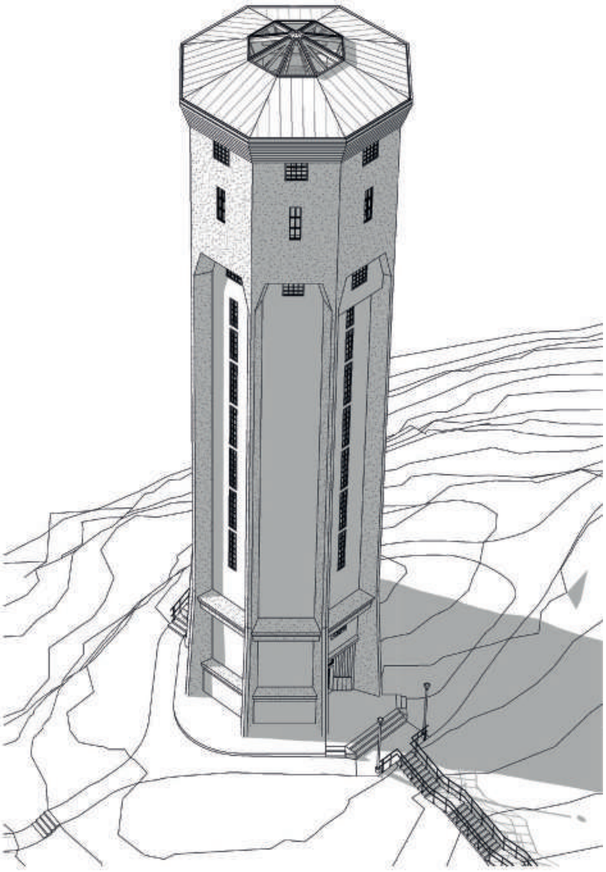
Lunden's Water Tower: A New Contribution

An Investigation into Transforming an Existing Water Tower into an Educational Center Focused on Water Conservation and Sustainability



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Department of Architecture and Civil Engineering
Examiner: Walter Unterrainer
Supervisor: Tina Wik

Thank you!

I would like to thank my supervisor Tina Wik, as well as my examiner Walter Unterreiner for their support throughout this journey.

I am also very grateful to my wife and friends who supported me during this time.

CHALMERS
UNIVERSITY OF TECHNOLOGY

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Supervisor: Tina Wik
Master's Thesis in Architecture and Planning Beyond Sustainability
Gothenburg, Sweden 2024

ABSTRACT

Fresh water is a finite and precious resource; it is about 2.5% of the Earth's total water (US. Geological Survey, 2019). In an era of increasing environmental concerns due to drought caused by global warming, and the difficulty of accessing clean water in some local regions because of the pollution of local water sources, it stands out - as does the importance of awareness for preserving fresh water especially and water in general.

According to the 2023 United Nations World Water Development Report, around 2 billion people around the world do not have access to clean and safe drinking water.

There exist many threats to local marine life: overfishing, climate change, plastic pollution, oil spills, and loss of biodiversity being just a few. Each year, an estimated 8 million metric tons of plastic waste enter the oceans (The Ocean Cleanup). It is crucial for us to promote awareness for methods of aquatic life conservation.

This thesis presents an idea to transform a symbol from the past into a beacon of hope for the future by reusing a water tower located in the Lunden district of Gothenburg and turning it into an educational center focusing on water conservation and sustainability especially drinking water, all while preserving the water tower's architectural identity as a protected building according to the 1987 Conservation Program of the municipality of Gothenburg.

In addition, the thesis also seeks to discuss the architectural design necessary to preserve the character of the water tower during this transformation process - such as the facades and other external and internal architectural elements that characterize the tower - as it is a part of Gothenburg's skyline and contributes to its historical.

This education center will function as a beacon of knowledge, inviting visitors to explore the vital role of water in our lives and ecosystems. This project will not only raise awareness about the importance of water, but it will also inspire individuals and communities to work towards a more sustainable and water-conscious future.

Therefore, the thesis will examine the architectural methods and concepts that can be incorporated into the redesign of Lunden's water tower to educate the public about the risks to which the earth's water is exposed such as; water scarcity, water pollution, destruction, fresh water, food, behavior change, water waste, health, corrosion, etc.

This thesis will explore the possibility of providing spaces for interactive exhibitions and enabling visitors to also learn about the water cycle, water saving techniques, and water conservation practices through practical experiences that they carry out during their visit.

Additionally, it will investigate some innovative green building technologies, such as rainwater harvesting and water recycling systems, further demonstrating the integration of sustainable practices into urban environments.

Keywords:

Clean water

Sustainable living

Behavior change

A BOUT THE AUTHOR

I have a great interest in rehabilitating old and abandoned buildings to benefit the local community, contributing to environmental preservation. This endeavor also provides opportunities to acquire new knowledge and experiences in sustainable design.

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- Sustainable transformation of a derelict industrial building.
- Sustainable architectural design.
- Planning and design for sustainable development in a local context.

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ByggKonsult Petra AB, Strömstad Sweden (Part time, 50%).

Responsible architect. My tasks and responsibilities included sketching for new projects and preparing A-drawings for the building permit in accordance with building regulations. Additionally, I was responsible for preparing shop drawings layouts.

2020-2021,

ARD BYGG AB, Gothenburg Sweden (Part time, 50%).

Co-owner of the company and a responsible architect. My duties and responsibilities encompass both administrative and architectural tasks. These include preparing A-drawings for building permits, offering advice on building permits in accordance with regulations, and providing quotations to clients.

2019,

PE Teknik & Arkitektur AB, Gothenburg Sweden (Full time).

Architect at PE Teknik & Arkitektur AB. I was responsible for preparing A-drawings, building permit documents, sketches for new projects, coordinating drawing materials, and providing advice on building permits.I also produced 3D models by using Revit or freehand sketches.

A BOUT THE AUTHOR

2017-2018, **Stadsbyggnadskontoret, Gothenburg Sweden (Full time).**

City planner at the Urban Planning Department. My assignments included working on development programs for the district of Gårda/ Gothenburg, as well as participating in the pre-examination process and handling planning decisions.

2009-2015, **Arab Bank, Damascus Syria (Full time)**

Supervising Architect at the Premises & Project Management Department at Arab Bank – Syria, I was responsible for coordinating and overseeing all architectural layouts related to the construction of new branches for Arab Bank in Syria. My role also involved ensuring the quality of design and implementation.

2008, **Fouad Takla's Company for Design & Development, Damascus Syria (Full time)**

Deputy Architect, I participated in the architectural design by using Auto CAD and 3Ds Studio MAX. I was also responsible for producing an architectural detail "shop drawings".

2002-2007, **Bachelor's Degree in Architecture,**
Damascus University, Faculty of Architecture.

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I. INTRODUCTION

“Global Water Stress:

According to the United Nations, by 2030, global demand for water is projected to exceed supply by 40%, primarily due to population growth, urbanization, and climate change.

This highlights the urgent need for sustainable water management practices to ensure access to clean water for future generations”.

Building educational centers focused on water conservation and sustainability is a topic of global interest and debate, reflecting a growing awareness of the importance of water resources and environmental sustainability.

Discussions revolve around raising awareness, enhancing community engagement, using technology, calling for policy changes, and aligning with global sustainability goals, according to the United Nations Sustainable Development Goals.

Goal 6: To ensure access to water and sanitation for all.

These centers such as; “Clay Center for the Arts and Sciences, West Virginia USA.” serve as important platforms to educate individuals and communities about the critical importance of responsible water use and environmental stewardship in the face of growing water challenges.

This topic is quite interesting and requires a complete understanding of all its aspects - such as the actual mechanism of water conservation.

Therefore, the thesis seeks to learn more about it in order to provide the water tower in Lunden with a more comprehensive idea of its future.

Fig.1 Four main sustainable development goals are addressed in this thesis (adapted from © United Nations)

MAJOR SUBJECT

The primary aim of this project is to adapt and convert an existing water tower to be an educational center focused on water conservation and sustainability.

Due to technical developments in water distribution, the water tower in the Lunden neighborhood is now out of service and is no longer being utilized for the same purpose for which it was built 94 years ago.

However, since the water tower has historical and cultural value that must be preserved (Lönnroth et al.,1999), the idea of the thesis addresses the continuation of use for Lunden's water tower, but in other capacities, instead focusing on raising awareness of the risks to which water is exposed to in the world.

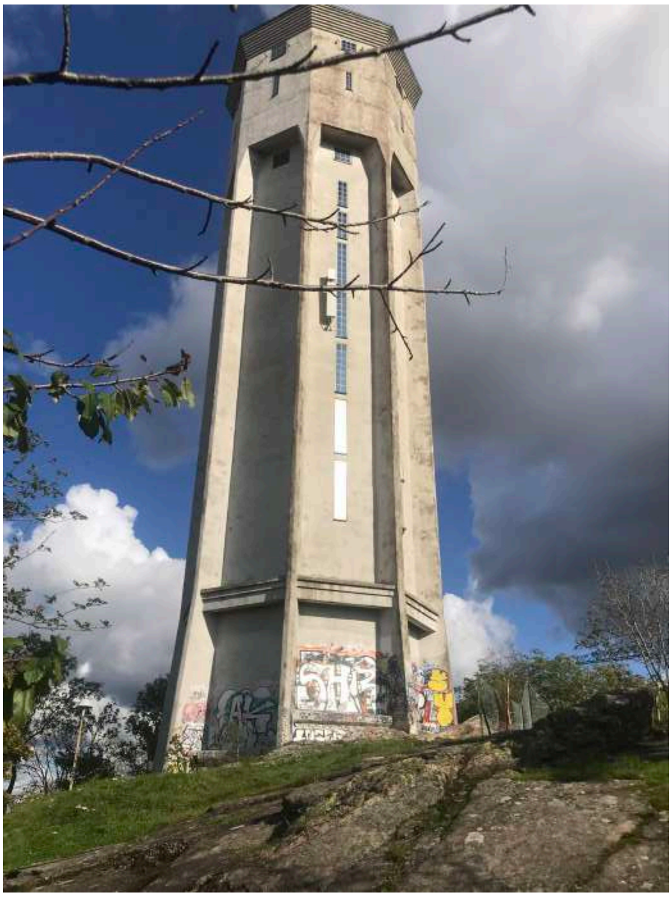
The tower in question was built in 1930, using concrete as a modern building material in the early twentieth century. It is a huge mass of concrete, and the built area is about 69 m², while its total height is about 46 m.

This project involves three main problems:

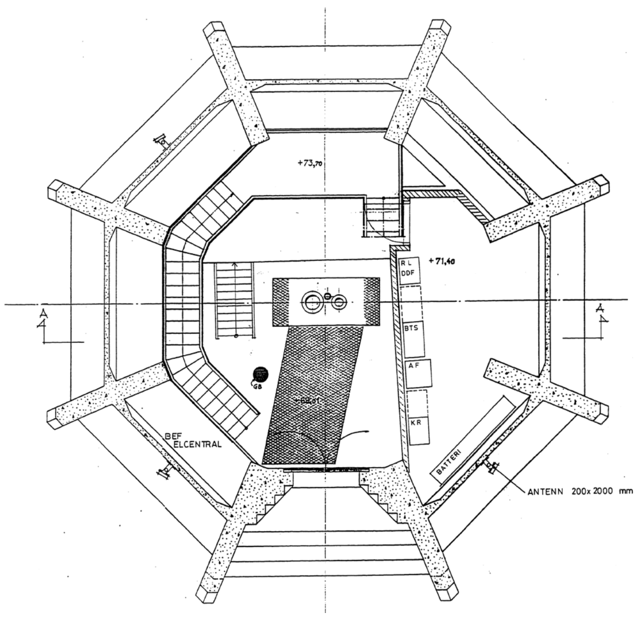
- The first issue is the potential of this massive structure to be repurposed, as the built area is about 69 square meters. and the structural elements are difficult to manage.

