the car lanes and the green areas (including the bikers) in order to help reduce air and noise pollution from traffic and promote the overall green aesthetics of the location. Below, we will detail the designs for each of the three parks, labelled A, B, and C in Figure 2.

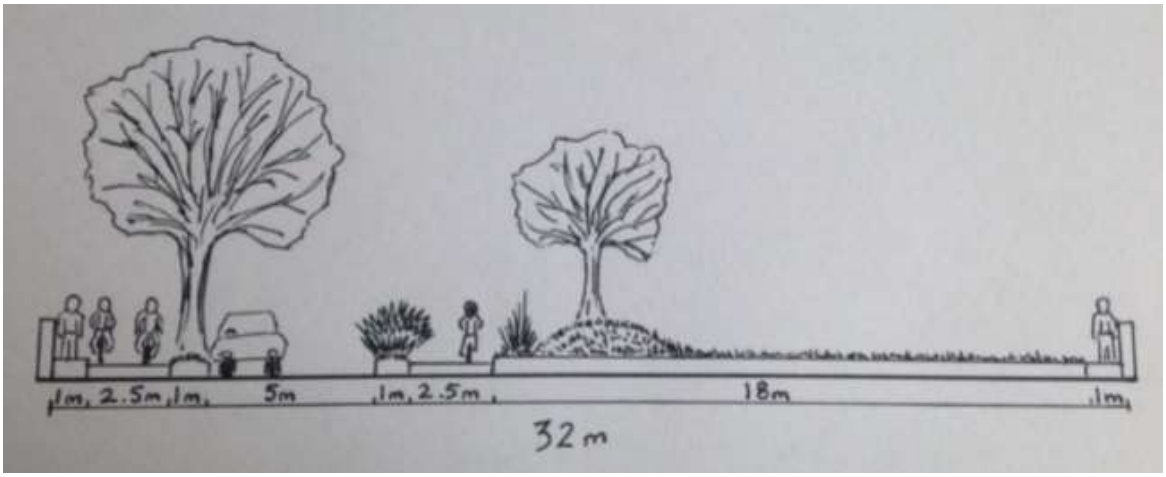

Figure 3: Cross Section of Langebro Design with Dimensions

Pocket A

The first pocket is designed to be the social hub of the Langebro green strip. Survey results indicated a high desire for a communal area for socialization, therefore, Pocket A is designed with a lot of sitting areas, like picnic tables, long benches, and open expanses of grass (Figure 4). To encourage people to barbeque without damaging the grass, we also integrated specific square meter areas on the ground, made of pavement or stone, for people to place their grills. For this area, minimal florals were incorporated in favor of mixtures of green shrubs, bushes, and grasses. This will still give the area a good atheistic, however large areas of florals could detract from the overall spacious design and likely be less appropriate in an area expecting high volumes of people.

This pocket is positioned closest to Amager and the Islands Brygge green strip, adjacent to the popular waterfront socialization area, the 'Harbor Bath'. By placing this pocket close to these areas, we hope to encourage people to use the space. We also positioned this area, as previously mentioned, so that it will receive the most sun in the afternoon hours, a time when Danes are frequently out sunbathing.

Figure 4: Revit Rendering of Pocket A

Pocket B

The surveys conducted on green space preferences also showed an overwhelming interest in biodiversity, so the second pocket is designed as a botanical garden. It is dedicated to highlighting a variety of vegetation and aesthetics including Danish flowers, bushes, grasses, and trees. We designed the entire space to be lined in green elements, with three prominent flowerbeds in the center of pocket. The dirt or gravel paths run through and around the pocket in an organic way. To facilitate relaxation, much of the area will be covered in grass and will also contain two raised mounds, about a meter high, with a tree on top. The space will also have benches facing different directions to allow for a variety of views. This pocket was chosen for the center facing east, because it was created as an environment for appreciating biodiversity so afternoon sun was less important.

Figure 5: Revit Rendering of Pocket B

Pocket C

The third pocket was designed to accommodate the people from our survey who favored using a green space as an area to quietly relax. We designed it in a way that would use greenery to promote a feeling of privacy and security. The small semi-circled areas with benches and tables, seen on the rendering, are lined with small shrubbery and trees. This was designed to provide a feeling of being surrounded by nature and a pseudo-privacy without impeding the view into or out of the spaces.

This pocket, like Pocket A, is positioned to receive the afternoon sun but will be closer to the inner city; the location of commercial buildings and the Royal Library. The hope for this design is that it will encourage people in the nearby area to use it for small meetings and lunch outings.

Figure 6: Revit Rendering of Pocket C

Limitations and Future Work

Significant Limitations to the design included inaccessibility to the building restrictions on Langebro. Even after research and interviews with various locals and city officials, we were unable to get a definite understanding of which parts of the bridge were protected and how strictly. As a result, the design was limited to the bridge's surface, presumably the area with the least likelihood of protections. If more concrete answers could be found as to the extent and permanence of the protections, more radical designs could be made to the green space proposal for Langebro.

We also suggest that further research be done to get the public's opinion on the final design renderings. Although we conducted interviews with a variety of locals, and incorporated many interests and suggestions, we did not have the resources to run a focus group to gather public

feedback after Langebro's green design was finished. As a result, we recommend doing further analysis to better understand how well the design will be received by the public and city officials.

A second, separate, analysis could be done to determine the overall technical feasibility of the design. We created a proposal that we believe to be realistic and achievable, however this should be confirmed by those with more expertise in environmental and civil engineering. A feasibility analysis of the Langebro design could also be completed and could include how difficult, both physically and politically, it would be to gather funding for the project, create a curved road through the area, and add soil and vegetation.

Conclusion

This Langebro design was created as a piece of a larger green strip from Nørrebro to Amager. Once all the pieces have been designed and combined, there will be a clear, obtainable, incentive to reduce traffic and car ownership across the city. This design could help promote healthier living and aid in moving forward with the green culture of Copenhagen. It is our hope that, upon construction, the winding road and pocket parks across the iconic Langebro will become a popular and prominent landmark of Copenhagen that draws locals and visitors to appreciate the potential of green spaces in the city.

"[This] project is a very good vision of what we could do in Copenhagen if we were free to make the city more livable in every way"
-- Morten Kabell, Mayor of Technical and Environmental Affairs

Authorship

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Chapter 1: Introduction

In November 2014, R. K. Pachauri stated "We have the means to limit climate change, the solutions are many and allow for continued economic and human development. All we need is the will to change, which we trust will be motivated by knowledge and an understanding of the science of climate change" (IPCC, 2014). Pachauri, the Chair of the Intergovernmental Panel on Climate Change (IPCC), was at a meeting to discuss the rising problem of global climate change.

Global climate change is the phenomenon in which pollution, often amplified by industrialization and urbanization, contributes to atmospheric changes. These changes can result in problems, including alterations in the severity and frequency of weather conditions (Ekwurzel, 2006). With population growth, as people move from rural areas to the city often in search of employment, there is an increasing need to expand the city to accommodate the people and the industries that emerge. This 'evolution' of a city results in the alteration of natural landscapes, increasing the amount and concentration of pollution within the area (EPA, 2012).

Denmark's capital, Copenhagen, experienced rapid population growth and expansion of the city following its industrialization, which lasted from mid to late 1800's. As this expansion occurred, many paved roads were created in Copenhagen to allow for a rise in the number of motorized vehicles. Unfortunately, vehicles produce harmful pollutants which, combined with today's traffic congestion, leads to both noise pollution and poor air quality, especially in areas near busy roads. Not only does this lower the quality of life of nearby residents, but it also contributes to global climate change. Recently, the increase in rainfall severity, which is partially attributed to global climate change, has caused severe flooding. This has been exacerbated by Denmark's flat landscape and impermeable roadways.

In 2009, Copenhagen acknowledged the severity of the effects of climate change by creating the Climate Adaptation Initiative, a plan detailing their steps to become the world's first carbon neutral capital by the year 2025. This plan promotes greener living and the reduction of harmful pollutants while still maintaining its city's standard of living (Copenhagen 2025 Climate Plan, 2012). In keeping to the plan, Copenhagen has been trying to deal with its problems with increasingly greener solutions.

Green spaces, especially parks, have been used across the world to increase aesthetics, reduce ambient air and noise pollution levels, and promote more environmentally-friendly stormwater management. The implementation of such green spaces in Copenhagen may help assist the city's drainage systems in handling the increases in flooding, and thus minimize further financial and environmental burdens. Increasing vegetation would also combat car pollution by absorbing CO_2 and dampening noises created by the vehicles.

Miljøpunkt is a non-profit organization heavily involved in helping Copenhagen and its residents lead a greener lifestyle and adapt to climate change. Divisions of this company are scattered across the city, in various prominent neighborhoods, each managing local green projects and assisting their community in different ways. In 2003, Miljøpunkt Amager was founded to promote "environmental issues and sustainable development" to the southern portion of Copenhagen located on the island of Amager (Om Miljøpunkt Amager, n.d.). They currently provide the local community with resources such as community gardens and a bicycle rental program. Over the past decade, Amager has seen a reduction in green space due to the dramatic rise in population. In response, Miljøpunkt Amager has become an active advocate for the preservation of pre-existing green areas as well as promoting the construction of new ones. One of their recent initiatives has been to create a design for a green space that would run north to south through Indre By (the inner city), over Langebro (Long Bridge), and into Amager. This design would, ideally, be incentive for the city to reduce traffic through the area.

The purpose of this project was to design the green space along Langebro which currently connects two busy roadways, H.C Andersens Blvd. in Indre By to Amager Blvd. on the island of Amager. To complete this we consulted professionals with experience in green spaces, architectural designs, Danish plants, and experience working with and on bridges. To understand the municipality's plans for the city, we interviewed political figures and to gather the opinions of the community we conducted street interviews. Finally, we created designs for the surface of the bridge and campaign materials, in the form of a web page and posters, to help educate the public and gain support for the design for Langebro and the larger green strip.

For this design to be feasible we followed the assumption that traffic would be significantly reduced on the areas over and around Langebro. This could be accomplished through the implementation of traffic tunnels, congestion pricing, and/or other methods. The municipality is currently discussing these methods to determine which would be the most effective and economic

way to reduce traffic. As a result, our project does not discuss the traffic situation and instead assumes that two lanes could handle the predicted future traffic.

The following chapter provides more information about the motivation behind this project and its overall importance in relation to global climate change. We explain potential solutions to these issues and how a green space addresses these problems. Chapter 3, the methods chapter, breaks down how we planned to accomplish the goal of our project with specific methods like interviews. The findings chapter explains what we discovered after arriving in Copenhagen and how these discoveries affected the project. Next, recommendations were made for the implementation and realization of our green space design. Finally, we conclude the project by discussing the results we were able to obtain. The deliverables presented to Miljøpunkt Amager included a collection of interviews and survey results, a web page for campaigning, and a final surface design for the greening of Langebro.

Chapter 2: Literature Review

In 2009, Copenhagen implemented the Climate Adaptation Plan-- a groundbreaking initiative to turn the city of 1.2 million people into the first carbon neutral capital of the world. To reach their goal, organizations throughout Copenhagen are working to reduce traffic, promote clean waste management, and create more green spaces -- including parks (Copenhagen 2025 Climate Plan, 2012). This project hopes to aid in reducing the local environmental and health detriments associated with pollution from heavy traffic on Copenhagen's Island of Amager.

2.1 Traffic Congestion

According to a recent report, transportation accounted for 10% of total CO_2 emissions in Copenhagen with 52% of the total resulting from cars (Copenhagen Climate Plan, 2009). This percentage, combined with an expected population growth of 35% in 2015, was significant enough to attract the attention of the city's officials and inhabitants (Statistikbanken, 2014). The Carbon Neutral Initiative aims to reduce personal car ownership to 25%, with subsequent increases in biking, walking, and public transportation (Copenhagen 2025 Climate Plan, 2009). As of 2010 an estimated 50% of residents used methods other than personal motorized vehicles to commute to work each day, yet car ownership has still risen slightly over the past 15 years (Tørsølv, 2010).

2.1.1 Health Impacts of Elevated Traffic Levels

Copenhagen has been working to reduce the amount of space dedicated to roadways, but this has caused a subsequent elevation in usage and congestion on and around the main roads of the city (Tørsølv, 2010). The particulate matter (PM), carbon dioxide (CO_2), and other chemical emissions that emanate from busy highways create air pollution that has been deemed as a carcinogen by the World Health Organization (WHO, 2014). It was also estimated that over 80% of the European Region lives in cities with levels of particulate matter emissions exceeding the Air Quality guidelines for health and safety (REVIHAAP, 2013). Research has proven that prolonged exposure to highly polluted air, like that found in areas near busy roads, can cause an array of minor and serious respiratory complications including inflammation, asthma, Chronic Obstructive Pulmonary Disease (COPD) and lung cancer (Bayram, 2006). In the year 2000 alone,

within 25 designated European countries, there was an estimated 350,000 deaths directly related to air pollution (Lehmijoki, 2009). In Denmark, air pollution from vehicle transportation can be attributed to up to 80-90% of total PM emissions during peak hours (Clean Air Copenhagen, 2014).

