# PASSIVE HOUSING THAT USES AND IMPROVES THE NATURAL LANGE BRETTEN AREA OF AMSTERDAM

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***Abstract***

*Nowadays, more and more people become disconnected from nature and its elements, while the natural quality of green areas such as the Lange Bretten decreases. The goal of this research is to improve the quality of this area, whilst allowing in a form of positive footprint housing where residents are in contact with nature. The research question is: How can the natural elements, that are present in the Lange Bretten of Amsterdam, contribute to positive footprint housing that improves the natural quality of the area as well? An initial research into these elements reveals the problems and possibilities of this area. To improve these elements and use them for positive footprint housing, the paper continues with discussing potential passive techniques that are applied in existing projects. Four case studies reveal passive techniques for improving the water, soil, air and acoustic quality, while also reducing the housing footprint.*

***Keywords***

*Passive housing, natural elements, Lange Bretten, positive footprint, natural area*

## 1. Introduction

### 1.1. Problem statement

Nowadays, more and more people are disconnected from nature. Most of the day, we stay indoors and have little connection with the natural environment that surrounds our homes and neighbourhoods. We are dependant on electrical devices such as heating, light fixtures and mechanical ventilation, which can be costly and produce indoors constant humming sounds. In our homes and interiors, nature's materials are not often present as well, as we surround ourselves with synthetic materials such as laminate flooring and plastic PUR insulation. The use of nature's free elements is not optimal either. The prevailing wind, falling rainwater, shining sun and the ground underneath our feet have lots of opportunities for our daily living, but we do not use them in the optimal way.

The disconnection from nature can particularly be found in densely populated cities, such as the metropolis Amsterdam. Unique to this metropolis though, are the eight green areas that penetrate deep into the city: the Scheggen of Amsterdam. These green areas are extremely important for the quality of life in Amsterdam, as they cool the city, improve air quality, prevent flooding, increase biodiversity whilst being a recreational area for city residents. Despite its importance, the green areas are not popular and lack publicity. This is reflected in the quality of the areas, as they are subject to cluttering, fragmentation, scattered building developments and peat oxidation (Parlement van de Scheggen, 2019, p. 12). The Lange Bretten for example, a natural area in the Brettenscheg, is unknown territory for a lot of city residents (Gemeente Amsterdam 1, 2019). The area is intersected by highways, railways and industrial areas, which results in noise, smells and a fragmented landscape. Plans for a park in this area, park Brettenburg, were only for a small part realised, resulting in an unusual lay-out in some parts of the area. The natural qualities of the Lange Bretten are not optimal either. It is important that a natural area as the Lange Bretten remains and is even improved, so that more visitors will come and learn to appreciate it.

### 1.2. Thematic research question

This research paper will form input for the design of a passive and nature inclusive housing complex in the Lange Bretten of Amsterdam. The design goals for this type of housing include the symbiosis between residents and their natural environment, the use of nature's free elements in passive techniques and the improvement of the natural quality of the Lange Bretten. This paper will research the last two goals in particular. The main research question of this paper is: How can the natural elements, that are present in the Lange Bretten of Amsterdam, contribute to positive footprint housing that improves the natural quality of the area as well? Having a positive footprint would mean that the housing form is able to locally produce a better earth, water or air quality than there was before, despite of their own usage of the elements. In terms of a positive energy footprint, this paper mainly focuses on reducing the energy need of housing, but not on producing renewable energy itself.

### 1.3. Method of research

To first understand the natural elements, their qualities and problems, chapter two will focus on the local earth, water, air, temperature and light characteristics of the Lange Bretten. The site will be analysed by the use of (climatic) maps, websites and other relevant documents about the area. Several field trips will contribute to this analysis as well. To improve the researched elements and use them for positive footprint housing, chapter 3 will discuss potential passive techniques that are applied in existing building projects. These projects have managed to reduce their footprint and found ways to improve the natural quality of their surrounding environment. The responsible techniques will be described in particular. The techniques will be researched with the help of plans, images, project websites, videos and other relevant project documents.

## 2. The natural elements of the Lange Bretten

The Lange Bretten is a natural area in Amsterdam-West, the Netherlands. The rectangular shaped area has a surface of 108ha. The Lange Bretten is located in the Brettenscheg, which is one of the eight extensive green areas of Amsterdam. The harbour area of Amsterdam is located on the north side of the Lange Bretten, while the residential neighbourhoods of Amsterdam New-West are on its south side. The Lange Bretten is furthermore surrounded by roads, highways and train tracks.

This chapter focuses on the four natural elements of the Lange Bretten. The following sub question will be researched: What are the earth, water, air and light characteristics of the Lange Bretten? The first paragraph will dive into the earth characteristics, such as the polder structure, the soil type and current plants. The water characteristics of paragraph 2.2 will include for example the quality of the surface water, the current polder of which the Lange Bretten is part of and the flood risk. The third paragraph will research the air characteristics, such as the quality of the air, the noise that travels through the air and the prevailing wind. The temperature and light characteristics of paragraph 2.4 will include for example the average temperature, the heat stress on warm days and the amount of light pollution at night.

### 2.1. Earth

The Lange Bretten has not always been a natural area. The land is situated in the previous Spieringhorner polder, which had been developed in the 11$^{th}$ or 12$^{th}$ century. To dewater the peat soils at that time, parallel ditches were dug to drain the water into the IJ lake. As a result, the ground level was lowered. Remnants of this ground pattern can be found in some areas of the Lange Bretten (Figure 1), while some of the original ditches are excavated again in the eastern part.