- The second concerns the site itself, as the tower is located on top of a hill. As such, green spaces around the tower are key issues to be considered in design concept.

- Thirdly, the environment inside the tower is poor, with acoustic issues that must be addressed during the design process.



(Source: Photo taken by author)



Drawing 1, GF.
(Source: Stadsbyggnadskontoret, Gothenburg)

PROBLEM STATEMENT

According to the United States Geological Survey (USGS), water covers about 71% of the Earth's surface.

Nearly 96.5% of Earth's water is in the form of salt water in the world's oceans, and only about 2.5% of Earth's water is freshwater, most of which is trapped in glaciers and ice caps. As for the rest, it is in other forms of saline water. Of the total freshwater on Earth, about 68.7% is locked up in ice caps, glaciers, and permanent snow.

About 30.1% of freshwater is stored underground in aquifers. Only about 1.2% of Earth's freshwater is found in surface water bodies such as rivers, lakes, and swamps (USGS., The distribution of water on, in, and above the Earth, 2019).

Global water withdrawal for agriculture, industry and domestic use is also significant. Agriculture is the largest consumer, accounting for about 72% of total water use, (Gleick,2014).

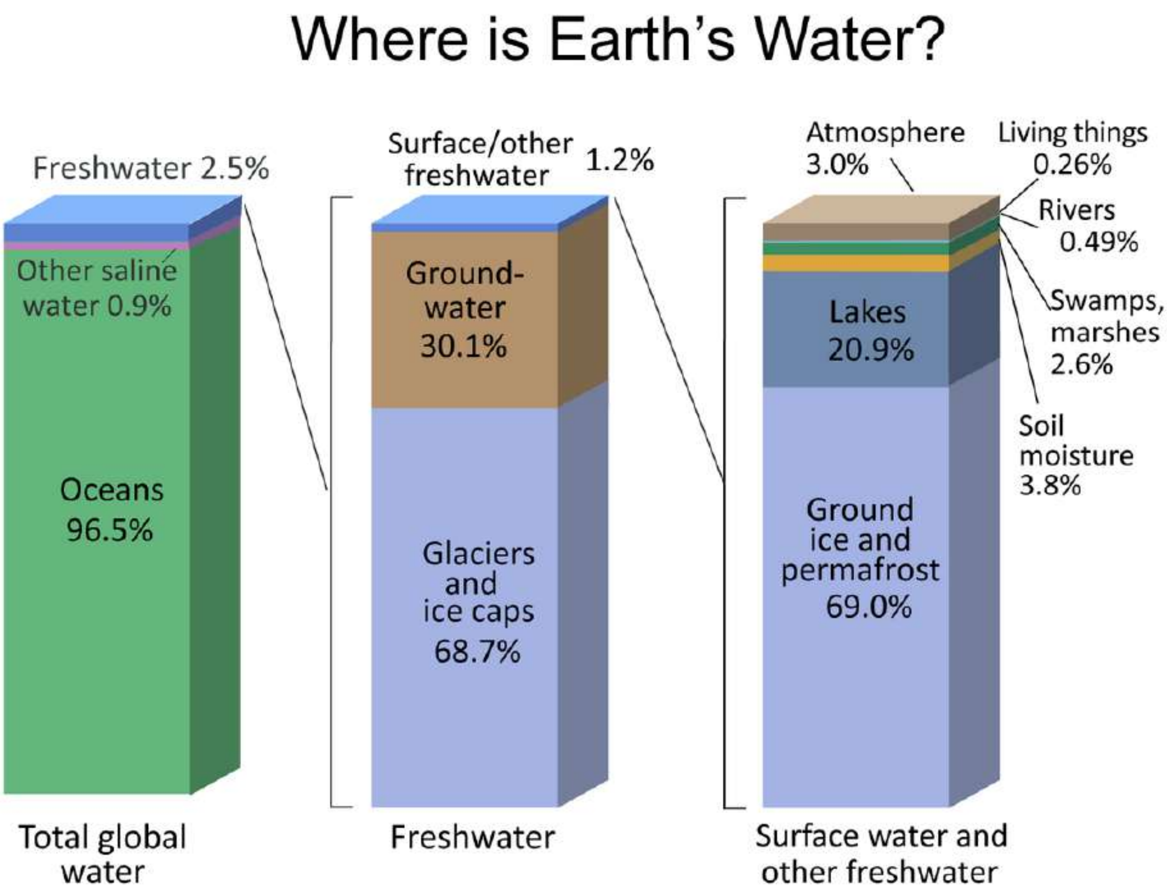


Fig.2 Credit: U.S. Geological Survey, Water Science School. Data source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the world's Fresh Water Resources. (adapted from © U.S. Geological Survey)

PROBLEM STATEMENT

Water scarcity is a growing concern in many parts of the world. According to the 2023 United Nations World Water Development Report (WWDR). By 2025, an estimated 1.8 billion people will live in areas with absolute water scarcity, and two thirds of the world's population may suffer from water-stressed conditions.

Although Sweden is not considered water-stressed according to the Sustainable Development Goal 6.4.2. Water Stress Level (0-25%), this does not rule out the possibility of future clean water shortages. This is especially true in the post-global warming era, as described by United Nations Secretary-General António Guterres in the summer of 2023, when some European and other countries experienced an unprecedented heat wave and drought, as well as extreme weather events. Guterres stated that:

"The era of global warming has ended, and the era of global boiling has arrived".

Swedish Context:

Industrialization in Sweden began during the second half of the 19th century, with factories contributing to the pollution of water sources in and around Gothenburg, including rivers and groundwater.

Population and industrial growth also significantly escalated total water consumption during this period. In 1891, the municipality of Gothenburg resolved to construct a new facility on the banks of the Göta Älv river to utilize its water for meeting the city's need for clean water. However, even then, levels of river water pollution remained alarmingly high (Rönnbäck, 2017).

In 1926, outbreaks of epidemics were traced back to bacteria in water supplied from Alelyckan. Efforts were undertaken to mitigate these contamination issues through the implementation of stricter regulations and enhancements to water treatment processes. The introduction of a chlorination stage in the water treatment process before distribution through pipelines was among the measures adopted (Rönnbäck, 2017).

Water scarcity poses a far graver concern than food shortages, thus prompting the production of drinking water at two primary plants, Alelyckan and Lackarebäck, where raw water is drawn from the Göta Älv River. Nevertheless, during the summer months, the pipeline network in Gothenburg can experience diminished capacity, rendering it inadequate to satisfy demand if there is substantial water usage concurrently. This underscores the imperative of rationalizing water consumption during the summer and devising strategies to conserve drinking water.

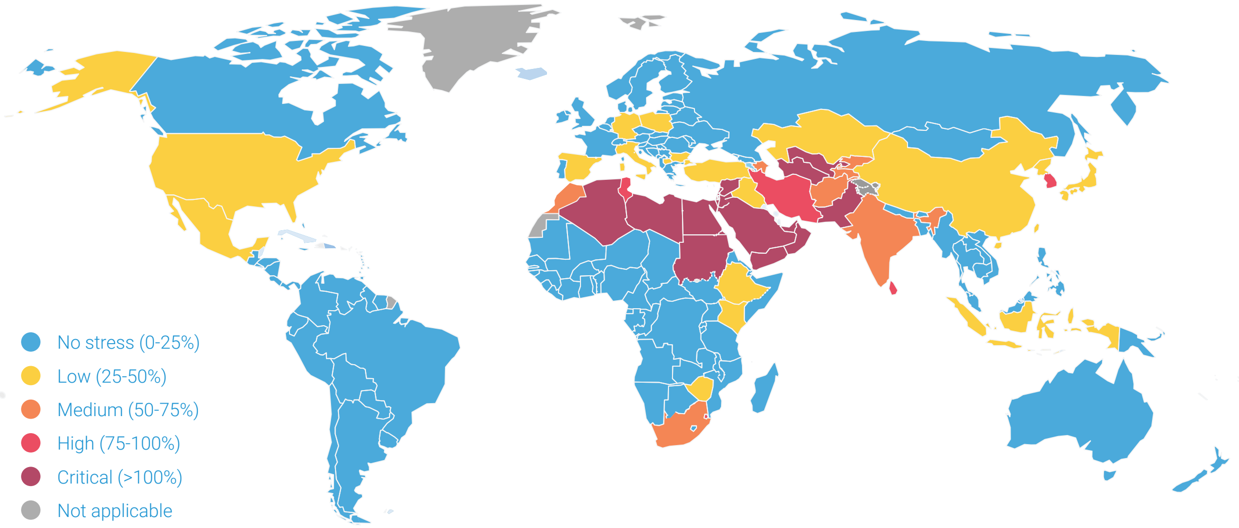
Food and Agriculture Organization of the United Nations

United Nations | UN WATER

SDG 6.4.2 LEVEL OF WATER STRESS

18% is the **global value** of **water stress.**

Levels of water stress by country



10% of the world population lives in conditions of high to critical level of water stress.

67% of that population lives in urban areas.

70% of the global water withdrawals are used in the agricultural sector.

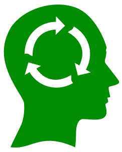
(Fig.3 Source: UN water SDG-Indicators)

AIMS

Education and Awareness

Raising awareness, disseminating knowledge, and promoting positive actions related to water conservation and sustainability, where visitors can learn about the importance of water conservation, sustainable water management and related environmental issues.

Behavioral Change



Raising public awareness about water scarcity, the importance of responsible water use, and the environme tal and societal impacts of water-related challenges as well as inspiring individuals and communities to adopt water saving practices and make sustainable choices in their daily lives.

Research and Innovation

Supporting research on water conservation technologies and sustainability practices. Additionally, sharing results with the public by offering interactive, hands-on exhibits and activities that make learning about water conservation and sustainability technologies memorable.

Advocacy and Cooperation

Calling for policies and regulations that promote water conservation and sustainable water management at the local, regional, and national levels by providing resources, information, and tools to homeowners, businesses, and policy makers to implement water saving techniques and practices.

AIMS

Community Participation

Engaging the local community and encouraging active participation in water conservation initiatives and sustainability projects by collaborating with local schools, environmental organizations, government agencies, and businesses to promote water conservation initiatives and sustainability projects.

Sustainable Transformation

Showcasing the water tower in Lunden as an eco-friendly structure and a living example of sustainable practices, such as rainwater harvesting, energy-efficient systems, and environmentally friendly landscaping.

Preserving Cultural Heritage

Preserving and reusing a historic and culturally significant water tower, contributing to the cultural heritage of the area.

DELIMITATIONS

It is about:

Working on this topic requires cooperation between many specialists from different fields to conduct a comprehensive study of all essential aspects of the transformation process.

This thesis examines the limits of the architectural possibilities offered by the Lunden's water tower in terms of functionality and the utilization of interior space to meet the requirements for its conversion into an educational center focused on water conservation and sustainability in general, and especially drinking water.

Consequently, this thesis offers a simplified solution to the research question, ensuring that the design concept aligns with feasible applications while preserving the architectural identity of the Lunden's water tower.

The thesis primarily revolves around these issues due to the broad scope of the topic and its interconnection with other specializations:

1. Interactive Exhibitions About Preserving Clean Water.

2. Historical Architectural Values.

3. Iconic Landmark.

4. Educational Opportunity.

5. Educational Content.

Therefore, the thesis and design proposal will focus only on drinking water as an exhibit element.

It is not about:

However, the thesis will not delve into these issues, despite their significance to the transformation process:

1. Financial Cost.

2. Maintenance.

3. Marketing and Communication.

4. Participatory Design.

5. Testing The Structural Durability and Stability / Re-inforcement Work.

6. Technical and Engineering Details such as Structural Details.

7. Zoning and Regulations.

8. Accessibility, this thesis addresses the minimum architectural interventions that can be included in the Lunden's water tower.