Along with the detriments of air pollution, increased traffic congestion can cause not only an increase of intermittent bursts of noise, but also an elevated level of ambient sound defined as noise pollution (EPA, 2012). Copenhagen reports 60% of daily average traffic noise to be above 58 dBA (A-weighted decibels). Limitations of 55 dBA have been designated as safe for long-term exposure with ranges above 75 dBA deemed hazardous (Hammer et. al., 2014). Living near busy highways has been proven to have many negative side effects related to noise pollution such as increased production of stress hormones, like cortisol, especially in children and infants (Ising, 2004). In their combined nature, noise and air pollution have been linked to many health problems including stroke (Sørensen, 2014) and diabetes (Krämer et. al., 2010). Although implementation of low emission zones and promotion of transportation via bikes have reduced the total carbon footprint and harmful emissions, busy streets still remain a prominent source of concern.

2.2 Traffic Solutions

One solution to the serious problem of car pollution is traffic tunnels. Moving traffic underground into manmade tunnels can reduce traffic congestion and have positive impacts on the community and the environment above ground. According to the US Department of Transportation's Federal Highway Administration, the benefits of implementing a traffic tunnel include reduced traffic congestion, improved air quality, reduced noise pollution, and improved aesthetics (2013, Chapter 1.2.5). The Central Artery/Tunnel project also known as the "Big Dig" was completed in Boston, Massachusetts in 2006. The "Big Dig" expanded the number of cars able to travel through the city by directing them through a tunnel to bypass the downtown area. This project reduced CO_2 emissions by 12%, and opened up 300 acres of lands for recreational use (Massachusetts Department of Transportation). For these reasons, the Big Dig tunnel project has been considered a success.

In Copenhagen, there are currently ideas and proposals for various traffic tunnels to alleviate air pollution and traffic congestion in the city. Out of all the proposals, two have received more attention from the local community and municipality than the rest: the Eastern Ring Road and the Københavnertunnellen.

The Københavnertunnellen proposal, as shown in Figure 1, describes a submerged traffic tunnel which runs from western Østerbro to Amager under the Copenhagen Harbor (canal). This tunnel would allow access to Amagermotorvejen and the aforementioned popular traveling areas from various locations throughout Copenhagen. Exits and entrances to the traffic tunnel would be located in nine places along the tunnel and be conveniently placed so that no matter what part of the harbor you are coming from, an exit or entrance will be nearby (Københavnertunnelen ApS, 2009).

Figure 1: The Proposed Tunnel Path for the Københavnertunnelen
(Københavnertunnelen ApS, 2009)

The first stretch of the Eastern Ring Road route, connects the western part of Østeboro, in northeastern Copenhagen, to the newly populated area of Nordhavn in eastern Østeboro. The second leg of the route connects Nordhavn to Refshaleøen in Indre By, the inner city of Copenhagen. The third leg of the route connects Refshaleøen to Kløverparken in Amager Øst, eastern Amager. The final leg of the route connects Kløverparken to Amagerfælled, a large green area located in Amager Vest, western Amager. This final leg continues past Amagerfælled to allow traffic to merge onto Amagermotorvejen, a large motorway, which leads to the Copenhagen

Airport and the Øresund Bridge connecting Amager to Sweden (Ramboll, 2012). These are some examples of how traffic tunnels are being proposed as a solution to traffic congestion, pollution, and flooding in Copenhagen and could continue to prove effective in other areas as well (Hvad er Åbn Åen?, 2015).

2.3 Stormwater

On a larger scale, long term high emissions have contributed to a phenomenon called global climate change, characterized generally by increased severity and variability of weather (WHO, 2014). As a result, increased rainstorms have become a particularly prominent problem in many European countries (REVIHAAP, 2013). During times of frequent and heavy rainfall, urbanized areas often experience flooding, which is exacerbated by materials commonly used in urban areas, such as asphalt and concrete, which do not allow the absorption of rainwater (Pazwash, 2011, pg. 1). The lack of natural filtration systems, such as vegetation or soil, in urban areas puts more pressure on the stormwater drainage systems implemented by the city. Unabsorbed rainwater flows through the city, picking up unwanted debris, making this runoff, a pollution hazard. Polluted water then accumulates, exiting into nearby bodies of water through a direct route or indirectly through the city drainage systems (EPA, 2003, pg.1). The most common pollutants reported in urban and agricultural areas in the United States originate from road salts, oil leaks, litter, fertilizers and pesticides, and septic systems (Pazwash, 2011).

2.3.1 Health Impacts

Accidental consumption or exposure to toxic substances can lead to numerous physical ailments. A study conducted in Copenhagen researched the health effects of consuming water polluted by runoff. Triathletes were examined in 2010, after swimming in water following severe storms, and again the following year when no recent storms were reported. The study found that the risk of illness from unintentionally consuming water increased 34% when swimming in the contaminated seawater of 2010 when compared to that of 2011 (Harder-Lauridsen et al., 2013).

Another physical health risk from flooding comes from exposure to the resulting mold. The World Health Organization reviewed a number of studies on exposure to mold within buildings and its effects on the human body. They found that, prolonged exposure to molds commonly found

in flooded or dampened buildings have been associated with complications such as respiratory distress, infections, and asthma (WHO, 2009). The severity of these symptoms is dependent on many factors, however infants, the elderly, and immune-compromised individuals, often experience more serious affects (Arumala, 2007, p. 78-9).

Health complications from flooding and stormwater runoff are not limited to physical symptoms; in fact flooding can also have a serious impact on the mental health of an individual. Symptoms of anxiety and depression were found to be more frequent in individuals after they had suffered through the effects of flooding (Ahern et al., 2005). Instances of post-traumatic stress disorder (PTSD) have also been found to be significantly higher in individuals who have been affected by flooding. PTSD can have critical effects on the afflicted individual's quality of life as well as the lives of those close to them. In the worst cases symptoms of this disorder can be so severe that they directly interfere with an individual's ability to function normally in society (Ahern et al., 2005).

2.3.2 Infrastructure Damage

Damage from flooding can cause a serious financial strain on a city's government long after the initial damage is done. Depending on the location and severity of the rainfall, the shear force exerted by the flow of stormwater runoff can damage and cause instability to buildings and other types of urban infrastructure (Nadal et. al., 2010). When certain building materials become submerged in water or suffer water damage, they can grow hazardous forms of mold which often must be removed at the expense of the business or resident (Arumala, 2007). Rural and agricultural areas can also fall victim to the high cost of flood damage if total rainfall is severe enough. Excessive stormwater runoff can alter, or even destroy crops, especially in their early stages of growth. The destruction of crops not only affects the farmers financially, but the citizens that rely on these crops as a food source. Farmers can also suffer damages when livestock are harmed or killed due to flooding (White & Howe, 2003).

2.3.3 Stormwater Management in Denmark

The geography of an area can have a large impact on the severity of damage caused by flooding. Denmark is one of the flattest countries (National Geographic, n.d.) and this lack of

elevated terrain contributes to the frequent flooding of roadways (Forman, 2003 pg. 188). When heavy precipitation occurs on flat land it stays stagnant if it has no way of being absorbed naturally into the environment or being diverted through the use of stormwater drainage systems. Denmark has undergone the construction of a vast network of roadways, especially in areas like Amager, and none of the roads are made of permeable substances like loose gravel (The World Bank, 2011). The combination of Denmark's flat landscape and impermeable roadways creates a high risk for serious flooding.

The severity of a flood depends on a number of variables but the frequency, amount, and rate of precipitation have a strong impact. The average annual precipitation in Denmark was 765 mm between 2001 and 2010 with an average of 179 rainy days per year (Danish Meteorological Institute, n.d.). Summer in Denmark has already seen an increase in the severity of rainfall over the past few years and meteorologists predict that this trend will continue. Denmark is predicted to see less precipitation overall during the summer season by a factor of 40% but the severity, or amount that falls in one storm, is expected to increase respectively (City of Copenhagen, 2011). The current expectation for subsequent winter seasons in Denmark is that precipitation will increase by 25-50% (City of Copenhagen, 2011). Stormwater drainage systems are only designed to hold a certain amount of water and when precipitation accumulates at a faster rate than the water can flow through the underground channels, flooding can occur. Based on the current seasonal predictions and capacity of implemented stormwater drainage systems, future flooding is very likely (City of Copenhagen, 2011) and has already been witnessed in recent years.

Due to the forecasted increase in severe weather, three potential approaches for combating flooding were detailed in Copenhagen's Climate Adaptation Plan (City Of Copenhagen, 2011). The first approach entails expanding the current stormwater drainage systems, which collect stormwater run-off and channel it toward a nearby body of water, to accommodate the heavier precipitation. This plan is not the preferred method because the estimated cost of construction alone would be two to three times higher than that of any other proposal. It also proves detrimental to the environment since it would increase the volume of pollution entering local bodies of water. The second plan involves containing the flooding to areas that would suffer the least amount of financial and environmental damage. This plan is also not preferred because it would not aid in the reduction of the total amount of water on the ground and therefore would not address the main concern. The third approach is more environmentally-friendly -- implementing natural filtration

systems in the form of vegetation or permeable surfaces to help absorb large quantities of water during storms. The planted vegetation would replace some impermeable surfaces, thus reducing the overall amount of runoff (City of Copenhagen, 2012). After much consideration, the city implemented the third approach and decided to utilize the second as an emergency backup plan in the case of flash-floods.

These solutions were soon tested when, on July 2nd 2011, a cloudburst hit Denmark and caused Copenhagen six billion kroner (apx. $910 million) in damages (Gerdes, 2012). Figure 2 depicts the severity of flooding following the cloudburst. Unfortunately, the plan to manage flooding proved to be mostly ineffective against the flash flood. In fact, even the back-up plan to divert the water to an area where it would do the least damage, failed. Due to the severity of the economic impact this cloudburst had, Copenhagen felt forced to create a new plan specifically designated to handle storms of this magnitude. The subsequent Cloudburst Plan entails combining emergency storage methods, such as the second solution in the Climate Adaptation Plan, with systems that carry runoff to the sea to be dispersed (City of Copenhagen, 2012).

Figure 2: Flooding After the 2011 Cloudburst

(City Of Copenhagen, 2012)

2.3.4 Green and Gray Stormwater Management

Many methods of stormwater management exist today and these methods are generally classified by their usage of green and gray infrastructure. The third plan regarding flooding proposed in the Copenhagen Climate Adaptation Plan is an example of green stormwater management due to its usage of natural water absorption through vegetation. Green stormwater management is any plan whose implementation poses no significant threat to the environment and ecosystem that currently exists (EPA, Green and Gray Infrastructure Research, n.d.). The first plan, expanding the stormwater drainage systems, illustrates an example of gray stormwater management since it utilizes man made materials that pose no benefit to the environment and its implementation would cause further pollution in the area. Any plan that effectively manages stormwater runoff but has negative environmental effects, such as pollution, is known as gray stormwater management (EPA, Green and Gray Infrastructure Research). The first plan proposed also shows the high financial cost of gray stormwater management as it was estimated to cost between thirteen to twenty billion kroner upon completion (City of Copenhagen, 2011). Both gray and green stormwater management methods offer a potential solution to flooding but the cost and benefits of both are quite different.

2.4 Green Spaces

Cities around the world have been pushing for more green spaces to combat environmental and health concerns. Green spaces, also called green strips or wedges, are areas of vegetation, usually within urban environments, created for recreational and aesthetic purposes. In terms of the issues Denmark is facing, green spaces can be used to safely absorb excess stormwater, photosynthesize excess CO_2, and dampen some of the noise pollution from traffic (Douglas, 2013).

2.4.1 Benefits of Green Spaces

In 2012, a study in Beijing, China attempted to determine how effective green spaces were at absorbing rainwater. After analyzing Beijing's scenario, the study concluded that the economic value per one hectare (about 2.47 acres) of green space was about $3,480 (22,674 DKK) and that one hectare in Beijing could absorb about 2,494 m^3 of water (Zhang et. al., 2012). While this data is useful, it is very specific to Beijing's environment which presents a problem when trying to

quantify the benefits of green spaces in general. Unfortunately, since the cities of the world have such diverse vegetation, micro-climates, and environments, it is impossible to universally quantify the amount of rainwater or CO_2 that a green space can absorb.

Green spaces can also help lower the likelihood of precipitation in a city. A research study done by the Forestry Commission in England determined that the amount of people, buildings, and traffic in a given area results in the 'urban heat island' phenomenon or "the warming of the local climate relative to surrounding rural areas" (Doick and Hutchings, Feb 2015). This extra heat can cause a warmer local climate and "warmer climates, owing to increased water vapor, lead to more intense precipitation events" (How is Precipitation Changing?, n.d.) which, in the case of Copenhagen, can lead to more flooding. The Forestry study also concluded that various types of green vegetation can help lower the atmospheric temperature of the area by up to 8° C and lower the surface temperature up to 20° C. By lowering the city's temperature, the frequency of rainfall in the area decreases, which helps alleviate some of the flooding. This ability to decrease temperature is yet another benefit of green spaces, and one that is of particular use to cities like Copenhagen.