The Spieringhorner polder was raised with silt rich dune sand in the 1960's, to become part of the harbour areas and business parks. The area we now know as the Lange Bretten was planned to become a recreational area with allotment gardens, parks and sport complexes (Gemeente Amsterdam, 2013). Not all of these plans were realised. Some areas of the Lange Bretten became dump sites in the 1970's. There are two hill areas right and left of the central Australiëhavenweg (Figure 1) that contain rubble, concrete and asphalt from construction demolitions in the neighbourhood (Wandelnet & NS, 2019). Apart from the hill areas, the Lange Bretten earth is located on average at NAP height with maximum a meter difference.

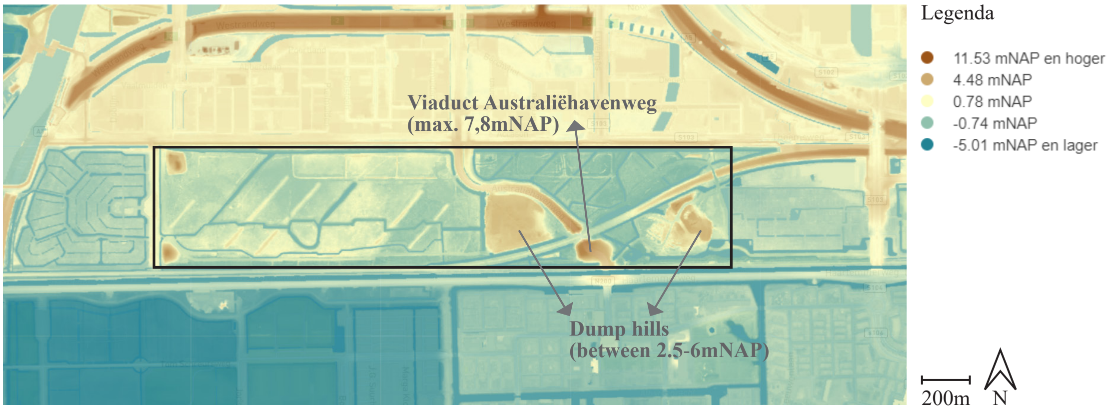


Figure 1. Height map, the Lange Bretten is marked with a black rectangle (AHN, 2014)

Apart from the dune sand and rubble, the Lange Bretten soil consists of peat and clay. The peat soil areas can sag during extreme drought and cause a lowering of houses and roads. It is furthermore interesting to know that the Lange Bretten is partly located on the primeval gulch that was the predecessor of the current IJ lake. This caused the first and second sand layer to erode. The gulch was then filled with weaker clay, which is not a loadbearing layer for certain constructions. Almost all constructions in the old gulch area have now foundations that reach the 3rd sand layer, to a depth of up to NAP -60m. (Gemeente Amsterdam 1, 2017)

Because the peat soils were raised with dune sand and other nutrient-rich substrates, it has a great variation in plant species (Figure 2). There are forest areas with bushes on moist, nutrient-rich soils. The rubble hills are also overgrown with trees and bushes. Grasslands are formed on moist and dry soils. Reed vegetation grows on the wet, nutrient-rich soils. Overall, the Lange Bretten mostly consists of the open, dry grasslands. (Gemeente Amsterdam 2, 2017)

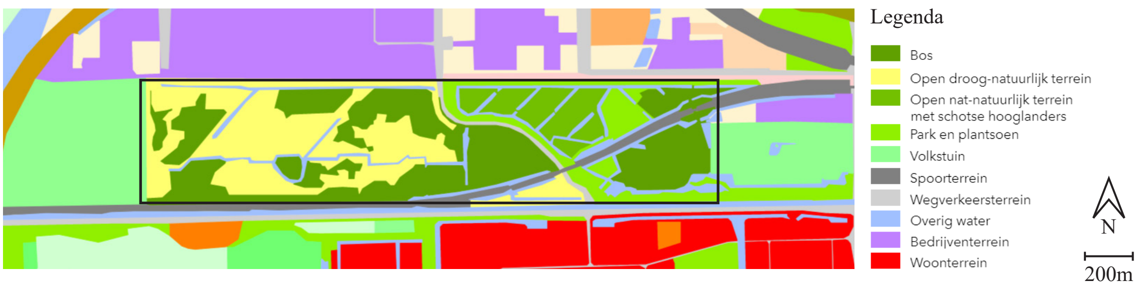


Figure 2. Different vegetation areas, the Lange Bretten is marked with a black rectangle (Gemeente Amsterdam, 2017)

## 2.2. Water

The water surfaces in the Lange Bretten are mostly formed in long, narrow ditches (Figure 3). There are no large water areas or lakes present. The Lange Bretten is almost entirely surrounded by these ditches, and diagonally crossed by the old parallel polder ditches. Along the train track and Australiëhavenweg are also ditches. The amount of water surface is very limited in the Lange Bretten, compared to the land surface. The Lange Bretten even has a quantity risk in term of water supply, according to the local water authorities (AGV, n.d.).This can result in a dropping of ground water levels during dry periods, which could damage water dependant vegetation and building foundations. The quality of the water surfaces is under high pressure in different areas (AGV, sd). There are too many toxic substances and potentially damaging bacteria (such as E-coli) present in the waters. The oxygen levels are also too low, which results in a loss of fish and other water based species.