9. Evacuation Plan.

METHODOLOGY AND TOOLS

Research, Design & Reflection Approach:

The research and design methodologies are based on research for design; it will be problem-centered, pluralistic, and real-world practice oriented with a pragmatic approach to the consequences of actions.

The methodology is based on gathering information, such as analytical drawings, graphs, statistics, or related projects, in addition to doing a site visit in order to collect some information from the site and touching the built space closely.

The core of the research approach is to study the topic and gather architectural information that will be useful in exploring how to convert the existing water tower into an educational center focusing on water conservation and purification.

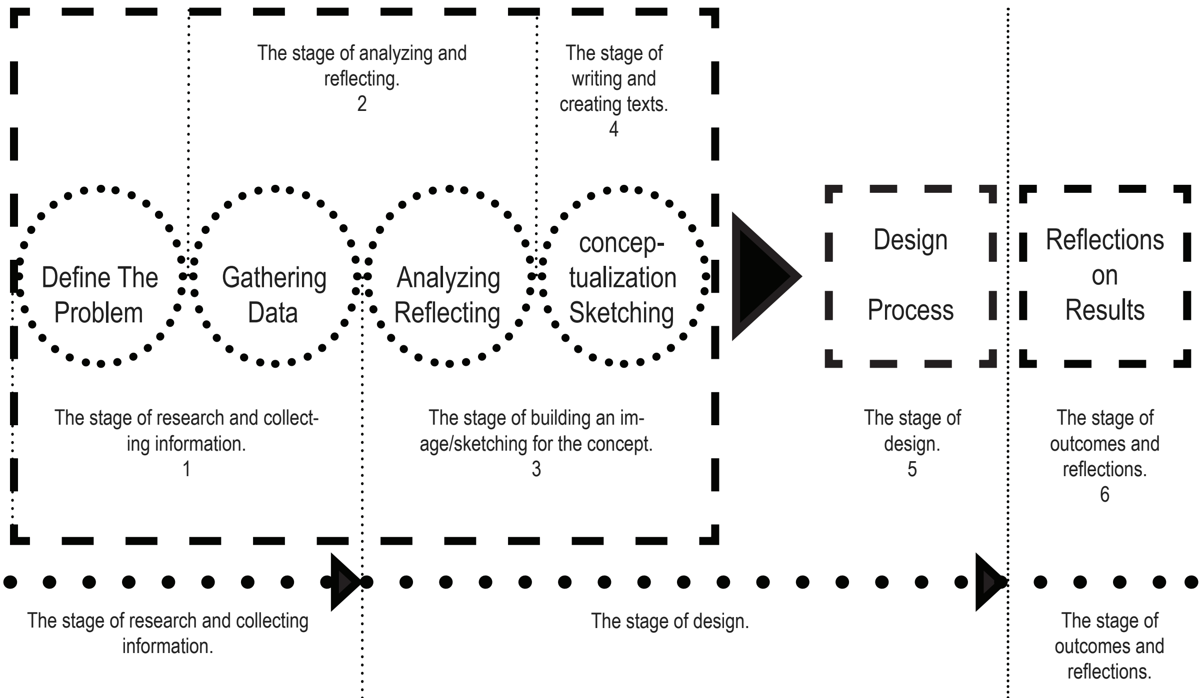
The design approach, by comparison, is based on experimental methods, such as sketching and modeling different proposals to reach the best-fit architectural design for the adaptation and transformation process.

The proposal presented in this thesis is based on a set of architectural theories that guide the design decisions.

This thesis adheres to the principle of minimal architectural interventions to achieve the best results in the water tower adaptation process and obtain excellent architectural outcomes.

To conclude, the findings and facts reached from the research and design studies will be reflected in the outcomes of the architectural implementation.

The Process:
The relationship between research and design is an intertwined process to reach the aims of thesis.



Tools:

Reading, reflecting, and analyzing.

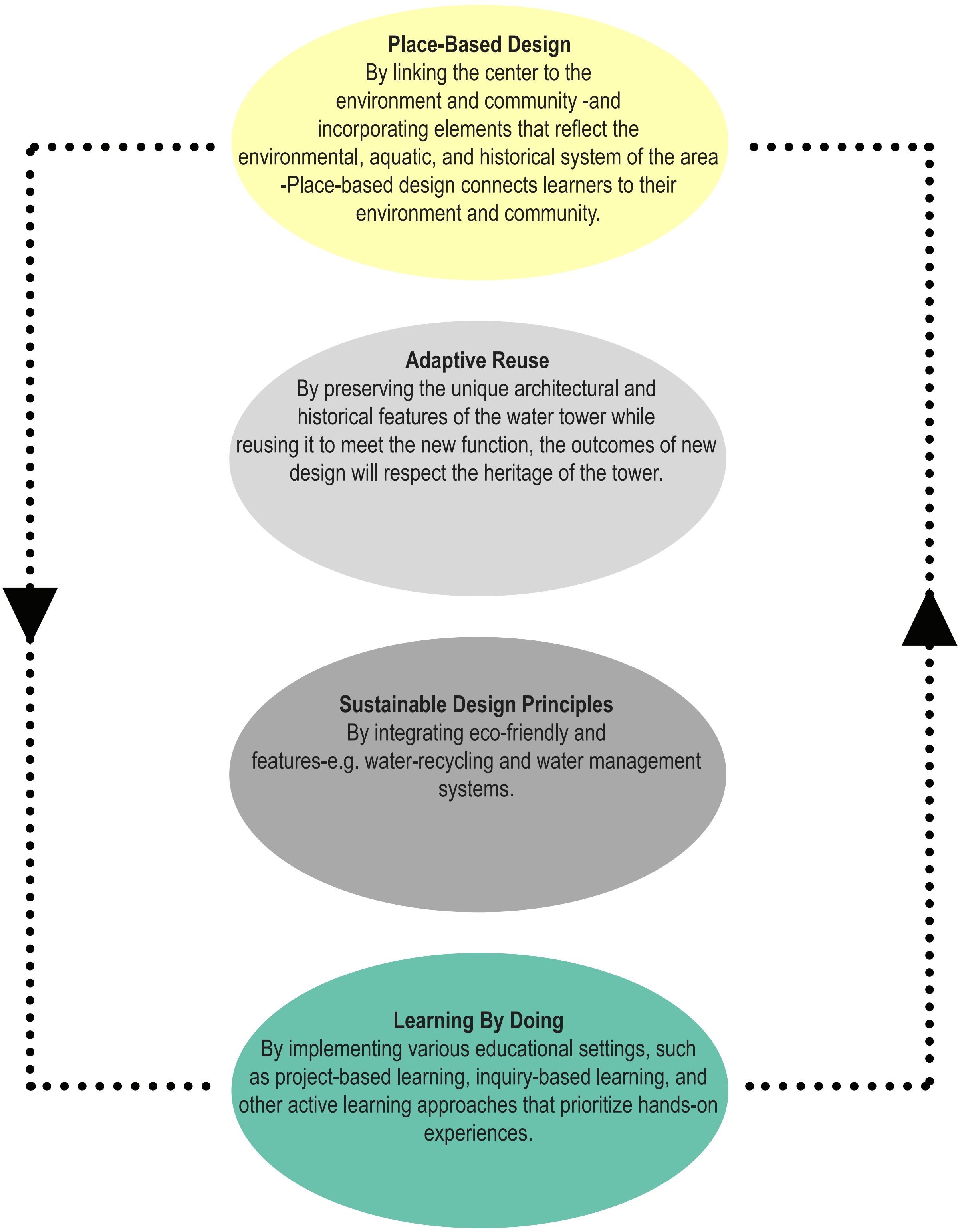
Writing, sketching, modeling, testing, experimental analysis, critical thinking, design assessment.

Critical thinking

II. THEORIES

THEORIES

The main theories are:



PLACE-BASED DESIGN

Place-Based Design:

"Any existing, functioning urban area has structure and identity, even if only in weak measure...A frequent problem is the sensitive reshaping of an already existing environment: discovering and preserving its strong images, solving its perceptual difficulties, and, above all, drawing out the structure and identity latent in the confusion.". (Lynch, 1960)

Physical spaces are not neutral; they are strongly influenced by the social, cultural, economic, and environmental characteristics of their surroundings.

Therefore, understanding the unique characteristics of the Lunden’s water tower, including its built context, history, geography, environment, culture, and social dynamics, is essential for creating architectural interventions consistent with the idea of transforming the tower into an educational center focused on water conservation and sustainability.

Involving local communities in the design process can provide valuable insights into creating solutions that reflect community aspirations and priorities, thereby enhancing the sense of place and identity within the community through the celebration of local heritage and traditions.

(Note: This thesis will not address participatory design due to the limited time available for thesis work).

Place-based design promotes sustainable and resilient design approaches that support the health and vitality of communities by creating environments that contribute to ecosystem regeneration, community empowerment, and equitable development.

Therefore, this theory is synonymous with adaptive reuse strategies for existing buildings and green infrastructure.

ADAPTIVE REUSE DESIGN

Adaptive Reuse Design:

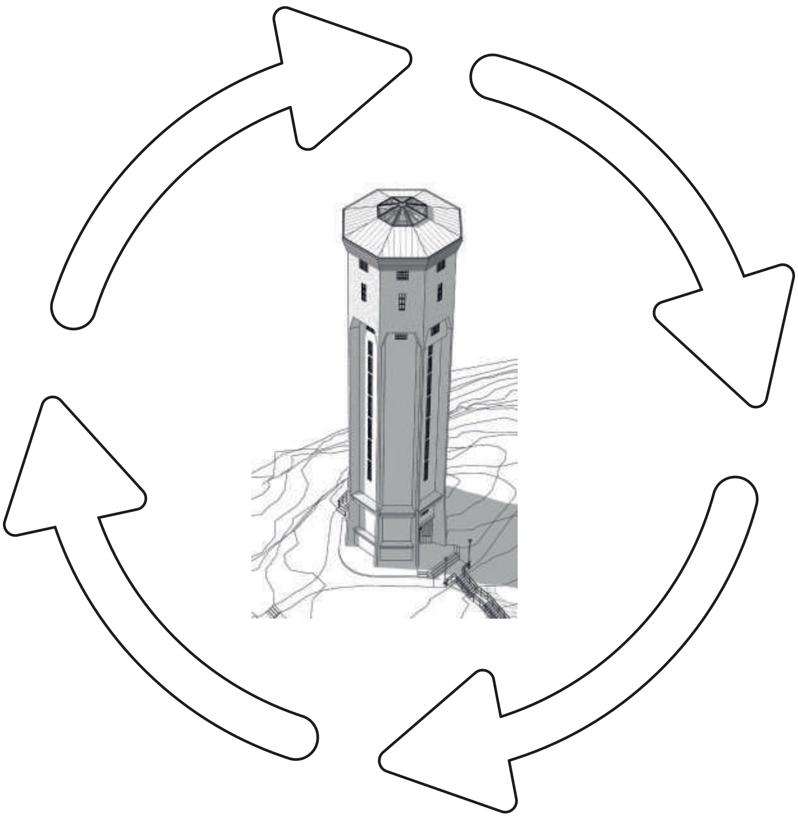
Designing based on the principles of adaptive reuse theory brings a sustainable and culturally sensitive approach to the architectural design of the Lunden's water tower.

This approach reinforces the principles of architectural heritage preservation and reduces the environmental impact associated with new construction, thereby decreasing energy consumption, carbon emissions, and waste generation.

According to the Global Status Report (GSR) for Buildings and Construction 2022, the sector's total energy consumption and CO2 emissions increased in 2021 above pre-pandemic levels. Energy demand in buildings rose by about 4% from 2020 to 135 EJ – the largest increase in the past 10 years. CO2 emissions from construction operations reached an all-time high of around 10 gigatonnes of CO2, approximately 5% higher than in 2020 and 2% higher than the previous peak in 2019.