Green spaces have benefits beyond helping the environment; they have also been shown to improve the physical and mental health of nearby residents. A study done in the Netherlands analyzed how people's self-reported health, documented individually by surveys, corresponded with access to green spaces in urban and non-urban environments. The study concluded that people perceived better mental and general health if they lived in a greener environment (Vries, S. D., et. al, 2003).

In 2009, New York City opened the first part of the High Line, a green strip built on a section of an abandoned, elevated railroad track. An image depicting a piece of the High Line is shown in Figure 3. This city park, which had been successfully lobbied for by a group called Non Profit Friends of the High Line, now gives back to its community. New York City has seen a boost in real estate prices as well as a decrease in crime on streets near the strip ("NY Highline", 2013; Lynch, 2008). Since 2009, two more sections of the railway have been transformed into public green space, and the Friends of the High Line organization still uses donations to maintain the park and run a variety of programs for people of all ages ("About the High Line", n.d.). This program was such a success that it encouraged other American cities to turn some of their abandoned urban infrastructure into flourishing green spaces ("NY Highline", 2013).

Figure 3: The High Line in New York

(Fehrenbacher, 2011)

2.4.2 Issues with Green Spaces

Although there are many successful examples of green space implementations around the world, there are also some that proved problematic in the long run. Green spaces in New Delhi were reportedly poorly maintained due to lack of funding and public support. As a result of the subsequent lack of use, these spaces deteriorated into "dumps" and have yet to be recovered (WHO, 2007). Poor maintenance is reportedly one of the biggest problems green spaces face. During an assessment of one third of the total green spaces in England it was discovered that 82% of them were considered in poor to fair condition. It was noted that lack of support from the local community likely played a large role in their decline (Department for Transport, Local Government and the Regions, 2002). Another problem green spaces often have is neglecting the needs of various demographics. For example, a green space in Melbourne was reviewed after its implementation and found to be difficult for some of the city's older residents to use. The space had not been well designed to support the needs of every age group -- an issue easily resolved with the addition of elderly-friendly benches and tables (WHO, 2007). The complexity of design and high maintenance requirements can impede green spaces from benefitting an area, but they can be solved with thoughtful design and local support.

2.4.3 Design of Green Space

Green infrastructure is a concept that encompasses many different types of design aspects, including parameters for increasing the vegetation on and near roads as well as within park areas. Rain Gardens are frequently used within these areas as a way of safely absorbing rainwater runoff from rooftops, sidewalks, and streets by mimicking natural hydrology infiltration (EPA, What is Green Infrastructure?, n.d.). The plant matter used for rain gardens is dependent on the climate of the area and the amount of sunlight, but it is mostly created using high absorption plants that can handle runoff (EPA, What is Green Infrastructure?, n.d.). This is also used in urban tree canopy creations, where large trees are used to slow and divert precipitation during times of heavy rainfall (EPA, What is Green Infrastructure?, n.d.). Trees are also used in the creation of pocket-parks, small quarter-acre versions of green spaces, popular in urban areas that have limited free space (NRPA, 2012). The main goal for pocket-parks is to give residents a healthy recreational area in which to spend time, however incorporating aspects like rain gardens can give the park a dual function.

The design of a green space, including the layout and types of vegetation, directly relates to the purpose of the space. Possible purposes include stormwater management, recreation/social space, or nature studies. Green spaces within Copenhagen generally have the primary purpose of stormwater management, however their uses for the public have been of high importance to the city. The spaces need to integrate Danish vegetation that is able to withstand the local climate, handle increased salinity from the heavy salting of the roads during winter, and absorb high levels of stormwater.

The benefits of green spaces match Copenhagen's mission to enhance the quality of life of its population while trying to make the city greener and healthier (Cph 2025 Climate Plan, 2009). For these reasons, Denmark supports the creation of green spaces, wedges, and strips throughout the city of Copenhagen. In fact, the importance of green areas was apparent as far back as 1947 when the Five Finger Plan was developed as a response to the expected population growth. The plan proposed creating five main roads, the 'fingers', which span out from Copenhagen's center to reach the outskirts of the city. As part of the plan, the areas between the 'fingers' were to be turned into green wedges to be used as natural recreational grounds (Copenhagen Regional Plan, 2012). At the time, the benefits of green spaces had not been studied, but Copenhagen knew it was

important to keep the 'country' close to the city. Since then, research has proven the environmental and health impacts of green spaces and Denmark has preserved and expanded these wedges (Caspersen, & Olafsson, 2010).

2.5 Amager

Amager is a heavily populated Danish island in the Øresund Sea off the coast of Copenhagen, connected to the city by several bridges. Amager is facing many of the same issues of traffic congestion and stormwater management as the rest of Copenhagen. To drive to the island there are currently four bridges available to cross. In 2013, during a given day, the average number of cars that crossed those bridges ranged from 29,400 to 57,900 with the heaviest traffic belonging to Langebro (Long Bridge), shown by a pin in Figure 4. On the Amager side of Langebro is Amager Boulevard which experienced approximately 57,400 cars per day, while the road on the Indre By side of Langebro, H. C. Andersens Boulevard, had approximately 57,900 cars per day (Traffic frequency in Copenhagen, 2013). Amager Boulevard and Langebro are still the heaviest traffic areas in Amager.

Figure 4: Langebro Connects Amager (Right) to the Inner City Portion of Copenhagen via H.C. Andersens Blvd from Amager Blvd.

(Google Maps, 2015)

Denmark's Aarhus University measures various air quality indicators (such as nitrogen oxides and particulate matter) in 18 site locations across the country in real time (Monitoring Programmes, 2015). As of this year, H.C. Andersens Boulevard has an average NO_2 emission of 55 $\mu g/m^3$ (Copenhagen (H.C. Andersens Bvld.), 2015). This is significantly above the global standard for safe emission levels of 40 $\mu g/m^3$ (WHO, 2014). The heightened level of emissions along this area is likely due to the large amount of cars that commute through to Amager in a given day.

Miljøpunkt Amager, which roughly translates to Environmental Point Amager, is a non-profit organization which focuses on supporting community projects and promoting an environmentally-friendly lifestyle in the community of Amager. One of their interests lies in reducing traffic in and through Copenhagen. This would promote an increase in bike traffic and open up a large portion of newly unused road space to be repurposed. Miljøpunkt Amager is particularly interested in creating a green strip running from the soon-to-be daylighted Ladegård River, through Indre By, over Langebro, and ending in Amager. In 2014 as part of this concept, Miljøpunkt Amager sponsored a bachelor project for a student named Inge Hopps, who created a concept design for a green space along Amager Boulevard. This year, Miljøpunkt Amager sponsored our team with the goal of extending Inge's potential green space design across the canal and creating a new surface design for Langebro. In order to create a design that would be feasible, we interviewed community members and Municipality workers so that our final design accounted for the interests of the local community, and the municipality's plan for Copenhagen. The following chapter explains how we accomplished this goal and the steps we took to accomplish it.

Chapter 3: Methodology

This project assisted Miljøpunkt Amager, an environmental non-profit organization, by analyzing the public opinion of green spaces in order to create a design proposal for the greening of Langebro (Long Bridge). To accomplish this goal we established the following objectives:

1. Understand the impacts and challenges of implementing green spaces in Copenhagen
2. Assess public opinion and preferences of green spaces on Langebro
3. Create green space surface designs for Langebro based on local and municipality preferences while integrating with the design for Amager Boulevard
4. Assist Miljøpunkt Amager in promoting a green strip through Copenhagen by creating a web page

Detailed in the remainder of the chapter are the specific methods used to best fulfill each objective under the designed timeline (Chapter 3.7). The goal of these methods were to establish the most efficient means of gathering information in order to create accurate and detailed deliverables for our sponsor.

3.1 Objective 1: Understand the Impacts and Challenges of Implementing Green Spaces in Copenhagen

When designing a new public space it is imperative to understand the effects it will have, on the surrounding area. For this project specifically, understanding the local policies and the municipality's interests regarding green spaces was vital to determining overall feasibility. We met with city officials and managers of various Miljøpunkt organizations to gather information on any legalities involved with greening a bridge, understand the Municipality's current plans for reducing traffic and greening Copenhagen, and understand the extent of local support for green spaces. Meetings with architects, landscape designers, civil engineers, and botanists helped us better understand the logistical and technical intricacies of designing on a bridge, and gather some design ideas for the space.

3.1.1 Semi-Structured Interviews with Miljøpunkt Amager (Political Challenges & Community Involvement)

Our sponsor is an active figure within the community of Amager -- making them knowledgeable on the current political situations. They also have a large volunteer base from the community and are highly experienced with environmental community projects. The purpose of interviewing the director, Claus Knudsen (Appendix A), was to help us better understand the opinions of local officials prior to interviewing them and also to give further insight into expectations of our project. We also wanted to learn about the extent of the community support the organization had received in the past and what kind of support they would anticipate for the new green space on Langebro.

3.1.2 Semi-Structured Interviews with Political Figures

By conducting interviews with Morten Kabell, the Mayor of the Environmental and Technical Municipality (Appendix D), and Andre Just Vedgren, the Second Chairmen of the Local Committee in Amager Vest (Appendix B), we hoped to get information regarding the political challenges and potential support our project could have. Due to Morten's busy schedule we were able to contact him via email through his secretary, Thomas Hjolt. Through the use of a semi-structured interview, and in Morten's case, emailed questions, we asked about local policies and management of public areas, since any alterations to public spaces must be approved by the city. The political involvement of our sources allowed us to understand whether or not a project like this would have the potential to be approved.

3.1.3 Semi-Structured Interviews with Experts in Green Space Design, Architecture, & Botanist

As we began designing a green space for Langebro (as later discussed in Objective 4) it was beneficial to understand the possible challenges that could have arisen in either the design or construction phase. In our interviews with Simone Hochreiter, a landscape architect working for Miljøpunkt Nørrebro (Appendix E), and Rene Sommer Lindsay (Appendix D), a project manager and architect in area renewal for Klimakvarter, we looked for information regarding the design process. Stefan Werner (Appendix G), a project leader for the Copenhagen Municipality and Civil

Engineer, was interviewed about how the municipality's plan for the area affected Langebro. Interviewing these individuals helped us understand what things we should consider or avoid in the green space design.

All of the aforementioned interviews were semi-structured which allowed for flexibility as we asked many impromptu questions (Berg, 2004). The impromptu follow-up questions helped us better explore or understand some of the answers we were given. All of the interviews were audio recorded, with consent, and notes were actively taken. Afterwards, the notes and audio recordings were used to create summaries of key notes, ideas, and questions for each interview.

3.2 Objective 2: Assess Public Opinion and Preferences of Green Spaces on Langebro

This objective focused on communication with the general public to better understand their impressions about green spaces, and specifically the implementation of one on Langebro. We were specifically interested in finding out if the public felt there was a need for green spaces and if so, what their preferences were for physical aspects of the design (e.g. benches, gardens, etc.). This information gave us ideas and criteria to consider for our design for Langebro (to be discussed in Objective 3).

3.2.1 Structured Street Interviews/ Surveys

Of particular interest to us was understanding the opinions of individuals who live and spend time in Amager as they would have the highest likelihood of using a green space on Langebro. To gather this information, we conducted 88 street interviews/surveys over the course of three days. We did this by printing copies of the survey (Appendix F) and, after engaging someone and giving a short description of the project, walked through the questions with them, filling out the paper with their guidance. To encourage participation we offered home-baked chocolate chip cookies. During the three days we conducted interviews we gathered 11 responses from Sundby Bibliotek (Sundby Library), 30 responses from Det Kongelinge Bibliotek (The Royal Library), 14 from Amagerbro Station Metro platform, and 33 from walking around the Islands Brygge area on Amager. These location choices represented a variety of areas on both ends of Langebro and reached a variety of different people. From these surveys we reached a variety of

age groups, though we had some trouble talking to the elderly as many of them did not speak English well.

3.2.2 Online Survey

To gather the opinions of a greater portion of the community, an online survey, containing the same questions as the street interview/ survey, was distributed through Miljøpunkt Amager's monthly newsletter. This newsletter reaches approximately 150 people, ~50% living in Amager. The survey was created using the online program Qualtrics which allowed for comprehensive analysis of demographics and responses. By reaching out through the newsletter we were able to connect with a higher number of people which helped to validate our data from street interviews.

3.3 Objective 3: Created Green Space Designs for Langebro Based on Local and Municipality Preferences while Integrating with the Design for Amager Blvd.

Information gathered from interviews, surveys, and the Amager Boulevard design allowed us to determine preferential physical components, which we integrated into our green strip proposal. Various structural specifications and restrictions on the amount of alterations that can be made to the bridge, helped us further detail and tailor the design to something that we expect will be both feasible and widely liked and utilized by the Copenhagen community.