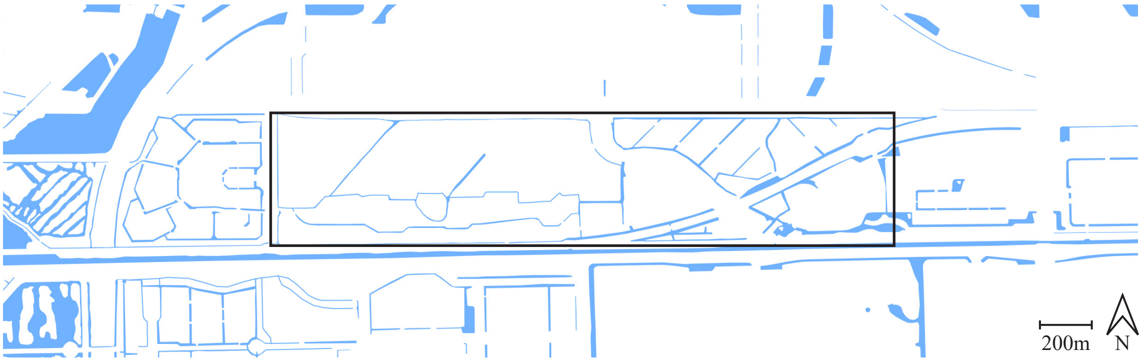


Figure 3. Surface water map, the Lange Bretten is marked with a black rectangle (image by author)

The current polder, of which the Lange Bretten is part of, has 4 different water level areas (Figure 4). Most of the Lange Bretten (the orange, northern part) has a flexible water level of NAP -1m to NAP -1.4m, influenced by the seasons and the amount of rainfall. The southern part has a fixed water level of NAP -1.2m. The Lange Bretten is exactly located in between the primary and secondary water barriers of the Netherlands (Waternet, 2020). The dyke on the north side of the polder, parallel to the bicycle path, is part of the primary water barrier. The lower dyke on the south side, parallel to the Haarlemmerweg, is part of the secondary water barrier. This position influences the risk of flooding during a possible dyke breach. The Lange Bretten remains most likely dry during a breach in the northern (primary) dyke, while it will be most likely flooded during a breach in the southern (secondary) dyke. The Lange Bretten could in the last situation have a flood depth of 0.5-2m, while some higher areas remain dry.

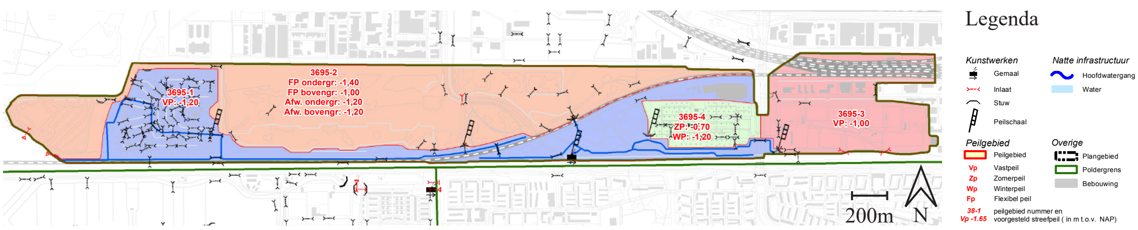


Figure 4. The Lange Bretten polder with its 4 water level areas (AGV, 2014, p. 36)

The Lange Bretten has a pretty similar rainfall amount all year round, around the 55mm per month (Meteoblue, n.d.). The area experiences on average 13.5 rainy days each month, which results in 4mm per rainy day. During a short and heavy rainstorm of 70mm in 2 hours, one that happens once in a hundred years, the Lange Bretten has little to no floodwater depth (Klimaateffectatlas, n.d.). This means that rain can easily infiltrate into the ground.

The groundwater levels in the Lange Bretten vary greatly throughout the year. The highest levels can reach higher than the NAP -0.2m in the winter. The lowest levels are even under the NAP -2m during summertime. There is only surface water going into the ground of the Lange Bretten, no groundwater is ever coming up. Interestingly, the groundwater below the left rubble hill remains under NAP -2m throughout the year. This would mean the groundwater is not rising during the winter, even though it does in surrounding areas. The construction waste could be the reason for this. There is no actual proof that this waste was ever isolated, the rubble even sticks out of the earth in some hill parts, creating small caves. (Klimaateffectatlas, n.d.)

## 2.3. Air

The air quality is highly influenced by the amount of infrastructure that surrounds and crosses the Lange Bretten. The A5 highway, the N200 Haarlemmerweg, the crossing train tracks and the Australiëhavenweg cause for a moderate to insufficient air quality. Higher concentrations of soot and particulate matter are present near the intersection of the Seineweg with the Haarlemmerweg. Nitrogen dioxide has a higher concentration around the crossing Australiëhavenweg. (Atlasleefomgeving, 2017)

The mentioned infrastructure also causes a lot of noise disturbance. The overall noise, as seen in Figure 5, includes the nearby Schiphol air traffic, wind turbines and harbour as well. The entire Lange Bretten area suffers from a moderate to very bad noise disturbance (Atlasleefomgeving, 2017). The noise reaches its peak at the southern Haarlemmerweg and at the central viaduct, where the raised Australiëhavenweg crosses the train tracks. The noise is also not reduced by any sound walls. The area at the top left corner of the Lange Bretten experiences the least noise disturbance.

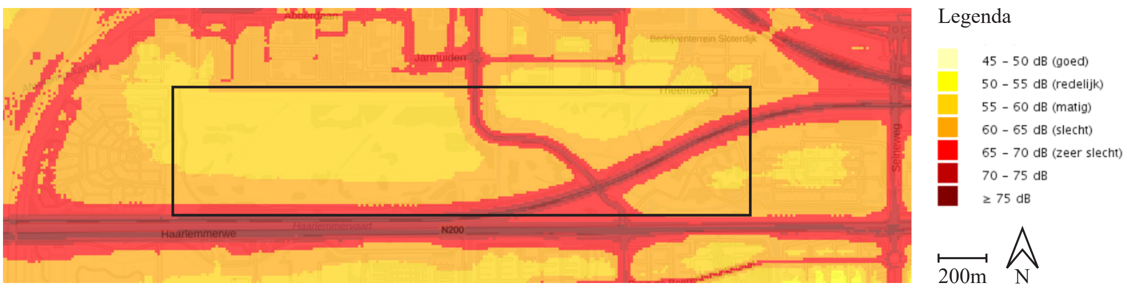


Figure 5. Overall sound map, the Lange Bretten is marked with a black rectangle (Atlasleefomgeving, 2017)

The prevailing wind in the Lange Bretten comes from the south-west. The windspeed is yearly less constant than the rainfall. The winter months only experience high wind speeds of more than 50 km/h. The summer months have more wind speeds of less than 20 km/h. Yearly, the average windspeed is 21.6 km/h. (Meteoblue, n.d.)