Architectural design based on this theory aims to create vibrant and resilient built environments where adaptive reuse provides cost-effective solutions. This is achieved by leveraging existing infrastructure and architectural features in the Lunden's water tower.

Relying on adaptive reuse requires thinking creatively about how to adapt existing spaces to accommodate new functions and uses. This promotes innovative architectural solutions that respect the original context and structure of the Lunden's water tower.



SUSTAINABLE DESIGN PRINCIPLES

Sustainable Design Principles:

Sustainable development is considered important by reusing the existing water tower and converting it into an educational center focusing on water conservation and sustainability principles.

This provides an opportunity for the existing structure to benefit the local community with a new function other than the one for which it was originally created.

The sustainable design strategies that the project offers include:

Water and Sanitation System:

Designing and installing rainwater a harvesting system, implementation greywater recycling systems, incorporating water-saving plumbing fixtures.

Sustainable Landscaping:

Designing trails that lead visitors through the landscape with interpretive signs explaining local aquatic ecosystems, water conservation practices, and native plant species and carefully located in the project levels.

Promote Cultural Heritage

Preserving the architectural identity of Lunden's water tower as an iconic landmark and part of architectural context of Gothenburg.

Community Participation :

Enacting an awareness plan to engage schools, universities, and local communities, collaborating with local water authorities, environmental organizations, and experts.

Learning By Doing:

The Lunden's water tower is a well-known landmark in Gothenburg due to its location and height. It is a popular tourist destination, but the exhibitions sections need to be engaging and informative in order to make the visit truly memorable.

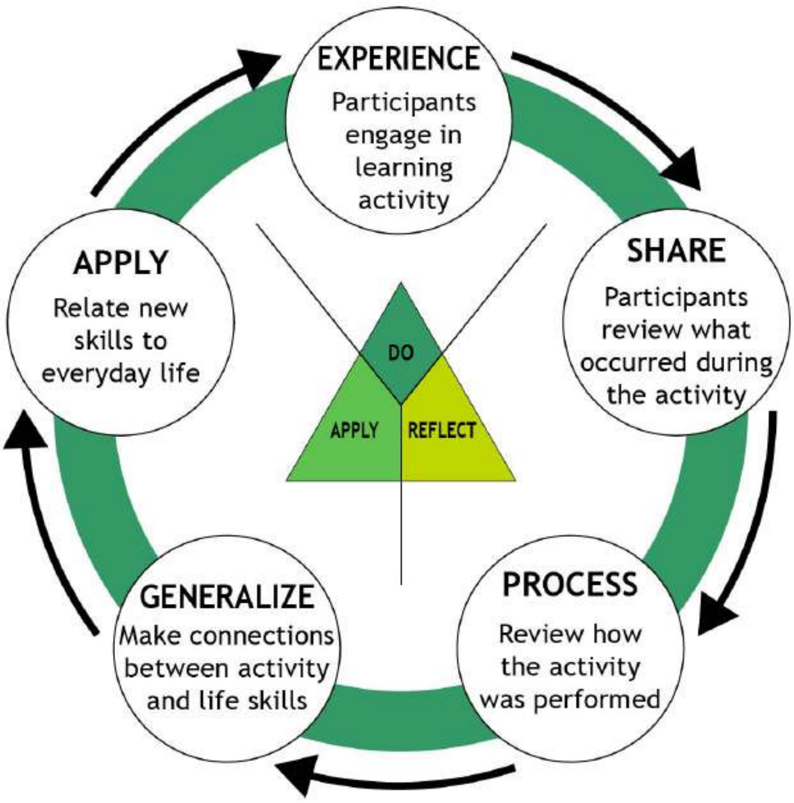
Therefore, this center is based on the concept of learning by doing and having fun.

In other words, visitors should have an opportunity to practice, test, and experience first-hand the different aspects of water usage and conservation in an enjoyable way.

Learning by doing theory, also known as experiential learning theory, is a powerful concept in education and personal development.

"LEARNING IS THE PRODUCT **OF THE ACTIVITY** OF LEARNERS"

John Dewey



(Fig.4 Source: University of Wisconsin-Madison)

RESEARCH QUESTIONS

Main question:

What are the architectural interventions that can be integrated into Lunden's water tower to facilitate educating the public about the risks facing Earth's water?

Sub-question:

How can these architectural interventions preserve the identity of the water tower in Lunden and effectively enhance awareness and practices related to water conservation and sustainability?

III. INVESTIGATION

RAINWATER HARVESTING SYSTEM

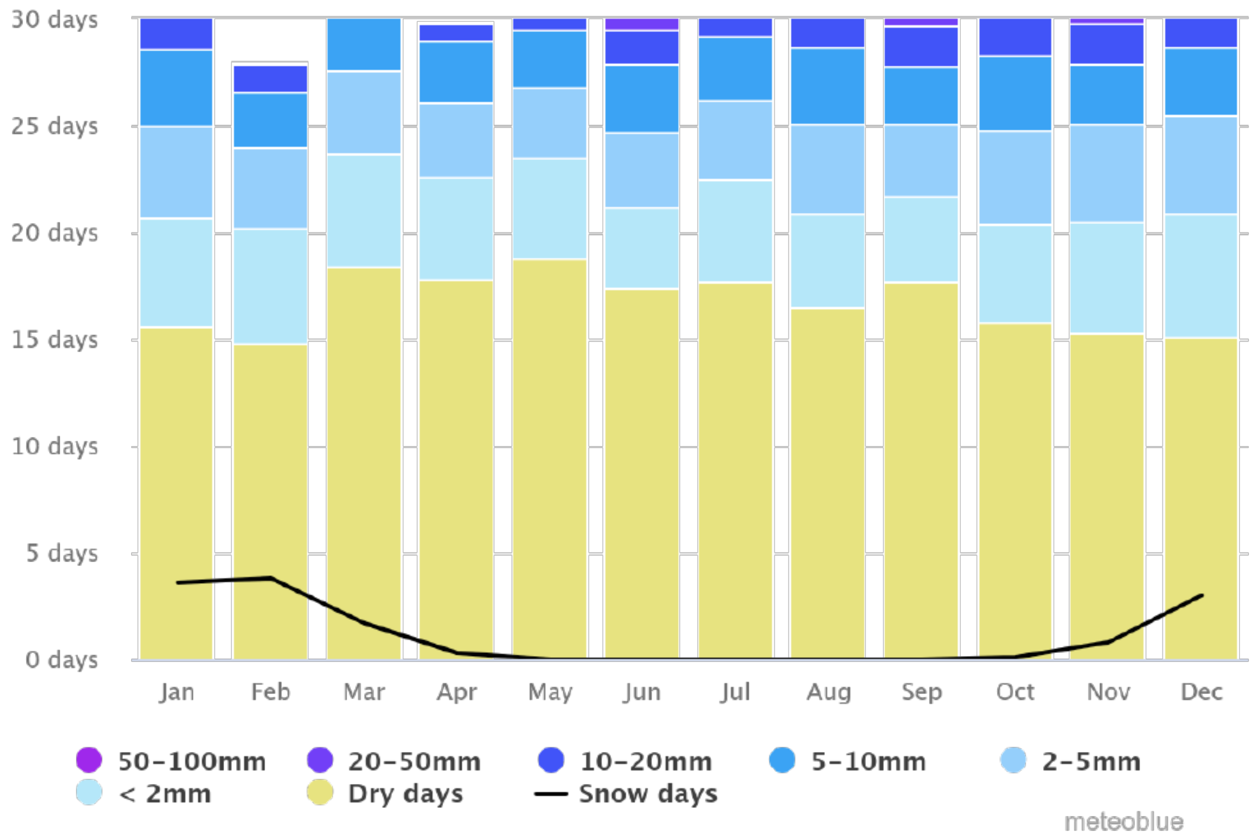
The basic principle of water conservation revolves around recycling and reusing water within this center. The proposed function of the Lunden's water tower requires the utilization of water throughout the learning journey.

Therefore, collecting rainwater through the tower's roof serves as a crucial source to fulfill the building's water requirements.

Designing a rainwater collection system is a multifaceted process, as it involves several steps and equipment tailored to the center's water demand.

Weather in Gothenburg:

The climate in Gothenburg is mild and temperate. Rainfall levels in the city are notable, with a substantial amount of rain occurring even during months typically associated with dry weather.



(Fig.5 Adapted from Meteoblue)

The precipitation diagram for Gothenburg shows on how many days per month, certain precipitation amounts are reached.

According to climate data website, the annual precipitation in Gouthenburg is approximately 998 mm (39.3 inch).

RAINWATER HARVESTING SYSTEM

Rainwater calculation formula:

The formula is;

$V_{SUPPLY} = A \times P \times C \times 0.623$

Where;

V_{SUPPLY} = volume of available water (gal)
P = annual precipitation (in)
A = collection surface area (ft2)
C = runoff coefficient (dimensionless)

Note: The value“0.623”is a conversion factor that converts “square feet x inches” into gallons.

The runoff coefficient (C):

The runoff coefficient (C) is a dimensionless parameter that correlates the amount of runoff to the precipitation received. It tends to be higher for materials with low permeability and high surface runoff, and lower for materials with greater permeability.

Rough, heavy-textured surfaces can thus impede water flow, allowing for some absorption before reaching the gutter.

For instance, a pitched metal roof is typically highly effective in collecting water, absorbing around 95 percent of the precipitation it receives (except during heavy snowfall). In contrast, a flat roof constructed with tar and gravel is less efficient in terms of runoff.

Roofing Material	**Runoff Coefficient**
Metal	0.95
Asphalt	0.90
Concrete	0.90
Membrane	
Type EPDM, PVC, etc.	0.95–0.99
Tar and Gravel	0.80–0.85

Rainwater harvesting:

The formula is;

$V_{SUPPLY} = A \times P \times C \times 0.623$

Where;

V_{SUPPLY} = volume of available water (gal)
P = 39.3 in per year.
A = 132.5m^2= 1426.2ft^2
C = 0.95 (The roof finishing is stainless steel sheets).

V_{SUPPLY}= 1426.2 X 39.3 X0.95 X 0.623= 33,172.99 gal

V_{SUPPLY}= 33,172.99 gal = 789.83 barrels per year.

V_{SUPPLY}= 125.57 m^3 per year.
V_{SUPPLY}= 344.03 liter per day.

Water tank as built by using concrete

RAINWATER HARVESTING SYSTEM

Estimation of water consumption:

The actual total area of the water tower's floors is approximately 640m^2, so the supoused capacity of visitors will be 30 visitor per day and 3 employees.

According to "SvensktVatten" each person per day needs:

_30 liters for toilet flushing which is 1.25 l per hour.
_2 liter for drinking which is 0.083 l per hour.

Estimation for personal use is:

400 liters per day

This center contains:

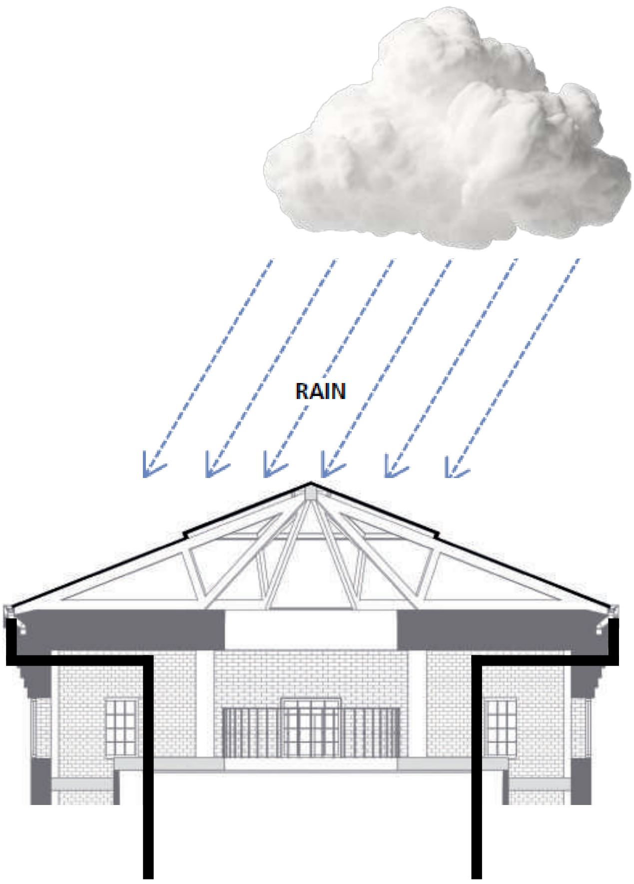
DIY Water filtration.
Drinking water exhibitions.
Water tables and water gaming.