An important factor of our design is that it will eventually be a part of a greater green strip through Copenhagen and should, therefore, have some cohesion through the entire strip. The street leading up to Langebro, Amager Boulevard, was redesigned as a green strip in 2014 by Inge Hopps, a Danish University student. In order to cohesively connect Langebro to Amager Blvd., we took some inspiration from Inge's design, specifically in her vegetation choices. In addition, we researched vegetation that would be most appropriate for the site location, looking for traits such as the ability to withstand the local climate conditions. This encompassed studies on various planting methods and structural supports so that things like the high wind levels did not impede the overall health and grow of the proposed vegetation.

Finally, sketches for a preliminary design were brought to Simone Hochreiter, a landscape architect, for consultation of feasibility and overall opinion. Simone made suggestions to alter a

few aspects in order to ensure that the space reflected Danish design and could be enjoyed by individuals using all forms of transportation. These suggestions were taken into consideration for the final Langebro surface design.

3.4 Objective 4: Assist Miljøpunkt Amager in Promoting a Green Strip through Copenhagen by Creating a Web Page

Public support and enthusiasm is vital to the approval and long term vitality of this project. Research has indicated the importance of public ownership and pride in the utilization and maintenance of a green space (C. Knudsen, S. Werner, and A. Vedgren, personal communication, April, 2015). To this end we decided to create a website to increase public awareness and support for the greening of Langebro.

3.4.1 Create a Web Page

We created a page on Miljøpunkt Amager's website to make the Langebro green space designs and other promotional information easily accessible to anyone interested in learning more. We met with Claus Knudsen and Lise Christensen, a project leader at Miljøpunkt Amager who works on the organization's website, and discussed what content they were interested in seeing on the page. After writing the content and finding relevant photos we met with Lise again to post the information to a web page on their website.

3.7 Timeline

	Phase Description	**Specific Tasks**	Week							
			1	2	3	4	5	6	7	8
Phase 1	Impacts and Challenges	Political Figures Interviews								
		Miljøpunkt Amager Interviews								
		Expert Interviews								
Phase 2	Public Opinion	Street Interviews								
		Online Survey								
Phase 3	Green Space Design	Create Design								
Phase 4	Web page	Create Webpage								
	Deliverables	Initial Deliverables								
		Final Deliverables								

Chapter 4: Findings

During our time in Copenhagen we were able to complete our objectives, as discussed in Chapter 3.0, in the timeline anticipated. Through completion of these methods we have come to determine three significant findings. These findings, explained and discussed below, help to explain the project and the recommendations we have arrived at. The full recommendations, limitations, and future work can be found in Chapter 5.

4.1 Finding 1: Various Proposals Exist to Reduce Overall Traffic in Copenhagen and Specifically on Langebro

Our project is predicated on the assumption that there will be reduced traffic throughout Copenhagen and especially over Langebro. It is important however, to understand how this could be achieved, since it would determine how many cars will travel over the bridge. This understanding also helped us explain the situation to those we interviewed so they were less skeptical of the Langebro design proposal.

The city of Copenhagen recognizes the problem that the current car usage presents. Morten Kabell, the current Technical and Environmental Mayor, was elected with a political focus on increasing bike and public transit usage in the city and reducing the car traffic along with the pollution it poses. The city has ideas and vague plans for how to reduce traffic through Copenhagen, which we consulted for the Langebro designs, though unfortunately, there are a wide variety of options, all of which have a variety of supporters and opposers.

Another important opinion for our project to consider, is that of our sponsor, Miljøpunkt Amager. As an environmental organization, they are concerned with the current amount of traffic because it corresponds to high air and noise pollution in the areas near the heavy traffic. Recently Miljøpunkt Amager has decided on a strategy for promoting a reduction in traffic. First they are working to make preliminary designs of a green strip running from Nørrebro, down H.C. Andersens Blvd., over Langebro, and down into Amager, as conceptualized in Figure 6. This design, once complete, will help to incentivize the people and officials of Copenhagen to find an efficient way to reduce the traffic, so that the green strip can become a reality. After showing their green strip design, Miljøpunkt Amager hopes to hand the city officials various traffic reduction

options, some of which are described below, and let the city decide its course of action. Our final design for Langebro will ideally become part of this larger green strip proposal.

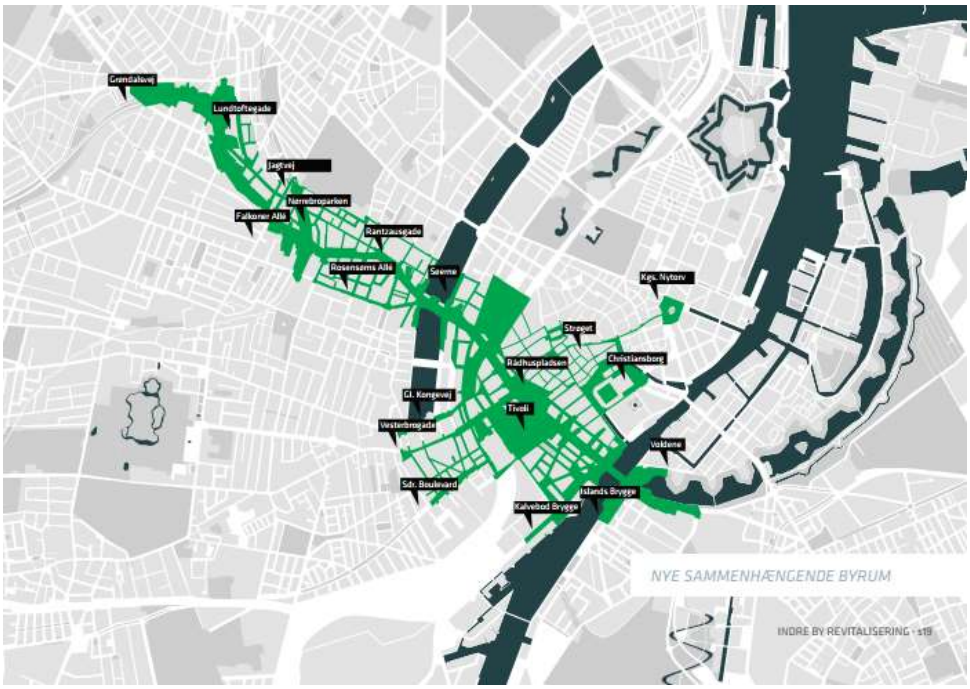

Figure 5: Design for Miljøpunkt Amager's Proposed Green Strip through Copenhagen (Jensen, 2014)

4.1.1 Traffic Tunnels

Traffic tunnels are one of the most prominently discussed ways of reducing traffic through Copenhagen. The idea is to remove the commuter traffic from the streets, which runs through the city without stopping. Two traffic tunnels, which were briefly discussed in Chapter 2.0, have been proposed to and discussed by the municipality while a third tunnel has been discussed between the Miljøpunkt organizations in Amager, Indre By, and Nørrebro. Through research and interviews with Claus Knudsen, the director of Miljøpunkt Amager, and André Just Vedgren, the second chairman of the local committee of Amager Vest, we were able to better understand the tunnel proposals and how they were received by the public and the city officials.

The first tunnel discussed by the city was the Københavnertunnellen (Copenhagen Harbor Tunnel). According to André, this is one of the least popular tunnels that have been formally proposed as a result of its location. The proposal, as described in Chapter 2.2, runs from northeast

Copenhagen, down the coast, and follows under the canal to emerge in Amager. André informed us that this design was discussed by the city but failed to be approved because, as opposition claims, it will likely ecologically and physically damage the canal during construction.

The second important tunnel is the Eastern Ring Road. This tunnel, which we also discussed in our interview with André, is the most feasible of the tunnel proposals discussed and the proposal was actually passed from the officials in Copenhagen to the Danish Parliament. It covers the same route and utilizes the same design as the havnetunnelens (Harbor Tunnels) proposal but was strategically renamed to gain funding from the state (upon Danish Parliament legal approval). The path, detailed in Chapter 2.2, runs from north eastern Copenhagen, under the harbor between the "mainland" and Amager, and diagonally under Amager from the north east corner to Amagerfælled. This can be seen in Figure 6 as the red line running from Strandvænget to Sjællandsbroen. According to André, the first section of this tunnel, which runs from west Østeboro, in northeastern Copenhagen, to east Østeboro, is currently under construction. The opposition for this proposal focuses on its outlet into Amagerfælled, the largest green area on Amager. In the interview with André, we learned that this tunnel was renamed to Eastern Ring Road so that it could move from the responsibility and funding of the city, to that of the country. Currently, it is in the hands of the Danish Parliament to decide if the project will move forward.

The third tunnel of note has not actually been proposed to the city yet. In northern Copenhagen, Miljøpunkt Nørrebro, an environmental non-profit organization in the neighborhood of Nørrebro, has proposed a traffic tunnel in its neighborhood in order to reduce the through traffic and reduce flooding by reemerging, or daylighting, the Ladegård river, which is currently piped underneath the city. There is an unofficial potential proposal to extend this traffic tunnel underneath Indre By and Langebro to the southern part of Amager, titled Ladesgårds River Tunnel. This extension, shown in Figure 6 as starting at Bispeengbuen, would have two exits, one in Forum and one just after Langebro in Amager, and connect to the Eastern Ring Road at the DR Byen exit (Jensen and Tredje Natur, 2014). This tunnel, which Miljøpunkt Amager is interested in, is of particular interest to the Langebro project, as it is the only tunnel proposal that will definitely alleviate traffic from the bridge. Anders Jensen, the director of Miljøpunkt Nørrebro, ran a preliminary traffic prediction algorithm for the extended traffic tunnel. It predicted a severe reduction in traffic on H.C. Andersens Blvd., Langebro, and Amager Blvd. This tunnel would also pose a more direct route of moving commuter traffic "through" Indre By rather than around it.

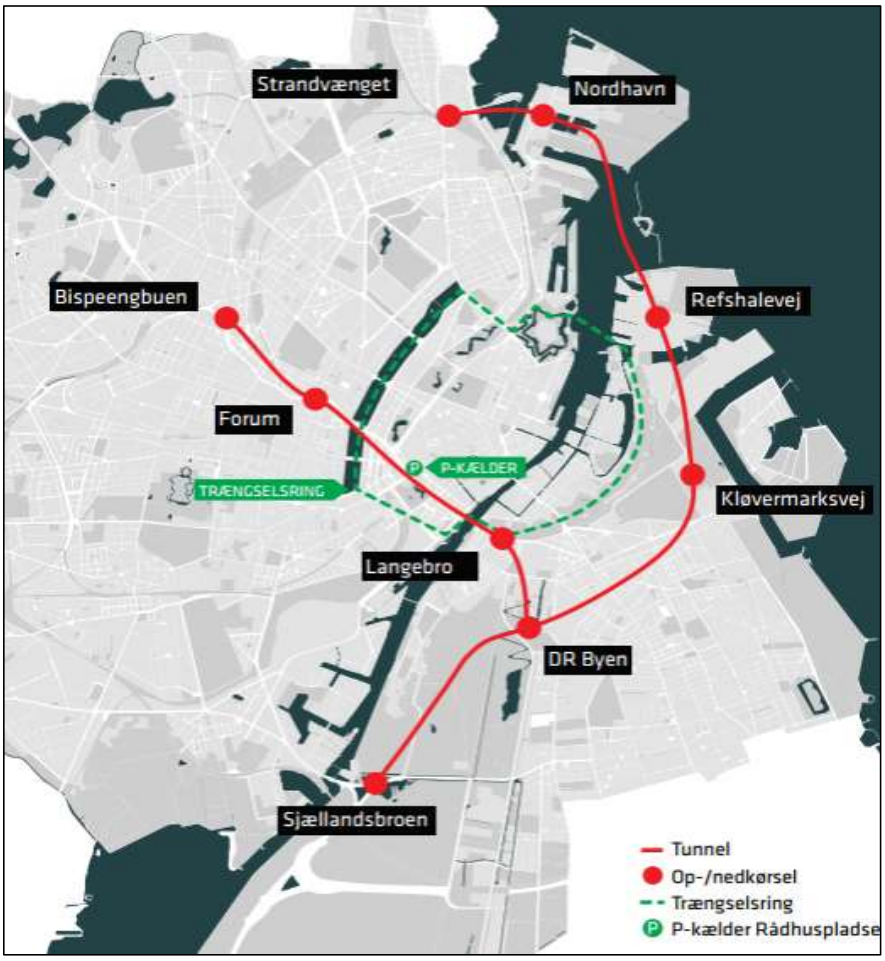

Figure 6: Eastern Ring Road Tunnel (Right) & Ladesgårds River Tunnel (Left)

(Jensen, 2014)

Unfortunately we have found a number of down sides to the implementation of a traffic tunnel. During our interview, Anders noted that making a tunnel might encourage people to use it which would promote car usage rather than discourage it. Tunneling is also one of the most expensive ways to alleviate traffic, and would cost the city through monetary expenses and in the time and hassle of its construction. As for its physical placement, the current metro system is underground in a place shallow enough that any tunnel would need to go beneath it but deep enough that the tunnel would need to be very far underground, a hassle for construction.

We have discovered that not only are there multiple tunnel proposals but there are a wide variety of opinions regarding these tunnels. We were warned by Claus that we might get opposition from car owners or car enthusiasts during interviews and surveys because many people are talking about removing their ability to travel through the city. We were fortunate enough not to have too

much trouble with this, however a few of our interviewees were focused on the traffic situation on the bridge as it pertained to the project's feasibility.