Odour nuisance in the Lange Bretten is most likely coming from the northern harbour area (PBL, 2009). Smells from industries and traffic can reach the Lange Bretten, depending on the current wind direction. Since the prevailing wind is coming from the south-west, the odour from the harbour will in most cases not reach the Lange Bretten.

## 2.4. Temperature and light

The temperature in Amsterdam differs throughout the year. During daytime, the temperature can reach an average of 22°C in the summer months and 6°C in the winter months. At night, the temperature cools on average down to 12°C in the summer months and 1°C in the winter months. This means that the temperature difference between the summer days and night is 10°C, which is quite a lot compared to the 5°C difference in the winter. (Meteoblue, n.d.)

Because of climate change, heat stress can occur more frequently, especially in a city like Amsterdam. The heat stress map (Figure 6) shows the physical equivalent temperature on an exceptionally warm day. This map takes the following parameters into account: the air humidity, the air temperature, the windspeed, the presence of trees and water, the height of trees and buildings, their created shadows and the width of roads (AGV, n.d.). Compared to the surrounding urban areas, the Lange Bretten has a definite cooler temperature. The coolest temperature of 34°C is measured in the more densely overgrown forest areas. The trees here provide shadow and humidity. It is very important that the green areas in a city provide as much of these 34°C temperatures as possible, to help cool the surrounding urban areas. However, most of the Lange Bretten has a temperature of 40°C. These areas are mostly open, dry areas that contain little to no bushes or trees.

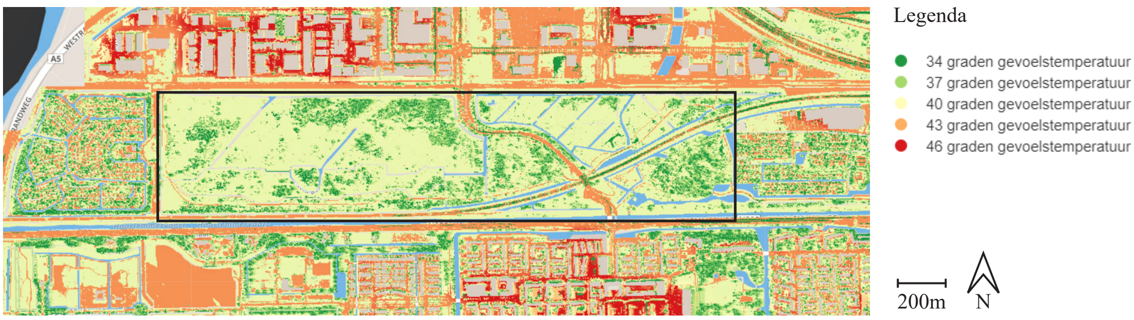


Figure 6. Heat map showing the physical equivalent temperature.
The Lange Bretten is marked with a black rectangle (AGV, n.d.)

The lack of enough 34°C areas is emphasized by the cooling effect map (Figure 7), which shows the temperature decline caused by vegetation and water (RIVM, n.d.). The Lange Bretten has a better cooling effect than the northern harbour area. However, the Lange Bretten cooling effect is quite similar to that of the southern Amsterdam New-West urban neighbourhood. This is interesting because the southern area has a lot of buildings and asphalt roads and much less vegetation.

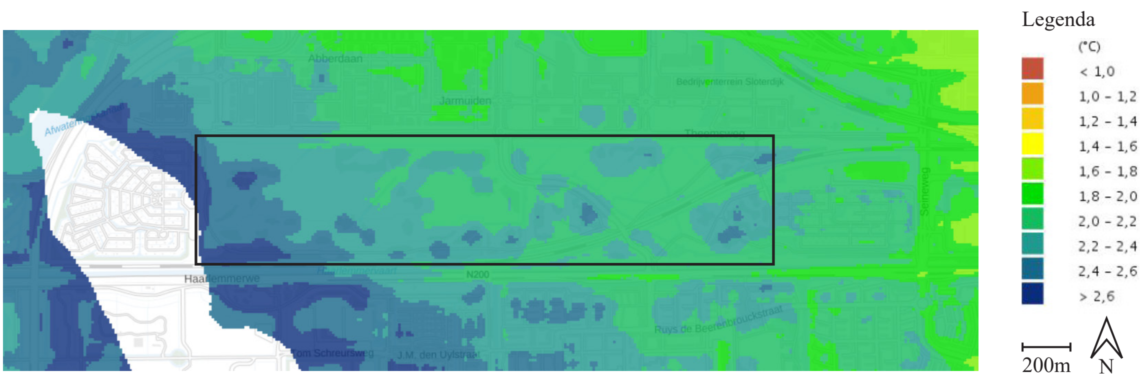


Figure 7. Cooling effect of vegetation and water. The Lange Bretten is marked with a black rectangle (RIVM, n.d.)

At night time, The Lange Bretten is subject to light pollution. Even though the night photo (Figure 8) shows a mostly dark area, the crossing Australiëhavenweg is very lit. The street and traffic lights of the southern Haarlemmerweg are also reaching deep into the Lange Bretten area.