Rainwater harvesting concept:

The idea is to replace the existing roof with a new one covered with stainless steel panels for some parts, while other parts feature a glass roof angled at 21.5 degrees towards the outside of the water tower.

This design facilitates the flow of rainwater into the gutter, then into drainage channels directing it to a distribution tube situated on the ceiling of the meditation room (referred to as the water tank).

From there, the water cascades freely down the wall of the tank to another basin at its base (this will be explained in detail later).



To the meditation room as non-potable water.

WATER PURIFICATION SYSTEM

According to the World Health Organization, approximately 80% of the world's wastewater is discharged into the environment without adequate treatment, contributing to water pollution. Water filtration is a complex process that requires technical tools to maintain water at safe levels.

Water purification as a complex process:

Since the project idea centers on converting the Lunden's water tower into an educational center with a focus on water conservation and sustainability, there is a significant emphasis on the imperative of preventing water wastage. Additionally, as the project involves collecting rainwater for utilization in the center's water exhibits, it is crucial to design a water purification system that aligns with the daily water consumption requirements within the tower.

According to RainKing Systems, the process essentially consists of seven stages to obtain pure water suitable for human use, namely:

1. Pre-treatment

In this stage, large particles and suspended solids are eliminated from the water source, which is a necessary step to safeguard the final equipment.

2. Sedimentation

This stage involves allowing the water to remain stationary inside a large tank until suspended materials settle, facilitating the settling of these materials to the bottom. This process is typically improved by the addition of coagulants, such as alum or polyelectrolytes, which aid in attracting small, suspended particles and forming larger particles.

3. Filtration

At this stage, particles, pollutants, and various impurities are eliminated. To filter these impurities, different types of media filters are utilized, incorporating a variety of materials such as sand, gravel, charcoal, and other synthetic substances. These filters act as a physical barrier between water and impurities.

4. Disinfection/Purification

In this stage, harmful bacteria, viruses, and other disease-causing organisms are eradicated. Disinfection is typically achieved using chlorine, ozone, or ultraviolet light, with chlorine being the most extensively utilized disinfectant due to its effectiveness in eliminating a broad spectrum of organisms.

80%

of the world's wastewater is discharged into the environment without adequate treatment

5. Adsorption

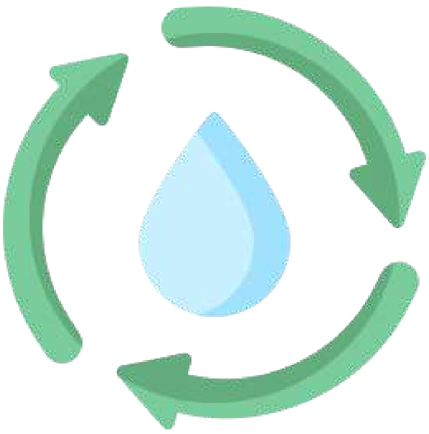
It is the process of attaching molecules of one substance to the surface of another substance. In water purification, adsorption is employed to eliminate unwanted particles from water. Adsorption is typically carried out with the assistance of activated charcoal or other granular materials containing particles with a large surface area.

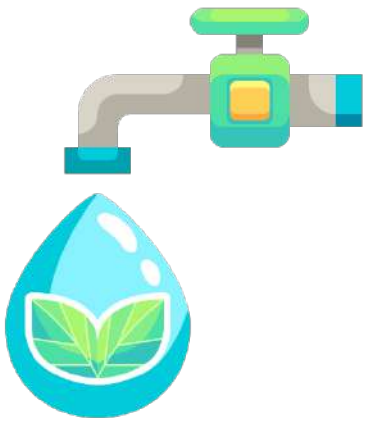
6. Ion Exchange

This stage eliminates charged impurities from the water by substituting the impurities with ions of a similar charge. Ion exchange entails the use of a strong acid or base to alter the pH of the water, facilitating the binding of charged molecules to the surface of the resin in the vessel. The resin can subsequently be extracted to eliminate impurities. Ion exchange can also aid in reducing the amount of chlorine in water, enhancing its safety for consumption.

7. Reverse Osmosis

At this stage, water is compelled through a membrane that permits only water molecules to pass while retaining suspended solids, bacteria, viruses, salts, and other contaminants. This process can eliminate up to 99 percent of all contaminants, rendering it one of the most effective purification methods.Reverse osmosis demands less energy than alternative methods, making it an efficient and economical option. Moreover, this method does not necessitate the use of chemicals, rendering it an environmentally friendly choice. Reverse osmosis is frequently employed in conjunction with other purification stages, such as activated carbon filtration and UV sterilization, to ensure the water is as pristine as possible.





Since the water to be purified is rainwater, these stages can be shortened to:

1. **Collecting rainwater**
2. **Sedimentation**
3. **Filtration**
4. **Disinfection: by using UV Sterilization**
5. **pH Adjustment**
6. **Storage**
7. **Distribution**

This system acts as a part of water exhibitions.

WATER PURIFICATION SYSTEM

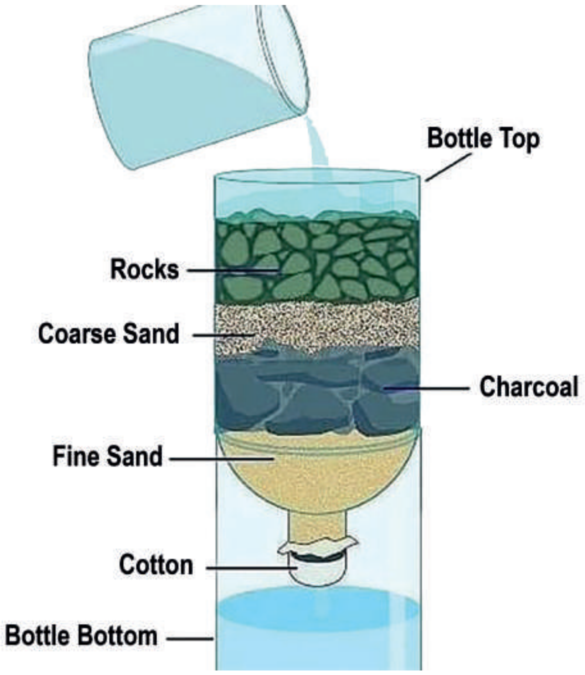
Based on the theory of learning by doing, the project offers stands where visitors can do an experiment about water filtration by themselves.

DIY Water filtration:

Visitors will acquire knowledge about designing and constructing a basic water filtration system using various materials, each serving to separate solids of varying sizes and dissolved molecules from water.

The experiments consist of three stages:

1. Pretreatment for screening large solid impurities.
2. Primary sedimentation to remove impurities through adsorption to solids.
3. Secondary treatment to break down or decompose the remaining impurities.



(Fig.6 Adapted from Reddit)

Method:

Visitors will construct their filtration system by placing an empty water bottle upside down on a designated table. They will observe that the optimal method for water purification involves layering materials based on their size.

Cotton wool should be placed at the bottom (in the neck of the bottle) to prevent other filter materials from falling out. On top of the cotton wool, crushed charcoal should be added, followed by sand, then gravel. As an optional extension of this exercise, the thickness of the layers can be adjusted to explore their effect on the refining process.

Through this hands-on activity, visitors will discover that each filter material is effective against specific types of solid impurities found in polluted water. When combined to create an effective water filtration system, these materials must be arranged in layers according to size.

The function of sand and gravel is to separate or filter solids of different sizes, with sand removing smaller particles.

Ground charcoal, when added, absorbs chemicals dissolved in contaminated water and removes color. Additionally, contaminated water flows through coal at a slower rate, providing more time for contact and absorption. The longer the dirty water stays in contact with the ground charcoal, the greater the chance that the charcoal will absorb color.

This experiment demonstrates that impurities in contaminated water can be effectively removed through a series of barriers, using either physical (gravel and sand filtration) or chemical (sorption with ground coal) processes. It is important to note, however, that this type of treatment is not effective against microorganisms.

Testing:

The proposal offers also stands where visitors can test their experiments by hand and look at the quality of water, like pH, turbidity, and dissolved oxygen. making comparison with polluted water.

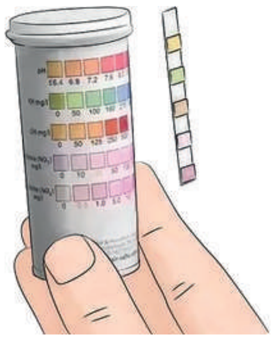
Discovering the chemistry of water, visitors mix different substances to learn about water chemistry.

WATER PURIFICATION SYSTEM

Testing:

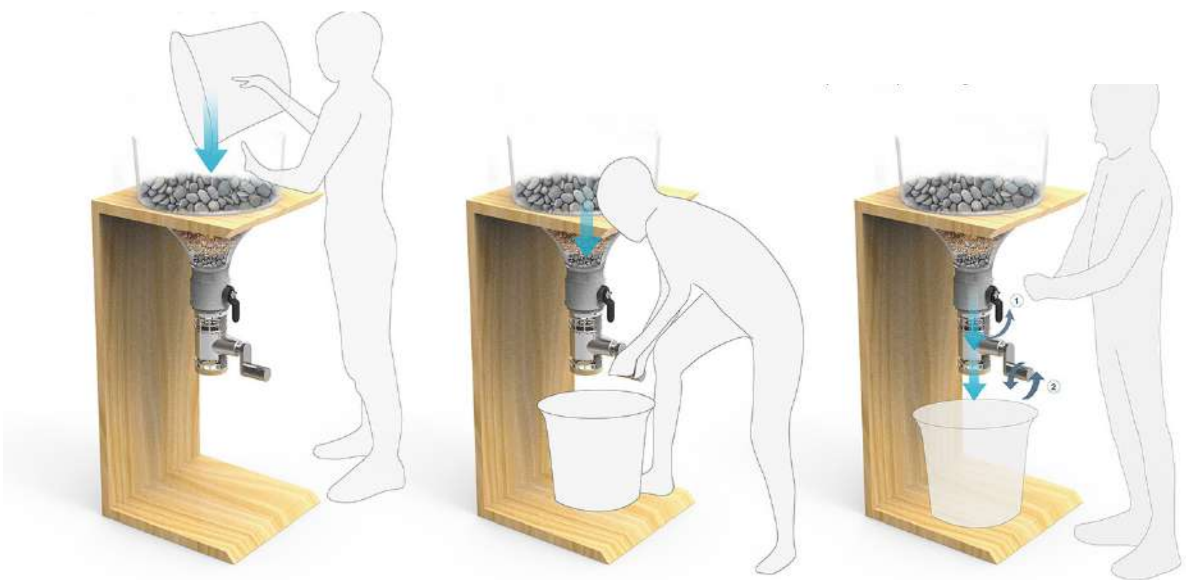
The proposal also includes stands where visitors can manually conduct experiments to examine water quality parameters such as pH, turbidity, and dissolved oxygen. They can then compare these findings with those of polluted water samples.

Additionally, visitors have the opportunity to explore water chemistry by mixing various materials and observing the results through microscopes and screens.