4.1.2 Other Options

Considering the steep price of creating any of the current traffic tunnel proposals, Miljøpunkt Amager (along with Miljøpunkt Indre By) has been considering other options. These include congestion pricing (tolling the road for usage where the price depends on the time of travel) and, somehow incentivize commuters to take public transit or bike. Congestion pricing is more indirect as it discourages rather than bars people from driving cars. Encouraging public transit could be done by adding more systems (such as a light rail) or by changing the routes of the current busses to broaden their reach.

The city is currently actively working to promote bike usage by adding bike paths and bridges to make commutes more direct. Recently, a design for a bike bridge that will cross the Harbor (canal) to the east of Langebro, was approved. This will promote biking and, ideally, displace most commuter bikes from Langebro, allowing for more casual biking.

4.2 Finding 2: Currently There are Restrictions and Limitations to Altering or Building on Langebro

Langebro is a historic and frequently traversed bridge that connects Indre By to Amager. Consequently, there are various limitations and restrictions pertaining to construction on the bridge. These limitations include historical protections on and around Langebro, the unnatural environment for vegetation, and the structure of the bridge. All of these restrictions and limitations must be considered in the green space design to ensure feasibility of the project.

4.2.1 Protection of Areas on and Around Langebro

The design location of Langebro, as we discovered from interviews with Claus Knudsen, is currently designated as a historic bridge as it was rebuilt in 1954 by the beloved Danish architect Kaj Gottlob and therefore holds significance to the local community. Due to the age of this bridge and historical significance it is also considered somewhat of a landmark by the local community and is even seen on the two-hundred kroner bill.

Historic areas such as Langebro are protected by the Municipalities to preserve the history of the Danish culture. Claus Borre, an employee of the municipality who was recommended to us by Tina Saaby, the municipality's architect, informed us that any alteration or modifications made to the bridge or its surface area must be handled delicately and no structural changes to the bridge itself could likely be made. However, according to Claus Knudsen, legislations and protections can be altered or lifted if the benefits are deemed to outweigh the detriments in a specific location or situation, such as the protections on Langebro. Claus also informed us that an application is required for submission to the municipality containing all the desired changes of the protected area before we are able to understand the current level of protection.

On either side of Langebro are two particularly important and protected buildings -- the harbor towers that are still currently used by the harbormasters. According to André Just Vedgren, these towers specifically are heavily protected and could not likely be altered in anyway. As previously stated, protective legislation can be altered if the benefits outweigh the costs, however it is unknown what protective measures would remain on these towers if approval for surface alteration was given.

Figure 7: Picture of Langebro- Indre By (Bottom) and Amager (Top)

(Danhostel, n.d.)

4.2.2 Environmental Restrictions and Limitations

The construction of a green area on the surface of any bridge warrants many environmental constraints due to the lack of soil for vegetation growth. The technical specifications of Langebro, given to us by the By og Havn (City and Harbor Authorities), state that the bridge is primarily made out of steel and its surface is constructed out of asphalt to accommodate bicycle and vehicle traffic. All of these materials make it problematic when considering planting vegetation on the surface of the bridge.

Direct observation of Langebro also showed us how exposed Langebro is to the elements as there are no structures around it to block from or redirect the wind. This could potentially cause trees or other vegetation to blow over, become damaged, or have hindered development. In order to reduce potential for wind damage to plants we had to consider soil depth requirements. For trees and other large plants, structural supports to the stems may also be needed to ensure proper growth and health. Details on vegetation choices/guidelines are provided in chapter 5.

We interviewed with local botanist Jann Kuusisaari, to confirm optimal soil depths estimations for the plants being recommended in high volumes across the bridge, like grass and small shrubs. He also mentioned that other vegetation with larger root systems, like trees, would need to be placed in bags or boxes such as those depicted in Figure 8, which have already been implemented in various areas in Copenhagen. Matured canopy size or width of any vegetation planted on the bridge surface would have to be considered to ensure that roadways or bicycle paths do not become obstructed over time. These larger vegetation options would also have to likely be braced to the ground and potentially given structural support to ensure they would not tip or break in the high wind conditions experienced on Langebro.

Figure 8: Pictures of Copenhagen Municipality Trees in Bags

(Saaby, 2013)

As previously discussed, global climate change has led to an alteration of the frequency and severity of rainstorms. Due to the lack of natural materials used during the construction of bridges, soil and other natural planting materials would need to be placed on the bridge's surface. This means that during the severe rain storms Copenhagen has been experiencing, this green space would have no natural filtration through the ground. So unless specific measures were taken, rainwater would be absorbed by the soil, have nowhere to go, and significantly increase the load on the bridge.

4.2.3 Structural Restrictions and Limitations

Langebro has a total length of 252 meters and the roadway width for car and bicycle traffic is 26m from face-of-curb to face-of-curb. The pedestrian walkways on Langebro are 3 meters wide and extend for the entirety of the length of the bridge giving the bridge an overall width of 32 meters. Langebro's surface is somewhat elevated with a maximum clearance of 7 meters for a width of 35 meters in the middle of the bridge and a clearance of 5.6 meters at the lowest clearance points located at either end of the bridge (By og Havn Authorities).

Langebro currently has two ramps, approximately 18 meters in length and 32 meters in width, in the center of the bridge that raise to allow taller ships and boats to pass into the harbor. Different experts have told us various frequencies for how often the bridge opens but based on the answers we received from Claus Knudsen, and Stefan Werner we believe the bridge only opens 5-

6 times a month. When a ship requires the bridge to be opened they must schedule it in advance. This project is working under the assumption that the bridge will be permanently closed since, according to Claus Knudsen, the municipality has been considering closing it anyway.

Alteration of any of the set dimensions of the bridge would prove to be too costly, according to Stefan Werner, a civil engineer and project leader at the municipality. This limits the green space design for Langebro to the current dimensions of the bridge. Modifying the bridge to have more reinforcement beams would also likely be too expensive, therefore the design will have to cater to the current weight restrictions and dimensions.

4.3 Finding 3: Locals Have Preferences in Green Space Implementation, Design, and Functionality

4.3.1 Determining Stakeholders

For this project to be successful, we needed to clearly understand the perspectives of the prominent stakeholders, political figures and general public. This was important because, although the public's utilization will be the main determinant of the overall success, the support of political figures will determine if or when this project will start moving towards approval and implementation. From the interviews and survey results we gathered, we found that there were often distinct differences between what the general public wants and what Copenhagen's municipality wants. Both stakeholders' preferences focused on either what physical biotic or abiotic features should be integrated, such as benches, trees, flowers, or what overall activity the space was designed for, i.e socialization, child-friendly, quiet/private etc. Overall though, 77% of the 100 participants that we spoke with said that they would -- traffic controversy aside -- benefit from an increase in green spaces (Appendix F). This was important because it affirmed that the public would benefit from the project. This affirmation was also crucial in getting useful responses to further questions of preference.

4.3.2 Political Perspectives

After interviewing with political figures we found some key aspects that were considered preferable by the local Committees of Amager and the Municipality of Copenhagen. Mayor Morten Kabell, discussed the municipality's current work towards increasing the overall greening of the city, in line with their Carbon Neutral Initiative, and decreasing the overall road speed of the remaining traffic. Simone Hochreiter, an architect for Miljøpunkt Nørrebro, also mentioned this, saying that the city is working to reduce the attractiveness of roads for drivers by making them smaller, slower, and more indirect. Another interesting preference our political sources discussed, was that of designing green spaces with minimal biodiversity of flowering/fruiting plants and trees. André Just Vedgren, explained that the increased pollen from these often exacerbate people's allergies resulting in complaints to the city council.

4.3.3 Public Preferences

While conducting street interviews, we were primarily interested in what aspects the general public wanted to see in the green space and what aspects we needed to try to avoid. From the 100 people that were surveyed, either on the street or online, we were able to collect an array of data to help propel our design process. Out of the survey questions asked, we focused on the public's responses to Questions 5: What was your favorite part of the green spaces/parks you have visited, Question 6: What was your least favorite part of the green spaces/parks you have visited, and Question 9a: What kind of activities would you use [Langebro] for? (Appendix F) during the design phase.

Figures 9 & 10 show the categorized responses to the open-ended responses we received from the surveys conducted. The results were categorized and counted to determine the frequency of each category. These graphs were created through manual sorting of each survey response into categories of predominant features or concepts. Each original response was kept for reference of what category it was assigned to (Appendix I). This method of data analysis allowed us to efficiently organize and understand results in order to better tailor the final design. The most prominent answer for locals favorites were, as expected, green elements like grass and trees- categorized as "Biodiversity/Design". On the other end, the most prominent dislikes were Litter and "Space Issues" a loose category encompassing answers like "bare", "too much concrete", and

"disrepair/poorly maintained". Many of the answers within the Space Issues category were considered for our recommendations. However, some other prominent answers such as "near water", or "in a good location", were less pertinent to our objective because we were working with a fixed location- Langebro. The "Misc" categories encompassed answers that were unique enough not to easily fit into a different category. For the Favorite Aspect question, the Misc category included "no traffic", "historic", and "part of home". For the Least Favorite Aspect question, the Misc category included "tied dogs", "weather", and "lots of birds".

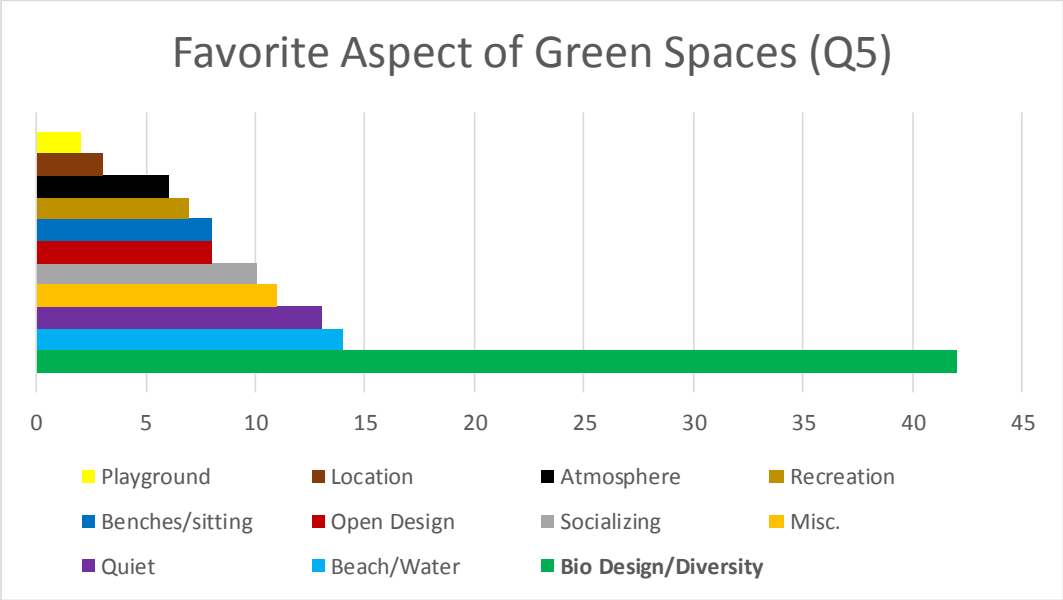

Figure 9: Response Categorization of Survey Question 5 (n=100)

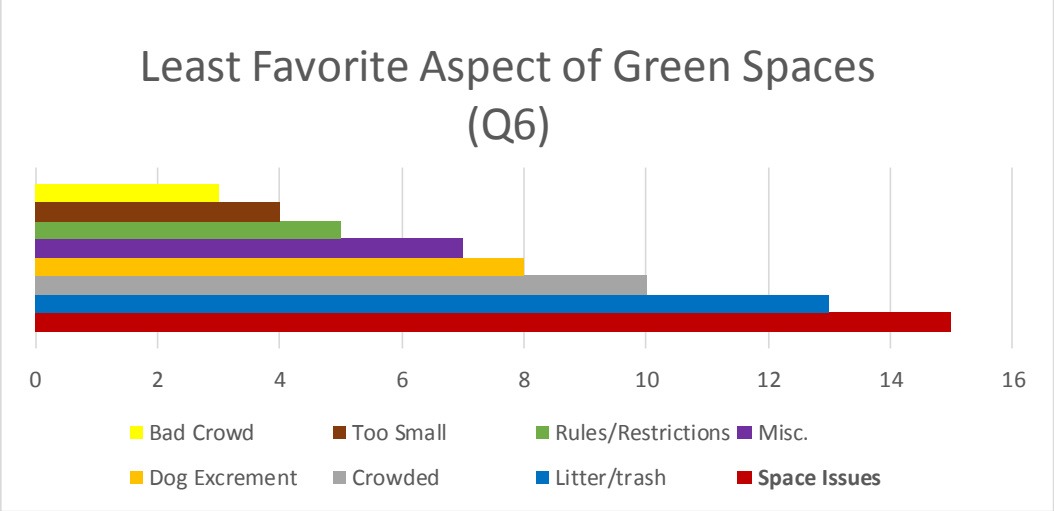

Figure 10: Response Categorization of Survey Question 6 (n=100)

4.3.4 Target Audiences

Not only was it important for us to establish which features to add or avoid in the Langebro green space, we also had to determine which activities we wanted to design towards. To do this, we reviewed responses from Question 9a of the survey -- what activities do you do in a green space -- and any relevant information gathered from any of the key informant interviews we conducted. Interestingly the results from our surveys showed high preference for both Relaxing (37%) and Socializing (27%). We also got similar percentages between Sun-Bathing and Exercising, 16% and 13% respectively. The lack of a predominant preference posed some conflict in design because we wanted to cater to as many people as possible so that our space would have the highest chance of utilization.