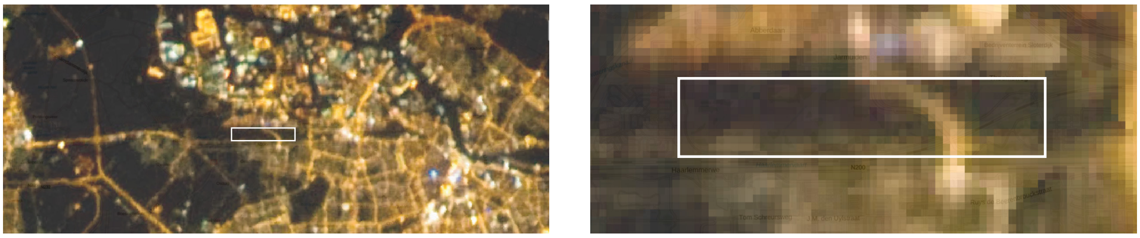

Figure 8. Amsterdam by night. The right photo is a zoom in from the left photo. The Lange Bretten is marked with a white rectangle. (ESA, 2012)

## 3. Passive techniques for housing in the Lange Bretten

To improve the natural elements of the Lange Bretten and use them for a housing form with a positive footprint, this chapter will discuss potential passive techniques that are applied in existing building projects. The following sub question will be researched: Which techniques could contribute to positive footprint housing that improves the natural quality of the Lange Bretten? Four case studies have been chosen to answer this question, based on their solutions for similar issues and on their footprint reducing abilities. However, these case studies are mere examples, many more case studies could have been done.

The first paragraph of this chapter will dive into the water concept of the Lanxmeer neighbourhood. This neighbourhood has found solutions for some of the issues that are currently present in the Lange Bretten, such as maintaining a high water quality and preventing heat stress. Paragraph 3.2 will include two projects that used earth related techniques. The landscape houses in the first project used the local ground to reduce their footprint, while the purifying office park in the second project found ways of improving the soil in a natural way. The last paragraph will discuss a wall prototype that combines techniques to improve the air quality and reduce noise at the same time.

### 3.1. Water and cooling techniques

Lanxmeer is a neighbourhood in the city of Culemborg, the Netherlands (Figure 9). It exists of 300 houses that vary from apartments, detached houses, semi-detached houses, green houses, combined office homes, elderly homes to tiny houses. From the beginning of the design process, the stakeholders wanted to integrate the urban developments with the natural elements and functions. They wished to maintain the existing landscape, strengthen its natural values, flora and fauna, as well as prevent any heat stress and water contamination (EVA-Lanxmeer 1, n.d.).

The water concept in particular can form an example for the housing project in the Lange Bretten, as it includes several techniques to maintain the water quality, reduce the footprint of a house and prevent any heat stress. The circular water concept of the Lanxmeer neighbourhood exists of several systems: one for the rainwater coming from roofs, the rainwater from street areas, the grey water, the black water and a drinking water system that abstracts water from the local ground. It is quite interesting to see that these systems are all connected, although in different ways.

The drinking water system is executed by the water company Vitens, which supplies the city of Culemborg with drinking water. This includes the Lanxmeer residents as well. Vitens benefits from a clean soil because it abstracts ground water from four sources in the Lanxmeer neighbourhood (EVA-Lanxmeer 2, n.d.). It is therefor important that any type of water that infiltrates the abstraction areas is not contaminated. To prevent this, street-, grey- and black water are led away as much as possible from these areas. The rainwater that comes from the roofs is however considered clean enough to be allowed in the abstraction areas. The separation of these water flows guarantees the high water quality in these areas.

The reduction of water footprint starts with the double sewage system. Every house in the Lanxmeer neighbourhood has a double sewage system for grey and black water. Black water from toilets is directly led to the sewer. Grey water from washing machines, showers and kitchens is via pipes led to three helophyte filters in the Lanxmeer neighbourhood (Figure 10). These filters have become part of the landscape and are covered with reed. The grey water enters the filter and lowers its way in a couple of days down to the plant roots, sand and gravel. The filtered water is then clean enough to be led to the nearest surface water stream in the neighbourhood (EVA-Lanxmeer 3, n.d.). In this way, the local sewage system processes less waste water than before, and hereby reduces its energy and labour costs. The helophyte filters can also have a cooling effect on the neighbourhood.

Figure 9. Part of the Lanxmeer neighbourhood (EVA-Lanxmeer 6, n.d.)

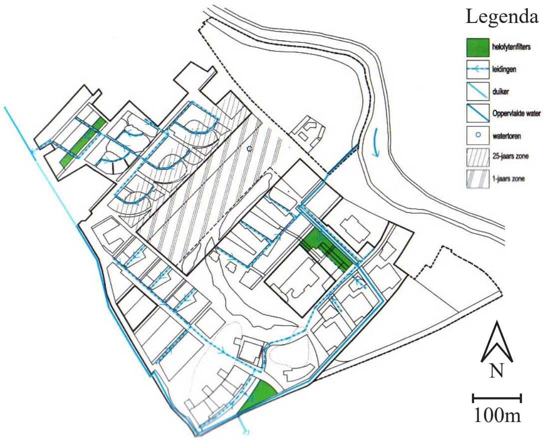


Figure 10. The greywater system of Lanxmeer with the helophyte filters (EVA-Lanxmeer, n.d.)