(Fig.7 Adapted from wikiHow)

The proposal also includes general water filters, which are water filters and UV sterilizers that operate without the need for an external power source. They are suitable for use in underserved areas where access to clean water is challenging and contamination with bacteria and sediments is common.



(Image 1. Source: Green Product Award)

WATER DISCOVERY AND HAVING FUN

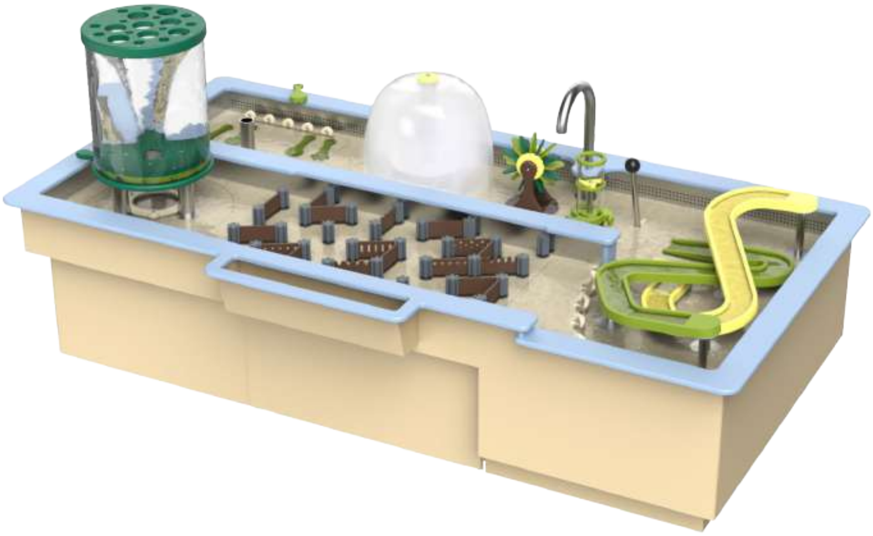
The proposed educational center creates spaces along the water trail to incorporate water tables for children.

The concept of these tables is to blend science with fun, as children learn about the scientific and hydraulic principles of water and its benefits in nature.

For example, children can construct a dam using plastic pieces to regulate the flow of water. This water flow can then activate a dynamo, generating a current that illuminates a lamp.

Alternatively, these tables can feature scientific experiments and interactive tests in an engaging manner. For instance, children can explore Bernoulli's principle by experimenting with water jets that propel plastic balls into a swirling vortex.

These tables can be redesigned and shaped to fit the spaces provided by the proposed design.



(Image 2. Source: Boss Display & Momentum Interactives).

W:1371mm
L:2590m

(Image 3. Source: Boss Display & Momentum Interactives).

W:1524mm
L:3962mm

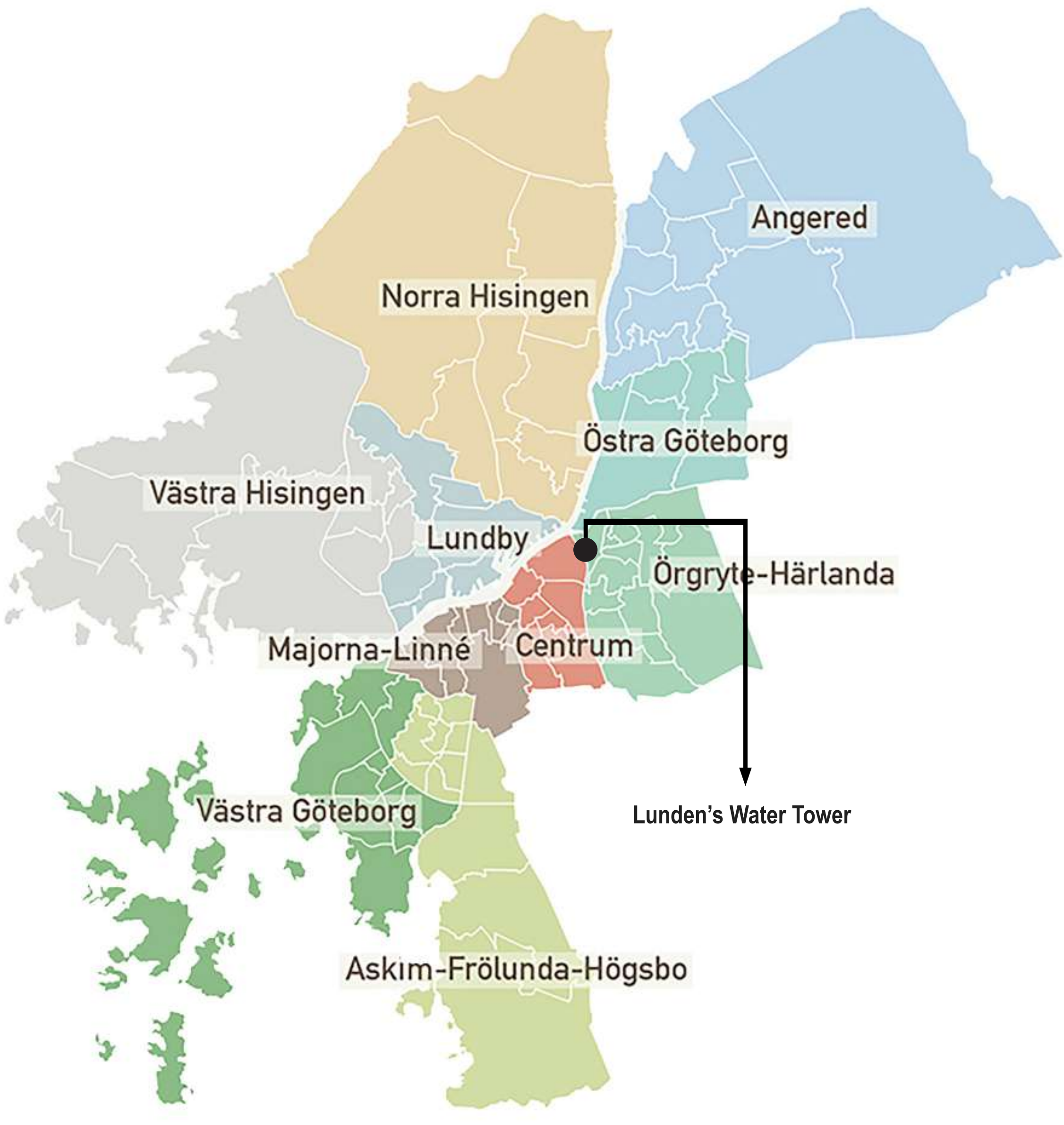
IV. CONTEXT

CONTEXT OF THE PROJECT

The water tower in question was built in Lunden district in 1930, near the center of Gothenburg, towards the east. The Lunden's water tower is a prominent landmark in Gothenburg because it is located at the top of a green hill that resembles a micro-forest.

The architectural context of the site consists of residential buildings built during the first three quarters of the twentieth century, some of which include small shops on the ground floors.

The tower can be reached via a street called Ingeborgsgatan and another street called Sankt Pauligatan, where stone steps lead pedestrians up to the tower and up the hill.



CONTEXT OF THE PROJECT

(Map 1. Source: Eniro.se)

CONTEXT OF THE PROJECT

The tower is an octagonal concrete structure covered with plaster and is approximately 46 meters high and the built area is about 69 m².

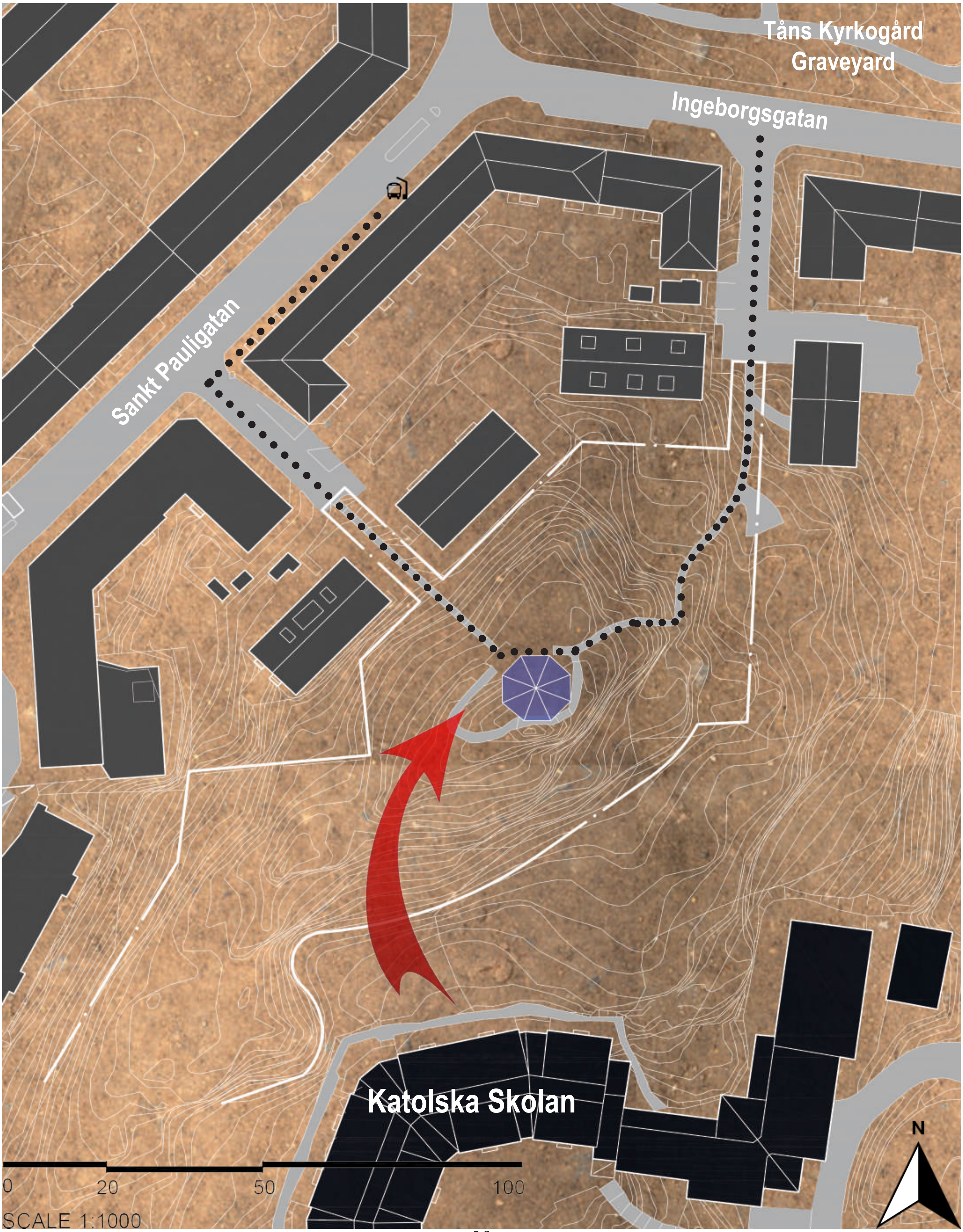
The entrance has a chamfered extension on the inside, and the tower ends upward with a strong roof. At the bottom, the corners are designed as wall columns that “hold” the upper part.

The Lunden’s water tower has a carefully designed exterior by the architect Eugen Thorburn and is an important landmark in the cityscape (Jonsson et al., 2017).

From the inside, the tower includes a concrete staircase 80 cm wide that leads to the top of the tower, where the water tank rests on eight concrete supports.