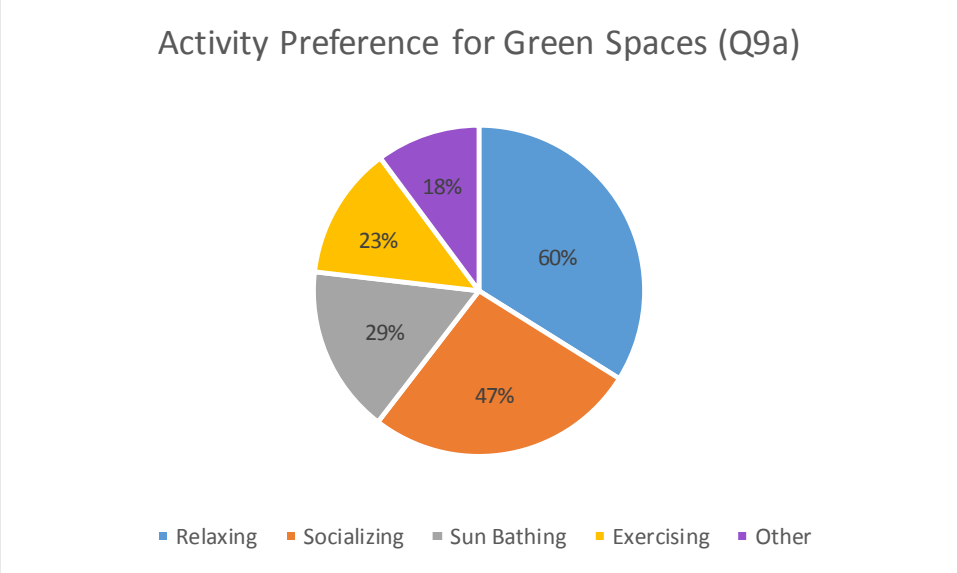

Figure 11: Response Percentage to Survey Question 9a (n=100)

Other prominent components that were mentioned during interviews and in survey results but did not make it into the bridge design, included playgrounds, community gardens, and waterfront extensions. Playgrounds were decided against because, although it was a common suggestion, people frequently commented that they appreciate the quiet, which is not an adjective often associated with playgrounds. Moreover, as Rene Lindsay, project leader and architect for Klima Kvarter, discussed, when you create a playground the space is specifically designed for only one group -- children. This limits the functionality of the space and leaves it unused when there

are no children around. Alternatively, creating a community garden in one of the bridge's pocket areas was seriously considered earlier in the design phase. It was eventually decided against because of the same specialization problem Lindsay mentioned, but also because, as André Just Vedgren stated in his interview, for a community garden to be successful it depends on ownership and effort from the locals to maintain it. Considering the location of our green space, we could not guarantee an adequate number of volunteers for its maintenance. If the space was left unmaintained it would degrade and become unappealing and unused, and would detract from the aesthetic of the entire bridge.

Finally, when interviewing Stefan Werner, a civil engineer for the municipality of Copenhagen, he was very interested in the idea of some sort of waterside extension on the bridge. Unfortunately, this seemed extensive and may have conflicted with the protections on the bridge. Stefan also discussed that it is currently illegal to swim in the Harbor due to boat traffic, which was good incentive not to allow access to the water from the bridge.

In the next chapter we discuss the recommendations we have compiled through analysis of our findings and the consideration of all data collected and interviews conducted. The recommendations include the overall surface design for the bridge, along with an explanation for our design decisions, as well as general considerations we have determined to be important if and when this design begins to be realized.

Chapter 5: Recommendations & Deliverables

The final deliverables of this project include notes and recordings from our interviews, results from the street and online surveys, a web page for publicity, and recommendations for the layout and content of the surface designs for Langebro including sketches and renderings. Our recommendations for the final design of the Langebro green strip include the conceptualization of the redesigned surface and the reasoning behind each design decision. This chapter includes drawings and renderings of the whole bridge as well as the individual pocket parks. As mentioned earlier, this design focuses on the bridge's surface and therefore does not include or consider the two towers or the stone 'railing' that lines the bridge. All of the details below for the greening of Langebro are suggestions based on our research and ideas.

5.1 Bridge and Road Design

The current dimensions of Langebro were given to us by the By og Havn (City and Port Authorities) and included a total length of 252 meters and width of 32 meters. With this area, we worked to maximize the amount of space available for greening while catering to as many interests as possible. The final design, as shown in Figure 12, is a sinusoidal-shaped road with two 'peaks' on one side and three 'peaks' on the other. This creates three large pockets with a half pocket on either end. We decided to utilize architect Simone Hochreiter's suggestion to create this winding road because it caters to preferences of the municipality by encouraging people to drive slowly, which makes it safer for pedestrians and discourages commuter traffic. We also decided on this overall shape because it allowed for the creation of large pocket parks which we tailored towards different interests and activities.

Within this final design, the car lanes are each 2.5 meters wide, the average minimum lane width (By og Havn), for a total of 5 meters. The bike lanes are each 2.5 meters to allow for 3 bikes to ride side-by-side. These dimensions can be seen in Figure 13, a sketch of a cross section of the bridge at one of the peaks. We decided to have the bike lanes follow the curves of the road but be separated from the traffic by a line of bushes and shrubs. This will help to reduce air and noise pollution from the cars while allowing the cyclists to be a part of the green space. This is shown below in Figure 12, where the thick grey line represents the barrier. Finally, we integrated a 1.5

meter pedestrian walkway on either edge of the bridge allowing pedestrians, the slowest form of traffic, to cross quickly and easily.

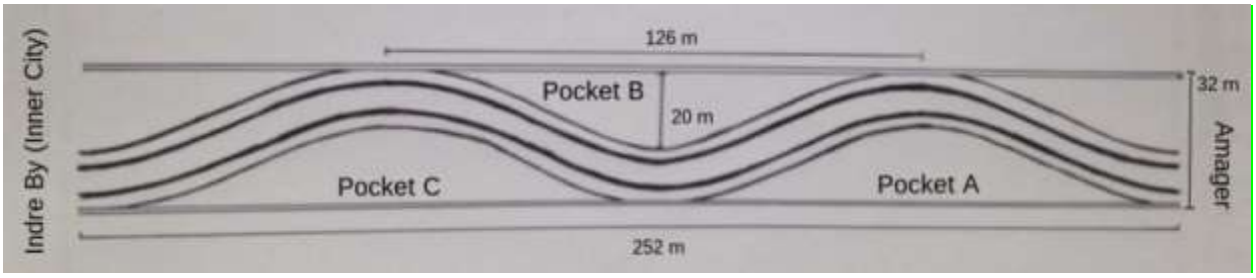

Figure 12: Aerial View of the Langebro Design Road with Dimensions

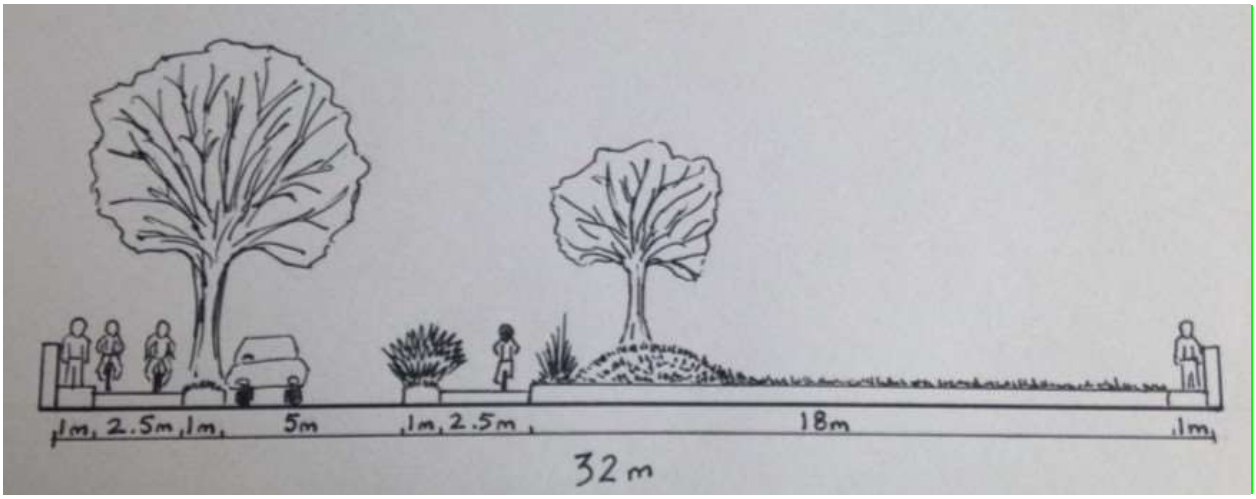

Figure 13: Cross Section of the Langebro Design with Dimensions

Each of the three full pockets have a 126 meters long base, with a maximum height (excluding the pedestrian sidewalk and bike lanes) of 18 meters, creating an area of 1134 square meters. The side pockets have the same height and a base length of 63 meters for an area of 567 square meters. We noticed from observing Dronning Louises Bro, a bridge between the rectangle lakes Søerne and Peblinge Sø, that people enjoyed sitting areas with a lot of sunlight. Using this information, we designed Langebro so that the side with two pockets faces west, to maximize the amount of sunlight it receives in the afternoon, leaving one pocket to face east. For simplicity, we designated each of these as either Pocket Parks A, B, or C. As shown in Figure 12, Pocket A faces west and is closest to Amager, Pocket B faces east and is in the center of Langebro, and Pocket C faces west and is closest to Indre By. Each pocket is designed to create a certain type of

atmosphere, though all contain a variety of vegetation. To accommodate the plants, we suggest using a half meter of soil to cover the ground of each pocket and elevate it from the road. This will, according to botanist Jann Kuusisaari, be enough to safely accommodate the vegetation we planned to have in each pocket. Unfortunately, we were unable to complete calculations for the weight of that amount of soil, dry and wet, and while we believe it to be within the weight tolerance of the bridge, we recommend verifying this conclusion.

5.2 Pocket Park A

Pocket A is designed to be the social hub of the Langebro green strip -- positioned closest to the Islands Brygge green strip and adjacent to the popular waterfront socialization area, the 'Harbor Bath'. By placing this pocket close to these areas, we hope to encourage people to use the space (Figure 14). We also positioned this area, as previously mentioned, so that it will receive the most sun in the afternoon hours, a time when Danes are frequently out sunbathing. This will likely give it an advantage by appearing as an optimal place for people to go to enjoy good weather with the popular view of the harbor.

From our survey results, as explained in the previous chapter, we determined green spaces are primarily used for hanging out and socializing. To accommodate this, Pocket A is designed with lots of communal sitting areas, like picnic tables, long benches, and open expanses of grass. Claus Knudsen, among others, expressed that barbecuing is a popular summer activity so, to encourage people to barbeque without damaging the grass, we integrated specific square meter areas on the ground, made out of pavement or stone, for people to place their grills.

Curving paths in this area allow for a natural flow of foot traffic, while creating smaller sub-pockets of grassy areas where people can congregate. For this area, minimal florals were incorporated in favor of mixtures of green shrubs, bushes, and grasses. This will still give the area a good atheistic, however large areas of florals would detract from the overall spacious design and likely be less appropriate in an area expecting high volumes of people.

Figure 14: Revit Rendering of the Design for the Social Pocket (A)

5.3 Pocket Park B

The second pocket of Langebro is designed as a botanical garden. As noted in our Findings, our green space surveys showed an overwhelming interest in biodiversity. From this, we decided to dedicate one of the pockets to promoting a variety of vegetation and aesthetics by highlighting Danish flowers, bushes, grasses, and trees. Potentially, this area could also have interpretive signs next to each group of plants within the area to serve as an educational aspect for those interested. As shown in Figure 15, we designed the entire space to be lined with green elements, with three prominent flowerbeds in the center of pocket. The paths follow the pocket's curve, going through and around the flowerbeds, radiating from the center out to the edges. To facilitate relaxation, much of the area will be covered in grass and will also contain two raised mounds, about a meter high, with a tree on top. The space will also have benches facing different directions to allow for a variety of views. Pocket B, out of the three, was chosen to be in the center facing east, because it was created as an environment for appreciating biodiversity so afternoon sun was less important.