The two rainwater systems cool the neighbourhood as well. The rainwater that falls on the roof of every house is the only water that is clean enough to be infiltrated in the abstraction areas of Vitens. The closed pipe system directs rainwater from each roof to the five retention ponds in the neighbourhood (Figure 11). The ponds are located in the middle of the neighbourhood and therefore instantly reduce any possible heat stress caused by houses and streets. The rainwater that gathers in these retention ponds is not yet used as secondary household water, such as flush water for toilets. This means that the houses still use the valuable Vitens drinking water for their toilets. Dutch buildings regulations didn't allow this yet (EVA-Lanxmeer 2, n.d.). However, a pump station for the distribution of secondary household water is already present near the biggest retention pond (Figure 11). To limit the direct rainwater flow to the retention ponds, several roofs are covered with vegetation (EVA-Lanxmeer 4, n.d.). The green roofs retain the rainwater longer and stimulate the micro-climate. The rainwater retention is specifically useful during heavy rainstorms. Rainwater that falls on the street and pavement is, according to the designers, less clean and suitable for infiltration in the abstraction areas of Vitens. Small ditches redirect this rainwater into central wadi's (Figure 12). The plants in these wadi ditches retain and filter the rainwater, after which it infiltrates into the ground.


Figure 11. The roof rainwater system in Lanxmeer with the retention ponds (EVA-Lanxmeer, n.d.)

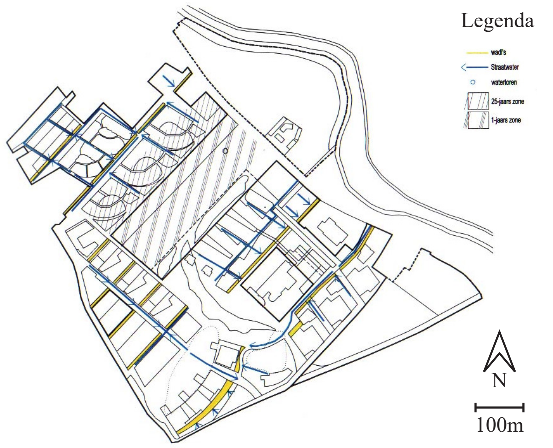


Figure 12. The street rainwater system in Lanxmeer with the wadis (EVA-Lanxmeer, n.d.)

## 3.2. Earth techniques

In the Lanxmeer neighbourhood are three landscape houses located that are partly formed by the local earth. The houses have two floor levels and are situated half underground (Figure 13). From the beginning, the goal was to incorporate the houses into the surrounding landscape (Cremer, 2014). The designers did this by attaching the three houses to each other and hereby forming a continuous hill area. The hill would fit well in the surrounding natural environment, since it contains two other hill areas as well (Figure 14). Because the soil consists of wet clay, it was only possible to construct the landscape houses with concrete. The earth was then placed against most of the walls, apart from the window and door parts. The houses have outdoor spaces as well, in the form of excavated gardens.

Figure 13. One of the half underground landscape houses in Lanxmeer. (EVA-Lanxmeer 5, n.d.)

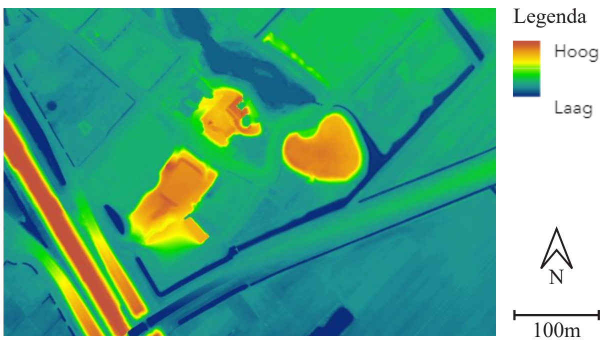


Figure 14. Soil height map of the hill areas. The top hill area consists of the landscape houses. (AHN, 2014)

Several earth related techniques reduced the impact of the landscape houses on their environment. The location of the houses was previously a ground depot for the developments elsewhere in the Lanxmeer neighbourhood (EVA-Lanxmeer 5, n.d.). The ground in this artificial, four meter high depot hill was then used for the construction of these landscape houses. The costs for any new to buy earth material, as well as the accompanying transportation costs, were hereby avoided. The use of the depot earth also prevented any more stress on the environment. The energy footprint is furthermore reduced by the use of the earth, because the houses require less energy to heat and cool. The earth acts as a buffer zone, providing a good insulation and climate regulation. Less heat is lost in the winter, while the summers remain cool for longer. The roofs of the landscape houses are also covered with grass and other vegetation. These green roofs benefit the micro-climate and reduce the need for rainwater drainage. The houses are therefore not connected to the rainwater system of the Lanxmeer neighbourhood. Lastly, the earth and vegetation have a noise reducing effect. Less noise can enter or leave the interiors of these homes.

The Ceuvel park in Amsterdam could be an inspiration for some of the rubble hill areas in the Lange Bretten. The Ceuvel is known as a purifying office park, containing several old houseboats. The park is located on a previous shipyard, which had been active for 80 years. The shipyard was part of the former industrial area of Buiksloterham. The former use resulted in a polluted soil and groundwater, containing harmful PAH substances and heavy metals (DeCeuvel, n.d.). Normally, such polluted soils are either excavated and removed or fully contained. The problem is in the first method essentially moved to another location. Both methods also come with labour, material and transportation costs. To reduce the costs and impact on the environment, the Ceuvel soil was purified with a technique called phytoremediation. It is a process in which certain plants are used that are able to absorb, stabilize and break down the pollution (Delva, n.d.). The mix of plants, such as willows, poplars and grasses, purify the soil and groundwater with their roots and leaves. A disadvantage of this technique is that it is relatively new, which means research is needed to measure and guarantee the purifying effect of the different plant types (DeCeuvel, n.d.). The process is also time consuming. Their latest annual report mentions their process of learning to measure the contamination levels after several years of phytoremediation, but no actual results have been communicated yet (Wijnja, 2018, p. 4).

The houseboats are integrated in the purifying park concept. The old houseboats were first renovated into office spaces and then placed on the plot in a playful setting (Figure 15). A central, raised boardwalk (Figure 16) was then added to connect the boats and serve as a smart grid for solar energy exchange. Besides the soil purification, the Ceuvel has other ways of reducing their footprint. Examples include compost toilets, a blockchain based energy trading system and struvite reactors that capture nutrients from urine (DeCeuvel, n.d.).