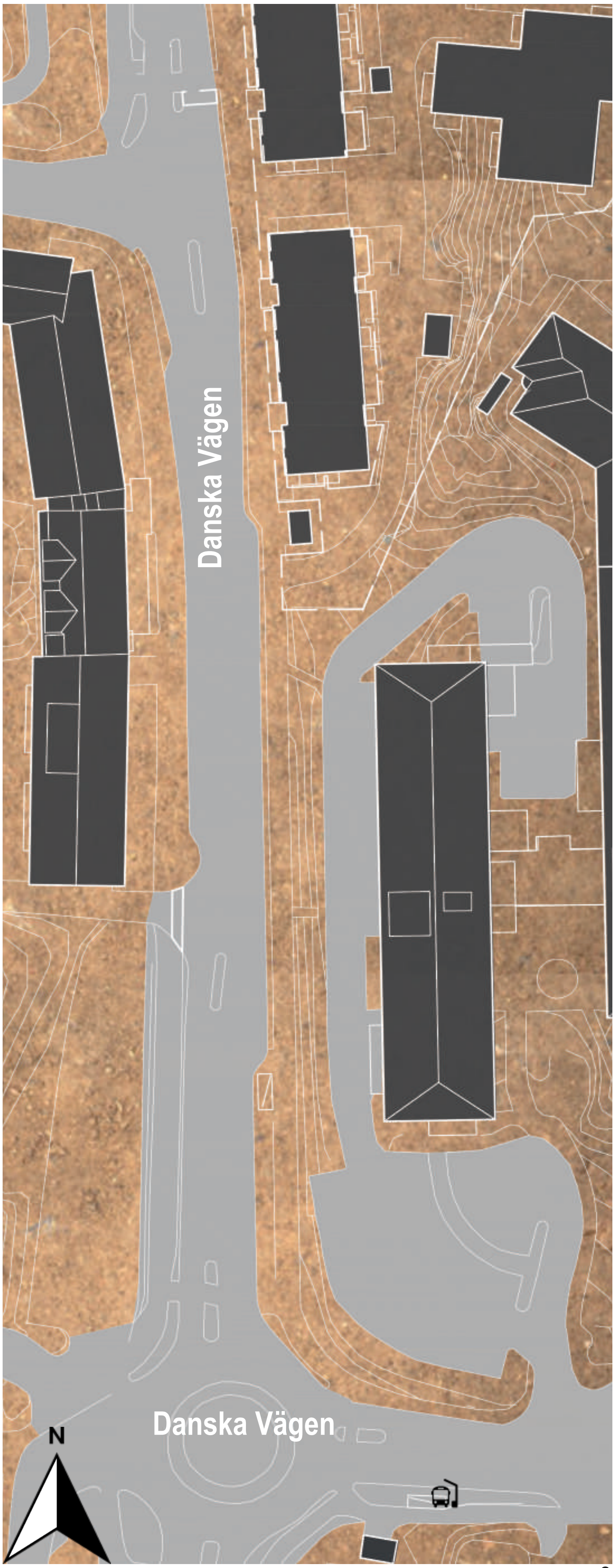
Water tower facilities do not have sufficient spaces for different and diverse uses as they were originally built for the sole purpose of storing and distributing clean water to the neighborhood. The height gives the water enough pressure as it falls freely to aid in the distribution process.

(Source: Photo taken by author)



Tåns Kyrkogård
Graveyard
Ingeborgsgatan
Sankt Pauligatan
Katolska Skolan
N
0
20
50
100
SCALE 1:1000

SITE ANALYSIS



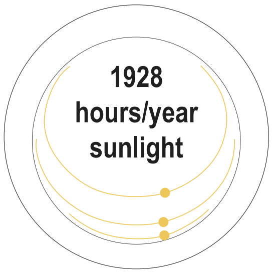
Residential.

School.

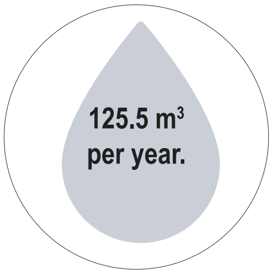
Water Towe.

Existing Trail.

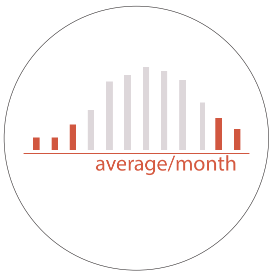
Bus Station.



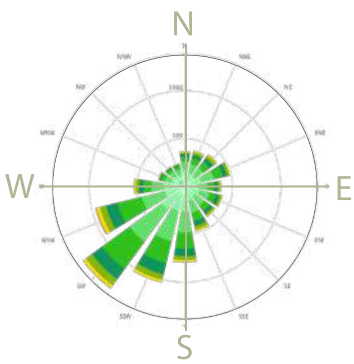
SUN



RAIN



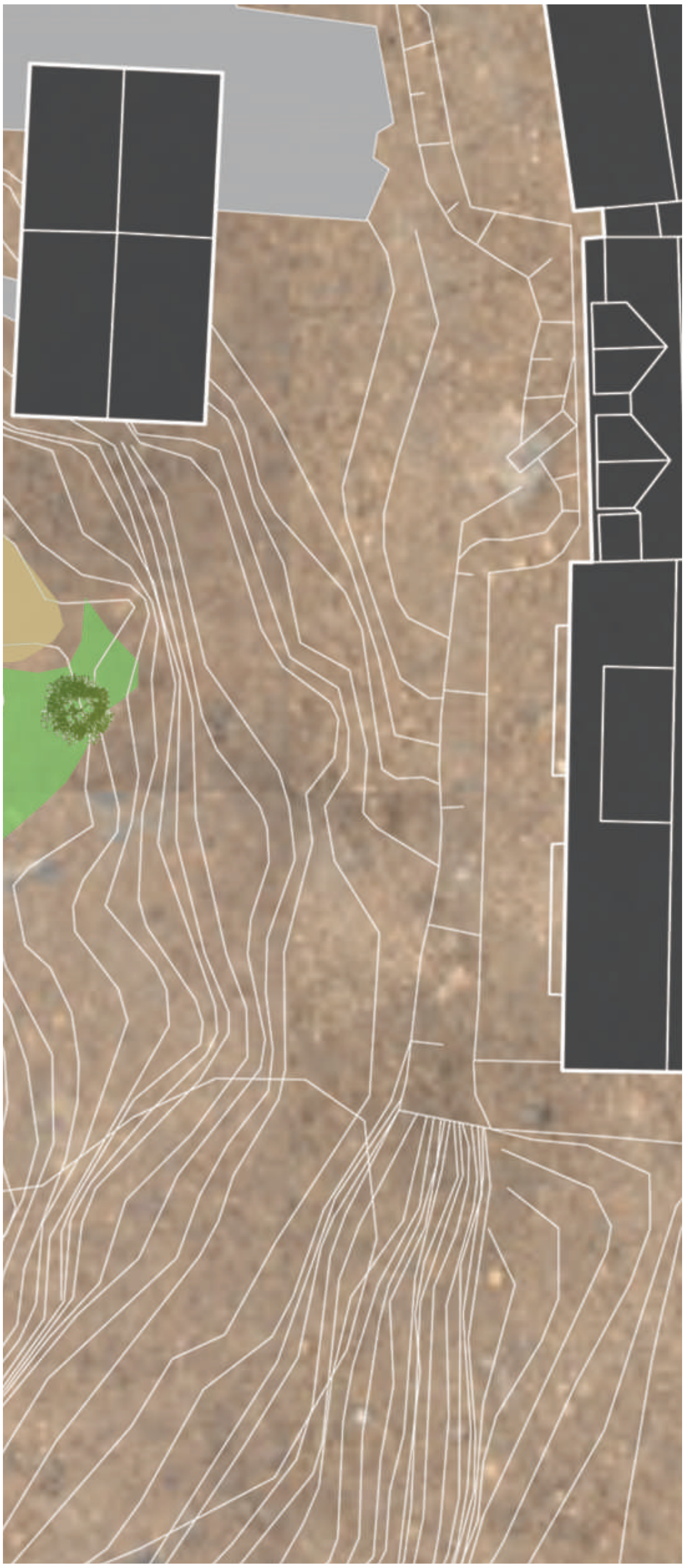
TEMPERATURE



WIND

SITE ANALYSIS

SITE ANALYSIS



Zone 1 no trees.

Zone 2 shrubs.

Zone 3 microforest.

Some types of plants found on the site:

Sycamore (Acer pseudoplatanus)

Carpinus betulus

Fagus japonica

Shrubs

(Source: Photos taken by author)

N

0 10 20 40

SCALE 1:500

HISTORY OF LUNDEN'S WATER TOWER

History of Lunden		History of Gothenburg's water supply
	1621	From Gothenburg's founding and during the roughly 150 following years, the inhabitants had to make do with the water that was in the canals and moat.
The area that is now the Lunden district has mainly belonged to the Lunden property, one of the larger farms in Örgryte parish.		
	1640	In the 1640s, the Fattighusån was built and the city's population gained access to that water as well. However, waste water and waste also ended up in the canals and moat.
	1787	The water line from Kallebäck's source was inaugurated following patterns from England and Scotland. From here, water was transported to the city through pipes made of filled logs.
	1860	At the end of the 1860s, there were 15 public water points between Masthuggstorget in the west and Drottningtorget in the east, and 15 lots with withdrawn water.
Tån's cemetery was added at Danska Vägen.	1867	
	1871	Over time, the water from Kallebäck's spring became insufficient to cover the city's needs, in 1871 the Delsjöverket was ready to be put into use.
In 1877 the owner, merchant Linus Strömsten, began selling plots and one of the first to buy plots was a person came from Tjörn and the area came to be known as Tjörbostaden after him.	1877	
	1880	In 1880, there were after this 64.3 kilometers of water pipes in the city, in contrast to 4.8 when Kallebäck's source was taken in. Then in the mid-1880s it was predicted that even with the Delsjöverket, the city's water needs could not be ensured.
The population receives water from a number of wells described in a newspaper article from 1884 as follows: ***"The number of wells is quite insignificant, and they all have, as was explained with great satisfaction, cold water, but how? Cloudy and black, and in a place where the householder pays the well owner 10 to 15 kroner annually so that the households will have the drinking, cooking and washing water they need, this was anything but suitable, at least for drinking".***	1884	
	1888	In 1888, the municipality of Gothenburg came up with a proposal to draw water from Göta River at Alelyckan to meet the growing water needs.
Örgryte's "Retirement home", was added after a donation by J J Dickson in Överås.	1889	

HISTORY OF LUNDEN'S WATER TOWER

History of Lunden

Befor 1894, residents of Lunden obtained water from local wells.

Turning point

1894

In 1894, the Alelyckanverket was put into use, so when Gothenburg's water began to be taken from the Göta River at Alelyckan in 1894, pumps were needed to maintain the pressure in the water pipes, with this, one of the main arguments for giving the high-lying districts like Lunden from getting access to municipal water.

1908

On a map of Örgryte parish from 1908, the then plans for Lunden can be seen. A large square next to Danska vägen, a church at Örgryte new cemetery, and a large primary school and a public park on the slopes on the eastern side of Danska vägen were planned for. Next to the elementary school, can also see a water tower drawn into the foundation of Brahegatan (today Torkelsgatan), which was then supposed to go further east than the current street does. The water tower is located in the corner of a small square that is named Olof Wijks-platsen on the map.