Figure 15: Revit Rendering of the Design for the Botanical Pocket (B)

5.4 Pocket Park C

The third park, Pocket C, was designed to accommodate the people from our survey who favored using a green space as an area to quietly relax (Figure 16). In line with this, we designed it in a way that would use greenery to promote a feeling of privacy and security. This design is created with many small semi-circles with benches and tables inside, edged in small shrubbery and trees. Although these green elements are not intended to be tall or big enough to create absolute seclusion for those inside, it is designed to provide a feeling of surrounding by nature and a pseudo-privacy.

This pocket is also positioned so that it will receive the afternoon sun, as it will be on the same side of the bridge as Pocket A, only closer to Indre By. Currently in this area in Indre By, there are mostly commercial buildings and the Royal Library -- a logical decision for the quieter pocket park. The hopes for this design is that it will promote people in the nearby area to use it for small meetings and lunch outings. The design also has expanses of open grassy areas and a flow of paths leading from the semi-circle strip to a central cobblestone area near the edge of the bridge. This gives people options of socialization, but not in the same open design method as Pocket A.

Figure 16: Revit Rendering of the Design for the Quiet Pocket (C)

5.5 Side Pockets

With the shape of the design, there are two side pockets, one on either side of the bridge, which are half the size of the full pockets described above. We did not create detailed designs for these side pockets because we did not feel that they had enough space to dedicate to a separate activity or interest. Potentially, these small areas could be incorporated into the greening proposals for the streets on either side of the bridge. This would help to promote overall flow and aesthetic cohesion through the larger green strip from Nørrebro to Amager. For these reasons, we did not want to spend too much of our limited time designing pockets that we think will be redesigned later. If, somehow, the Langebro design is constructed before the designs for H.C. Andersons or Amager Boulevard, then grassy areas with mounds and bushes or trees could be integrated.

5.6 Biotic Features

We evaluated the potential of a variety of different types of biotic elements for implementation in this green space. As previously discussed in Chapter 4, we needed to be aware of the height and stem strength of taller elements like trees and shrubs because of the windy nature of our site location. However, for this design, we are also suggesting plants with moderate to high salt tolerance (from road salting during cold weather), and ones that can handle the high amounts of sun. We created a list of potential trees, shrubs, grasses, and flowers that we wanted to incorporate on the bridge as an appendix for future reference (Appendix H). Many of these biotic

suggestions are inspired from the design Inge Hopps created for her green design for Amager Boulevard. This was done so that, in the ideal case where both proposals move forward to implementation, there will be some cohesion and flow between the designs.

5.7 Universal Features

5.7.1 General

For this green strip there are some features that we believe should be integrated across the entirety of the Langebro for safety, maintenance, and atheistic reasons. First, one of the main concerns we gathered from our interviews was keeping the area clean—free of litter, cigarette butts, and dog waste. Because of this, we suggest that city garbage cans with cigarette disposal rings and pet waste bags be available at regular intervals across each pocket.

Also, in keeping with the overall organic and natural feel of the green space all of the pathways, other than the main sidewalk, are suggested to be packed dirt or loose gravel. Surveys indicated that people did not want any pavement in the design because it would feel unnatural and detract from the green space.

5.7.2 Innovate Lamps

We also suggest increasing the current amount of lamps along Langebro by placing more within the areas of the each pocket. This can potentially be done with the use of bioluminescent algae lamps -- an innovative, self-sufficient, means of lighting an area. These lamps, although still quite new, are currently able to light an area through the use of the algae's natural bioluminescence. There is a model of these lights (our ideal preference for Langebro), called Biolamps, that utilize the algae to power an extra LED bulb (see Figure 17). On top of the overall innovative and buzz-worthy aspect of these lamps, they are also incredibly efficient at removing carbon dioxide from the atmosphere. Just one of the lamps shown below can reportedly remove as much CO_2 in one year as the average tree will in its entire lifetime (Algae Powered Lamps, 2013)

Figure 17: Biolamp with LED Attachments

(Environmentally Friendly Biolamp, 2013)

5.7.3 Bike Parking

Finally, we wanted to cater to the prominent biking culture of Copenhagen by making our green strip as bike-friendly as possible. For this design we decided to integrate specific bike parking areas on the tips of each green space. These areas would be paved with cobblestone so that bikers can come into the area from the bike path and park. Originally we considered bike racks in this area, however we realized this would potentially lead to people indefinitely parking their bikes in the area, something Claus Knudsen told us is a frequent problem for the city. These areas on either end of each pocket park will, hopefully, encourage bikers to stop in the area, leave their bike in the designated area, and enjoy the park.

5.7.4 Crosswalks

One important feature for the whole design, is the addition of crosswalks for pedestrians. We discussed two possibilities; the first is one center crosswalk between the top of the center pocket on the eastern side of the bridge, to the space between the two western pockets, while the second would be two crosswalks in a 'V' shape -- one going directly from the Pocket A to Pocket B and the second directly connecting Pocket B to Pocket C. We believe that while the second

design will allow people to more naturally cross between the parks, it may pose a problem as cars and busses would frequently need to stop. Although we suggest discussing the pros and cons of both perspectives further, the final design presented here has one crosswalk.

5.8 Limitations

A significant limitation to our design was the dilemma of potential building restrictions on Langebro. Even after research and interviews with various locals and city officials, we were unable to get a definite understanding of which parts of the bridge were protected and how heavily. As a result, our design was limited to the bridge's surface, presumably the area with the least likelihood of protections. This means that there is still potential for additional designs that would alter the bridge in more substantial ways. For instance, during our interview with Stefan Warner, he mentioned the possibility of extending the green space design down to the water beneath the bridge. We were unable to consider this idea for our final design because we wanted to propose something with reasonable feasibility for implementation, and thus wanted to avoid any substantial alterations to the structure of Langebro. However, if more concrete answers could be found as to the extent and permanence of Langebro's protections, more radical designs could be made to the green space proposal for Langebro.

We also suggest that further research be done to get the public's opinion on the final design renderings. Although we conducted interviews with a variety of locals, and incorporated many interests and suggestions, we did not have the resources to run a focus group to gather public feedback after Langebro's green design was finished. As a result, we recommend doing further analysis to better understand how well the design will be received by the public and city officials. A second, separate, analysis could also be done to determine the overall technical feasibility of the design. With our limited experience we created a proposal that we believe to be realistic and achievable, however this should be confirmed by those with more expertise in environmental and civil engineering. This analysis could also include how difficult, both physically and politically, it would be to gather funding for the project, create a curved road through the area, and add soil and vegetation.

The Langebro design was created as a piece of a larger green strip from the Ladegård river to Amagerfælled, so the next step after this project is be to create a design for H.C Andersens

Boulevard. After the full green strip is designed, the entire culmination of projects will hopefully be used as incentive for the public and city officials to reduce traffic.

5.9 Web Page

The second deliverable we provided to Miljøpunkt Amager was a web page on their existing website. This page describes the overarching green strip through Copenhagen, detailed in chapter 4, links to Inge Hopps' project, a green strip along Amager Blvd., and explains the surface design for Langebro. The web page, located at www.miljopunkt-amager.dk/langebro-design, contains our results and recommendations for design decisions for Langebro as well as our limitations and suggestions for future research. Also included are renderings of each pocket park, an image of our design on Langebro against the Amager skyline, a sketch of the overall bridge and road design (as seen from above), and a sketch of a cross section of the bridge with dimensions. We recommend that additional pages or sections be added to the website as more green strip designs are created. It is our hope that the page will be used to explain the designs to people and show the implications of reducing traffic to further green Copenhagen.

Chapter 6: Conclusion

During our time in Denmark we were able to successfully complete our objectives and present our final deliverables to our sponsor, Miljøpunkt Amager. This included the creation of a green surface design for Langebro with recommendations for its layouts and features as well as the reasoning behind these decisions, and a web page to publicize the final conceptualizations and help promote public knowledge and support for the green strip through Copenhagen.

This project is a part of the greater green strip design that will be used to incentivize the alleviation of traffic. With less traffic through the city air and noise pollution would decrease, improving the health of people living or working near large roads. The decrease in traffic could lead to an increase in green spaces in the city which would further improve people's quality of life. An increase in green spaces would also help alleviate the severe repercussions of flash floods in the future while turning Copenhagen into an iconic city.

Although the official proposal and potential implementation of this project is likely years off, Mayor Morten Kabell, stated that "[this] project is a very good vision of what we could do in Copenhagen if we were free to make the city more livable in every way". It is our hope that, upon construction, the winding road and pocket parks across the iconic Langebro will become a popular and prominent landmark of Copenhagen that draws locals and visitors to appreciate the potential of green spaces in the city.

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Appendix A: Semi-Structured Interview with Claus Knudsen

Preamble: A.1

We are conducting this interview to learn more about your experience with local green space designs/implementations and previous local public support of green projects. Your participation in this interview is completely voluntary and you may withdraw at any time.

Questions: A.2

Do we have your permission to audio record this interview for future reference?

1. How many green initiatives or projects has Miljøpunkt Amager worked on/developed in the past? How many projects did you assist on?
2. How much local support did you receive? Do you feel like the amount of local support you received for those projects was adequate?
    a. Did certain types of projects generate more support than others?
3. Have any past projects included the design and implementation of a green space?
    a. If yes,
        i. How did locals feel about the project?
        ii. Was there any form of support for local political city officials?

(Impromptu) Are there any parts of Amager that are worse than others?

(Impromptu) How can we avoid these issues?

4. Did you encounter any challenges in the design or implementation processes and how did you overcome these obstacles?

(Impromptu) Would the city planner know about the protection?

5. Was there any form of post analysis done on the project? If so, what were the positive and negative outcomes of the implementation?
6. Do you think there is a need for more green spaces in Amager?
    a. If yes,
        i. What part of Amager do you believe needs green spaces the most?
        ii. How do you believe Amager could benefit from more green spaces?
    b. If no,
        i. Do you think Amager would suffer from the implementation of more green spaces?
            1. If yes, what do you believe the potential detriments to be?
7. What kinds of local political support or opposition are there towards green spaces in Amager?
8. What age groups in Amager do you think would benefit most from a green space?

(Impromptu) Who might not benefit?

9. What methods has your organization used in the past that were successful in getting feedback from the public on various projects?

(Impromptu) How can we do that?

(Impromptu) What kind of questions?

Appendix B: Semi-Structured Interview Andre Just Vedgren

Preamble: B.1

We are a group of students from Worcester Polytechnic Institute in Massachusetts, USA. The project we are working on is being conducted in cooperation with Miljøpunkt Amager, and your participation is greatly appreciated. We are aware that there are various proposals for traffic tunnels under the city and our academic project is focused on greening areas above ground that would have reduced traffic as result of the tunnels. Our goal is to design a successful green space for Langebro in Amager that caters to the wants and needs of the public while taking into consideration key features that have been successful or unsuccessful in other urban green spaces.

Your participation in this interview is completely voluntary and you may withdraw at any time. If you are interested, a copy of our design and results can be provided at the conclusion of the project.

Questions: B.2

Do we have your permission to audio record this interview for future reference?

1. Out of the various tunnel proposals for the city, are there any you support more than others?
2. Have you ever been involved with green space implementation or regulations in the past?
    a. Who did you work with? Please tell us about your experience
    b. Has the Amager Vest Local Committee been involved with any green space implementations or regulations?
3. How much local support have green space projects received in the past?
    a. Why do you think there was a lack/abundance of support? (physical aspects in design, locations, etc.)
4. Do you believe the local community would oppose or support the implementation of a green space on Langebro? Why?

(Impromptu) Do you think we might get opposition because it's an icon?

(Impromptu) Why is it protected?

(Impromptu) Is the bridge protected?

    a. Are there any physical aspects you think the various demographics or age groups in the area would require or want in the design?
5. How do you feel about the implementation of a green strip along Langebro and Amager Blvd?
    a. Do you believe Amager would benefit from more green spaces? If so, how?

(Impromptu) Isn't Amagerfælled protected?

    b. Do you believe the implementation could have any detrimental effects? If so, what?
    c. Are there any factors about the implementation that strongly drive your feelings about the project?
    d. Are there any physical aspects you would like to see in the design/ do you have any suggestions for the design?

6. Do you believe political parties will support or oppose the implementation of a green strip on Langebro?
    a. Would certain parties oppose while others support? Why?
7. Do you believe local businesses would support or oppose the implementation of a green strip on Langebro?
    a. Would certain companies oppose while others support? How much political sway do the opposing companies have?
8. Do you know anyone who might be useful for us to interview further about our project?

Appendix C: Semi-Structured Interview with Morten Kabell

Preamble: C.1

We are a group of students from Worcester Polytechnic Institute in Massachusetts working on an academic project with Miljøpunkt Amager. We are conducting interviews with various political figures to determine the feasibility of and support for the project and your participation is greatly appreciated. We are aware that there are various proposals for traffic tunnels under the city and the project is focused on greening areas above ground that would have reduced traffic as result of the tunnels. We are also aware that Langebro currently opens, however we are designing under the assumption that bridge movement is no longer a factor due to the declining use of the harbor for commerce and the discussion to permanently close that feature. The ultimate goal is to design a successful green space for Langebro in Amager that caters to the wants and needs of the public while also taking into consideration key features that have been successful or unsuccessful in other urban green spaces and your insights will be extremely useful. If interested, a copy of the design and results can be provided at the conclusion of the study.