Figure 15. Part of the Ceuvel from a bird's eye view (Delva, n.d.)

Figure 16. The raised boardwalk is surrounded by the purifying plants (Delva, n.d.)

## 3.3. Air techniques

The air quality innovation program (IPL) has led several researches and practical tests to gain more knowledge into the improvement of the air quality along highways and roads (Blokland van, Hooghwerff, & Tollenaar, 2009, p. 8). One of the possible solutions uses (sound) walls, for which extensive research has been done. The IPL invited market companies to come up with new solutions for sound walls that have a positive effect on the air quality along roads (Blokland van, Hooghwerff, & Tollenaar, 2009, p. 25). Through a competition, 30 entries were submitted in total. The ‘Bite the Dust’ entry was one of the winners in the category of promising wall ideas that can improve the air quality and could be ready for production in the long term (Blokland van, Hooghwerff, & Tollenaar, 2009, p. 25). This wall prototype could be inspirational for some of the air related problems in the Lange Bretten, as it combines several techniques to improve the air quality and reduce noise at the same time. Even though the wall would be installed next to highways, its techniques could be applied in buildings as well.

The wall is a modular system, where each module is 4m high and 4,2m wide. A section of the module shows the triangular shape of the wall (Figure 17). The module has an open shaft in the middle. The module works as a chimney with a large opening at the bottom, facing the infrastructure, and a smaller opening at the top. Polluted air is sucked in and its particles adhere to the interior walls, which are made of wood fiber concrete. This material works well for adhering fine dust. The air flow in the chimney is mostly driven by the wind that hits the wall. The effect of a solar chimney would be increased if the wall would be higher than 4m. The triangular shape also makes sure that the windspeed is rather low at the bottom, which gives the particles more time to adhere to the wood fiber concrete. The filtering effect is also increased by adding horizontal partitions in the shaft, which makes the way to the opening last longer. The sound reducing effect is achieved by the shaft, as well as the outer walls (Figure 18). Sound waves that hit the closed part of the wall are partly reflected by the wood fiber concrete and partly absorbed. The sound waves that enter the bottom opening are mostly absorbed by the interior walls. The sound reducing effect is also increased by profiling the interior walls. (DLA+, Climatic Design Consult, Durisol, 2008)

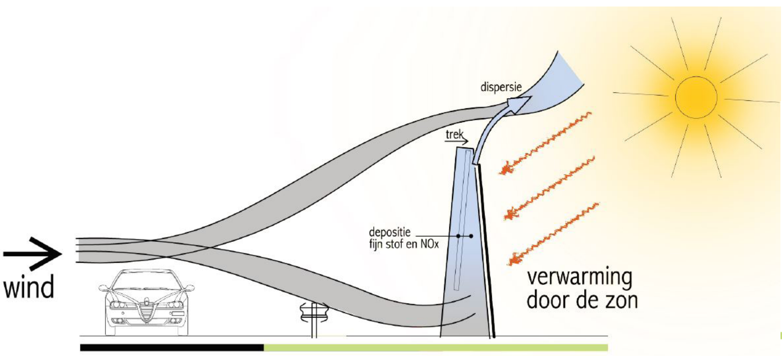


Figure 17. The air purifying concept of wall (DLA+, Climatic Design Consult, Durisol, 2008)

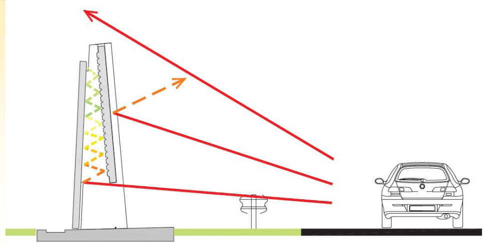

Figure 18. The noise reducing concept of wall (DLA+, Climatic Design Consult, Durisol, 2008)

## 4. Conclusion

This paper focused on the following research question: How can the natural elements, that are present in the Lange Bretten of Amsterdam, contribute to positive footprint housing that improves the natural quality of the area as well? To first understand these elements, their qualities and problems, chapter two focused on the characteristics of the local earth, water, air, temperature and light.

The Lange Bretten earth is situated in the previous Spieringhorner polder. Some of the polder ditches are still present today. The original peat and clay soil was raised in the 1960’s with dune sand. Some areas became trash hills in the 1970’s, made of construction waste. The Lange Bretten now has wet, moist, dry and nutrient-rich areas. Its earth is covered with a great variation of plants, but mostly grass. The Lange Bretten does not contain a lot of surface water. This water can mostly be found in narrow ditches and its quality is under high pressure. Most of the Lange Bretten has a flexible water level, influenced by the amount of rainfall, which is pretty constant annually. Rain can still easily infiltrate into the ground during a heavy rainstorm. The Lange Bretten will only flood during a breach in the southern, secondary dyke. The surrounding and crossing infrastructure causes a bad air quality and a lot of noise disturbance, especially around the central viaduct. The infrastructure also causes light pollution, the crossing Australiëhavenweg in particular. Any odour nuisance can come from the northern harbour area, but is in most cases blown away by the prevailing south-west wind. The temperature in Amsterdam differs throughout the year, on average between the 6-22°C. In terms of heat stress, the physical equivalent temperature on a very warm day is in the Lange Bretten mostly 40°C, because of the open, dry grasslands. There are only a few very cooling forest areas and water surfaces, resulting in not an optimal cooling effect.

To improve these natural elements and use them for positive footprint housing, chapter 3 discussed potential passive techniques that are applied in existing building projects.

The water concept of the Lanxmeer neighbourhood forms an example for the housing project in the Lange Bretten, as it includes several techniques to maintain the water quality, reduce the footprint of a house and prevent any heat stress. The high water quality in its five retention ponds is guaranteed by the separation of different water flows. Rainwater that comes from the roofs of the houses is clean enough to be directed in these ponds, while grey, black and rainwater from the streets are led away as much as possible. The reduction of water footprint starts with the double sewage system, where grey water is led to three helophyte filters in the neighbourhood. The roots of the plants in these filters purify the water, after which it is led to the nearest surface water stream. The footprint can be reduced even more by using the water in the retention ponds as secondary household water, with the help of a distribution pump. The neighbourhood is furthermore cooled by the amount of surface water, formed by the centrally placed retention ponds and helophyte filters. Minimal pavement, green roofs and central wadi's cool the area as well.

The landscape houses could form an example for the Lange Bretten project, because they applied several earth related techniques that reduced the impact on their environment. To start, the houses are partly formed by the earth of an existing, artificial depot hill. The costs for any new to buy earth and their transportation costs were hereby avoided. Because the houses are situated half underground, the earth acts as a buffer zone. It provides a good insulation and climate regulation, so that less energy is needed for heating and cooling. Lastly, the vegetation on the roof reduces the need for rainwater drainage and together with the earth, provides a noise reducing effect.

The purifying office park, the Ceuvel, could be an inspiration for some of the rubble hill areas in the Lange Bretten. The earth of this park was previously used as a shipyard, which resulted in a polluted soil and groundwater. To reduce sanitation costs and impact on the environment, the Ceuvel soil was purified with a technique called phytoremediation. This implies that certain plants are absorbing, stabilizing and breaking down the polluted soil. Old houseboats were then integrated in the purifying park concept, together with a raised boardwalk.

The wall prototype of the 'Bite the dust' project could be inspirational for some of the air related problems in the Lange Bretten. The wall combines several techniques to improve the air quality and reduce the noise. The modular wall system has an open, triangular shaped shaft in the middle, which works as a chimney. Polluted air is sucked in and its particles adhere to the interior walls, which are made of wood fiber concrete. The shaft and outer walls of the module provide the sound reducing effect, by reflecting and absorbing the noise. Sound waves that enter the shaft are absorbed by the profiled interior walls. This techniques could be applied in buildings as well, improving the indoor air and sound quality, as well as the natural and recreational quality of the Lange Bretten.

The research of this paper is summarized in the overview image, as seen in figure 19. The overview can be read from left to right, starting with the analysis of the natural elements, their qualities and problems. The overview mentions the most characterizing pros and cons of the local earth, water, air, temperature and light. The second part of the overview consists of four case studies, which are reacting to some of the problems in the Lange Bretten. The overview continues with the responsible techniques that enabled the improvement of the natural quality of the projects environment, as well as the techniques for reducing the projects footprint. To be clear, these case studies are presenting possible solutions, but many more case studies could have reacted to the problems of the Lange Bretten.

| | Pros & cons | Case studies with solutions | Techniques to improve natural quality | Techniques to reduce (housing) footprint |
|---|---|---|---|---|
| **Earth** | • Variation in plant species<br>• Visible historical polder ditches<br>• 1970's rubble hills<br>• Fragmented land-scape, caused by infrastructure | **The Ceuvel office park** | • Phytoremediation (soil purifying plants) | • Old houseboats are renovated & integrated in the park<br>• Energy trading system, compost toilets, etc. |
| | | **Landscape houses** | • Continuous hill can reduce noise<br>• Green roofs benefit micro-climate | • Ground of previous depot hill used for housing construction<br>• Earth provides a buffer, less energy is needed to warm/cool<br>• Green roofs |
| **Water** | • Rainwater infiltrates well into ground<br>• Similar rainfall annually<br>• Water quality under high pressure<br>• Limited water surface<br>• Water supply has quantity risk<br>• Flood risk during 2nd dyke breach | **Lanxmeer neighbourh.** | • Seperation of water systems, letting only rain from roofs into retention ponds<br>• Adding retention ponds, a large pond and helophyte filters in the neighbourhood | • Double sewage system<br>• Grey water is filtered through helophyte filters |
| **Air** | • Odor nuisance from harbour is mostly led away by prevailing wind<br>• Bad air quality<br>• Noise disturbance | **Bite the dust wall prototype** | • Wind-driven chimney effect<br>• Wood fiber concrete adheres fine dust<br>• Sound waves are partly reflected & partly absorbed by profiled interior walls | |
| **Temp. & Light** | • Small amount of forest areas provide cooling during summer<br>• Most areas remain dark at night<br>• Cooling effect is not optimal, because of many dry grasslands<br>• Light pollution from (crossing) roads | **Lanxmeer neighbourh.** | • Adding retention ponds, a large pond and helophyte filters in the neighbourhood<br>• Central location of ponds & wadi's | • Reuse of rainwater for secondary house-hold water<br>• Green roofs |

Figure 19. Concluding overview of this research paper (image by author)

The results of this paper will form input for the design of a passive and nature inclusive housing complex in the Lange Bretten. The research in chapter two already enabled the designer of this complex to have a better understanding of the current natural quality of the area and what problems to tackle with the design. This research also allowed the designer to select potential locations within the Lange Bretten for the development of the housing complex. Some of the described techniques of chapter three could be integrated in the design without much further research, such as the separation of different water systems, the central location of cooling water areas and the use of local earth for the housing construction. More research would be needed to implement other techniques, such as the integration of an air purifying and noise reducing shaft within the architectural housing design. More research and time would also be needed to follow up on the earth purifying results of the phytoremediation technique in the Ceuvel park. The case studies have lastly inspired the designer to expand the housing program, by for example adding a drinking water facility or earth purifying plant park.

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