The design we are currently considering would be a winding road that would allow for green pockets under each of the curves for a total of three pockets. This decision was made to reduce the speed of car traffic and make it easier for pedestrians to access the green pockets. The design also allows us to design three distinct green areas that can either be similar for cohesion or disjoint to accommodate different interests. For example one pocket could have a garden while another contains trees and benches.

We have attached a very rough, sketched, preliminary design for the bridge showing the overall structure we are looking to achieve. Because we do not yet have a final design for the green spaces, the sketch contains some basic possibilities.

Questions: C.2

1. Are there currently any plans that the city has for Langebro? In regards to greening or any other alterations of the surface of the bridge?
2. Besides the reduced traffic lanes, do you foresee anything that might cause opposition toward the design or project?
3. As the design currently stands do you believe that the curvature in the road would be feasible and/or well received by the community or political parties?
4. We are interested in talking to the designers of the bike bridge that is being built next to Langebro to ensure that the two bridges complement each other, however we have been unable to find who that is. Do you have any information on who is designing or building the bike bridge?
5. Do you think there is a way to tailor the Langebro design to promote leisurely biking as opposed to commuter?
6. After hearing the goal of the project, is this something you would provide political support for? Do you believe there would be overall political support from the Copenhagen political heads?
7. Are there any physical aspects you believe we should incorporate into the design of the bridge that might help it gain more political support? For example if any parties

(especially those currently in the majority) would be more supportive of a community garden or a playground for children.

8. Do you have any other suggestions for us regarding this project?

Appendix D: Semi-Structured Interview with Rene Sommer Lindsay

Preamble: D.1

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with various organizations who have implemented and designed green spaces before to learn more about their experiences. This project is being conducted for Miljøpunkt Amager, and your participation is greatly appreciated. Our ultimate goal is to design a successful green space for Langebro in Amager that caters to the wants and needs of the public while also taking into consideration key features that have been successful or unsuccessful in other urban green spaces and your insights will be extremely useful.

Your participation in this interview is completely voluntary and you may withdraw at any time. If interested, a copy of our design and results can be provided at the conclusion of the study.

Questions: D.2

1. How many projects involving green spaces have you worked on? Could you tell us briefly about them?

(Impromptu) We saw that you used to do communications. Have you talked to people about what they do and don't like?

2. What was the general public reaction to the idea and implementation of a green area? Were there any common compliments or critiques to the design and what were they?

(Impromptu) Were there any common compliments or criticisms to any designs that the public had seen?

3. What were the expected social and environmental benefits from the implementation of the green space?
4. Was there any specific challenges that were encountered during the design and implementation processes?

(Impromptu) Does the municipality see some vegetation as better than others?

5. We have conducted research into successful green spaces prior to this interview, but based on your experience, what aspects of a green space design contribute to its success or increase public support? Are there any key features you believe every successful green space has?

(Impromptu) Do you think there are any key features of Danish design or culture that every successful green space has?

6. Do you have any other advice or suggestions regarding the design and implementation for greening Langebro?

Appendix E: Semi-Structured Interview with Simone Hochreiter

Preamble: E.1

We are a group of students from Worcester Polytechnic Institute in Massachusetts, USA. The project we are working on is being conducted in cooperation with Miljøpunkt Amager, and your participation is greatly appreciated. We are aware that there are various proposals for traffic tunnels under the city and our academic project is focused on greening areas above ground that would have reduced traffic as result of the tunnels. Our goal is to design a successful green space for Langebro in Amager that caters to the wants and needs of the public while taking into consideration key features that have been successful or unsuccessful in other urban green spaces.

Your participation in this interview is completely voluntary and you may withdraw at any time. If you are interested, a copy of our design and results can be provided at the conclusion of the project.

Questions: E.2

1. How many projects involving green spaces have you worked on?
2. What was the local community's feelings about these projects?

(Impromptu) You focused a lot on green stormwater management. Did you focus on other benefits for the community?

(Impromptu) Did you have any park areas or areas that were designed for people to come? What was in the area?

3. What were the expected benefits to the community from the implementation of the green space?
4. Were there any specific challenges that were encountered during the design and implementation processes?
    a. What do you believe caused these obstacles?
    b. Were you able to overcome these obstacles?
5. Are there any key features you believe every successful green space has?
6. In your opinion, what is the definition of Danish design? What can we do to incorporate Danish design into our Langebro design?

(Impromptu) Do you have any ideas about our design?

(Impromptu) Where do you get dimensions for your design?

(Impromptu) We are thinking of putting in a garden. What are your thoughts?

7. Do you have any other advice regarding the design and implementation processes or do you have any ideas or suggestions for the design on Langebro?

Appendix F: Structured Street Interview/Online Survey

Preamble: F.1

We are a group of college students from Worcester Polytechnic Institute in Massachusetts, United States working with Miljøpunkt Amager on an academic project. We are aware that there are various proposals for traffic tunnels under the city and our academic project is focused on greening areas above ground that would have reduced traffic as result of the tunnels. Our goal is to design a possible green space for Langebro that caters to the wants and needs of the public while taking into consideration key features that have been successful or unsuccessful in other urban green spaces.

We are conducting surveys with the local community to learn more about your experiences with green spaces and what physical aspects of the space are important for design. Your participation in this survey is completely voluntary and you may withdraw at any time. Please be assured that any comments or responses you provide will remain completely anonymous. No names or identifying information will appear on the questionnaires or in any of the project reports or publications. Thank you so much for your time.

Questions: F.2

1. Age: __ Under 23 yrs __ 23-34 yrs __ 35-50 yrs __ Over 50 yrs __Undisclosed
2. Gender: __ Male __ Female __ Other/Undisclosed
3. What is your relation to Amager? __ Live in __ Visiting: How often do you visit? _____
4. How often do you visit green spaces/parks? (Circle one) Never Less than once a month Once a month 2-3 times a month Once a week 2-3 times a week Daily
5. What was your favorite part of the green spaces/parks you have visited? _____
6. What was your least favorite part of the green spaces/parks you have visited? _____
7. Do you believe there is a lack of green spaces in Amager? __ Y __ N __ I don't know
8. Do you think you could benefit from increased green spaces? __ Y __ N __ I don't know
   How: _____
9. If a green space was implemented on Langebro would you visit it? __ Y __ N __ Maybe
   a. What kinds of activities would you use the space for?
      __ Exercising __ Socializing __ Sun bathing __ Relaxing
      Other:_____
8. Do you support the idea of having a green space on Langebro? __ Y __ N __ Maybe
   If you don't, why not? _____
9. How do you currently commute to work? __ Walk __ Bike __ Drive __ Public Transit
   Other:_____
   Why? __ Faster __ Practical __ Cheaper __ Good for the environment
   __ Occupation Requirement __ Don't own a car
   Other:_____

Appendix G: Semi-Structured Interview with Stefan Werner

Preamble: G.1

We are a group of students from Worcester Polytechnic Institute in Massachusetts, USA. The project we are working on is being conducted in cooperation with Miljøpunkt Amager, and your participation is greatly appreciated. We are aware that there are various proposals for traffic tunnels under the city and our academic project is focused on greening areas above ground that would have reduced traffic as result of the tunnels. Our goal is to design a successful green space for Langebro in Amager that caters to the wants and needs of the public while taking into consideration key features that have been successful or unsuccessful in other urban green spaces.

Your participation in this interview is completely voluntary and you may withdraw at any time. If you are interested, a copy of our design and results can be provided at the conclusion of the project.

Questions: G.2

Do we have your permission to record this interview?

1. What are the dimensions of Langebro?
2. What are the weight restrictions for Langebro?
3. Do you know anything pertaining to the protected areas on or around Langebro?
    a. If yes, what areas are protected? What does the protection entail?
4. Have you ever worked on any green space design projects for the municipality?
    a. If yes, how many? Please explain the project or projects to us briefly.
5. Given the rough sketch of the conceptual design we are considering (show him drawing), what do you think about it?
    a. If no, how can we alter our design to accommodate the municipality's plans?
6. Do you have any suggestions for the project or design?

(Impromptu) Would the municipality maintain an urban garden?

(Impromptu) Do you see a conflict of interest from Amager side or Indre By side?

Appendix H: Botanical Feature Suggestions

Trees	Name	Genus,Species	Max Height	Leaf Density	Salt Tolerence	Light Req.	Source
	Common Aspen	*Populus tremula*	15m	low	high	high	Inge
	Field Maple	*Acer compestre*	15m	moderate	high	high	Inge
	Hawthorn	*Crafaegus laevigata*	8m	moderate	high	high	Inge
	Black Alder	*Alnus glutinosa*	20m	moderate	moderate	moderate	Inge
Shrubs	Elder	*Sambucus nigra*	5m	moderate	low	moderate	Inge
	Blackthorn	*Prunus spinosa*	3m	moderate	high	low	Inge
	Buckthorn	*Rhamnus cathatic*	8m	moderate	high	high	Inge
	Blueberry	*Vaccinium mytillus*	1m	moderate	low	moderate	Inge
Grasses /Rush	Orchard Grass	*Dactylis glomerata L.*	1m	N/A	moderate		
	Millet Grass	*Miliumeffusurn L.*	1m	N/A	moderate		
	Wavy Hair Grass	*Deschampsia flexuosa*	30cm	N/A	high		
	False Oat Grass	*Arrhenatherum elatius*	1.5m	N/A	moderate		
	Field Wood Rush	*Luzula multiflora*	15cm	N/A	low		
Wild Flowers	Bog Asphodel	*Narthecium ossifragum L.*			moderate	high	
	Creeping Valarian	*Valariana sambucifolia*	<60cm				
	Chicory	*Cichorium intybus L.*	<60cm				
	Unilateral Bell	*Campanula rapunculoides L.*	<60cm				

Appendix I: Categorization of Survey Results

Category (count)	Favorite Aspect of Green Spaces	Category (count)	Least Favorite Aspect of Green Spaces
Atmosphere (6)	relaxing (atmosphere)	**Dog Poo (8)**	dog poop
	relax		dog poop
	calm		dog poop
	relaxing		dog poop
	relaxing		dog poop
	air		dog poop
			dog shit
Recreation (7)	area for activities		dog shit
	recreational spaces	**Crowded (10)**	crowded
	walking		crowded
	being able to bike		crowded
	running		crowded
	recreational spaces		crowded
	walking		crowded
Quiet (13)	quiet		crowded
	quiet		too crowded
	no noise		too crowded
	quiet		too many bikes
	quiet	**Litter/trash (13)**	litter
	quiet		cigarette litter
	quiet, birds		cigarette litter
	quiet, green part in city, nature		garbage

	quiet, secluded		lack of trashcans
	quiet nature		Litter
	quiet nature		litter
	secluded		litter
	silence		littered
Bio Design/ Diversity (42)	animals		littered
	dog		trash
	elephants		too small trash bin
	flowers		trash
	flowers	**Rules/Restrictions (5)**	can't use all year round
	flowers		no biking
	Flowers - in spring it is the best		no walking on grass
	forest parts		no biking
	green		too many restrictions (access, can't sit on grass, etc.)
	green	**Size (4)**	small
	green new environment		small size
	plants and gardens		too small
	nature		too small
	Nature	**Bad Crowd (3)**	bad crowd
	nature		drug dealers
	Nature		noisy people
	nature	**Space Issues (15)**	bare
	nature		concrete areas
	nature		houses
	flowers		disrepair

	green		having a bicycle lane without pedestrian
	plants and eat veggies		just grass (plain)
	trees		mud, trash
	birds		not natural (structured)
	green part in city		not well maintained
	nature		too cultivated
	animals		too much pavement
	tall grass		too enclosed
	trees		too many paved roads in park
	lake		too structured
	variety		trimmed vegetation
	variety flowers	**Misc (7)**	lots of birds
	variety flowers		nowhere to sit
	variety of plants		tied dogs
	variety of plants		tied dogs
	nature		furniture
	vegetation		dog no leash
	flowers		weather
	nature		
	wilderness		
	natural		
	wild not planted		
Open Design (8)	sun		
	sun		
	open sky		
	large		
	less claustrophobic		
	open space		

	open space
	sun
	view
	scenery
Benches/sitting (8)	benches to sit
	benches to sit down
	grass to sit
	benches
	places to sit
	lounging
	places to sit
	places to sit
Playground (2)	Playground
	playground
Socializing (10)	alot of people
	drinking
	appropriate to be together with friends
	atmosphere (attracts people, relaxing)
	places to hangout
	bbq
	stuff happening
	community
	drink
	socialize
Beach/Water (14)	beach
	beach
	beach
	beach water
	waterfront
	bathing
	close to water
	water side

	water view
	water
	water
	Water
	waterfront
	Waterfronts
Location (3)	location
	location
	location
Misc. (11)	read
	clean
	closeness
	difference from city (calm, fresh air)
	no traffic
	historic
	live in city with green spaces
	part of home
	small intimate spaces
	smell fresh
	reading