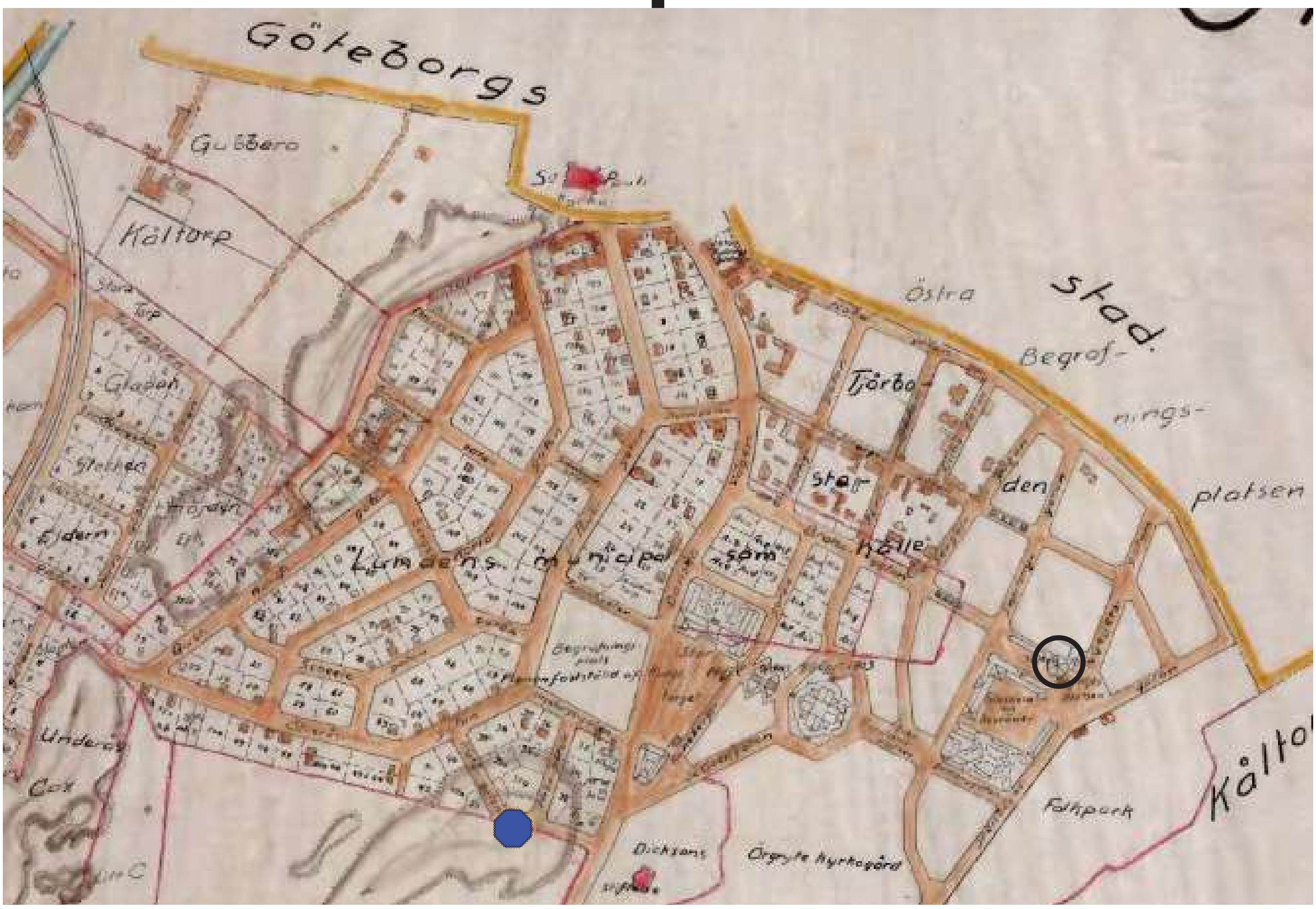
History of Gothenburg's water supply

1894

The Alelyckanverket was put into use, then with slow filtration of the water before it was pumped out into the city's network.

The existing water tower, built 1930

The planned water tower,1908



(Map 2. Source: Det gamla Göteborg)

HISTORY OF LUNDEN'S WATER TOWER

History of Lunden	Year	History of Gothenburg's water supply
Lunden school was built for the relatively large population in and next to it was Örgryte's new cemetery.	1914	
Of the buildings planned in Lunden during the last two years of the 1920s, the drawings show that all are planned with access to running water. The architect Eugen Thorburn who is responsible for the drawings for the tower that is being built. He had previously drawn Johanneberg's water tower in 1925, and also Lundenskolan in 1914.	1920	
	1930	In 1930, there were 296.3 kilometers of water mains in Gothenburg. By then, even the city's high areas had begun to be supplied with water.
AB Skånska Cementgjute¬rier was the contractor for the construction of the water tower, and in June 1931 the work was inspected, approved, and the water tower could be put into use. In the same year that the water tower was built, water was pumped from Alelyckan to the water tower in Lunden.	1931	
	1965	In 1965, Gothenburg's fourth waterworks was inaugurated when the Lack¬arebäcksverket began supplying the city with water that was pumped from the Göta river to be purified at Lake Delsjön before being pumped into the mains.
In 1968, the waterworks in Lackarebäck was inaugurated so, Lunden ended up in a so-called mixed water zone, which meant that the water came from both Alelyckan and Lackarebäck. From then on, the water is pumped up to Lunden's water tower via a pumping station on Kärralundsgatan.	1968	
	1987	In the Conservation Program for Buildings of Historic Cultural Value of the City of Gothenburg, the Water Tower in Lunden is included and must therefore be interpreted in accordance with Chapter 8 § 13 of the Planning and Building Code "a building of special value from a historical, cultural, environmental or artistic point of view and may not be distorted" .
	2023	

Lunden's Water Tower is out of service today, and it is a protected structure according to the 1987 Conservation Program of the municipality of Gothenburg.

HISTORY OF LUNDEN'S WATER TOWER

View towards the mountain where the water tower would be built, from the northwest in 1922.

(Image 4. Source: Kulturmiljöunderlag Lundensvattentornet)

View to the west from the mountain on which the water tower was later built,1922.

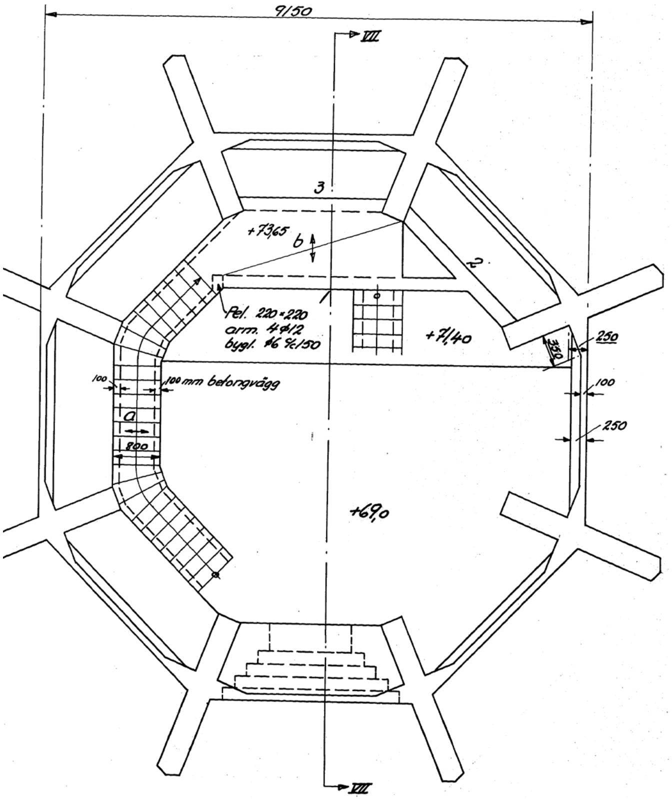
(Image 5. Source: Kulturmiljöunderlag Lundensvattentornet)

Lunden's water tower, Tåns cemetery and the nearest buildings seen from the east in 1955.

(Image 6. Source: Kulturmiljöunderlag Lundensvattentornet)

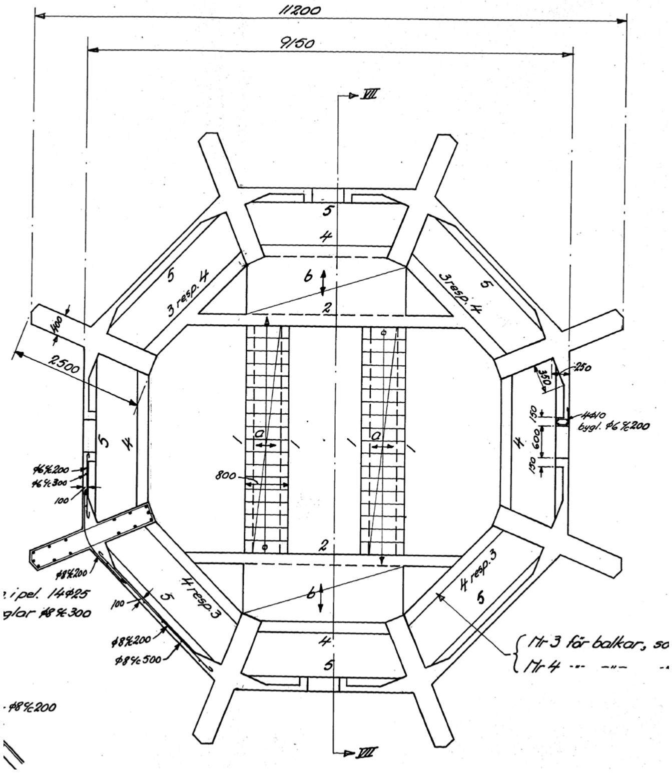
V. DESIGN PROPOSAL

LUNDEN’S WATER TOWER AS BUILT



Level 1

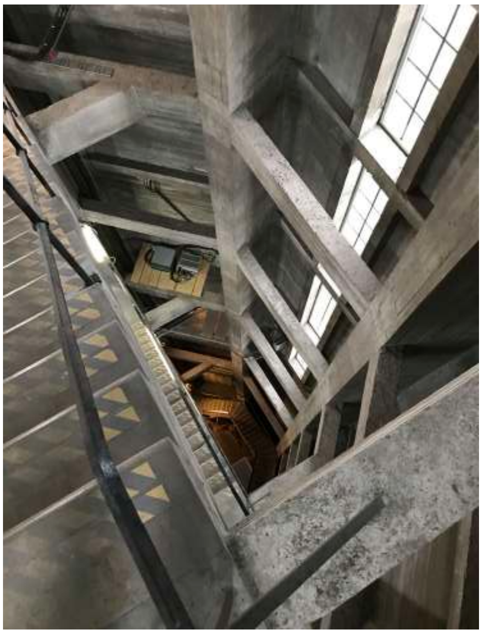
(Drawing 2, Source: Stadsbyggnadskontoret, Gothenburg)



Repeated Floor

(Drawing 3, Source: Stadsbyggnadskontoret, Gothenburg)

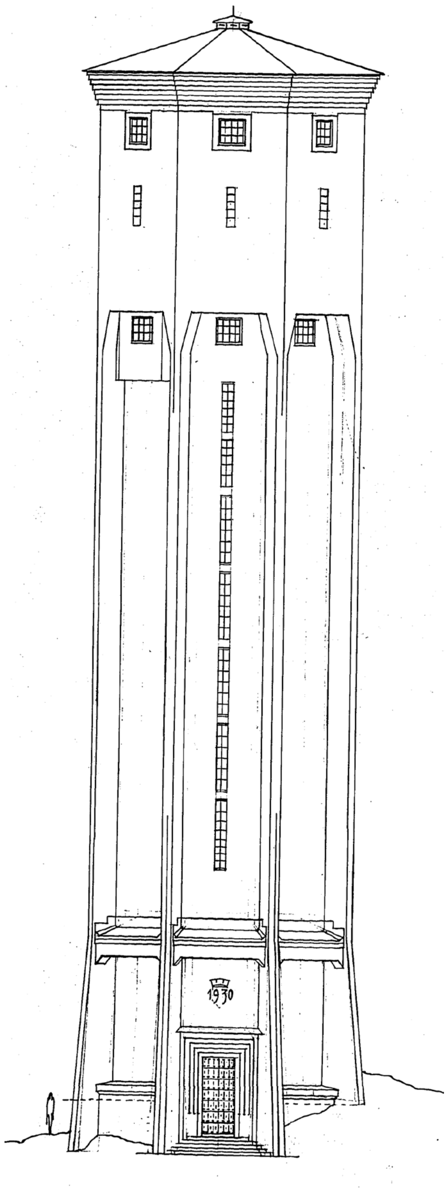
The level under the water tank



Repeated Floor

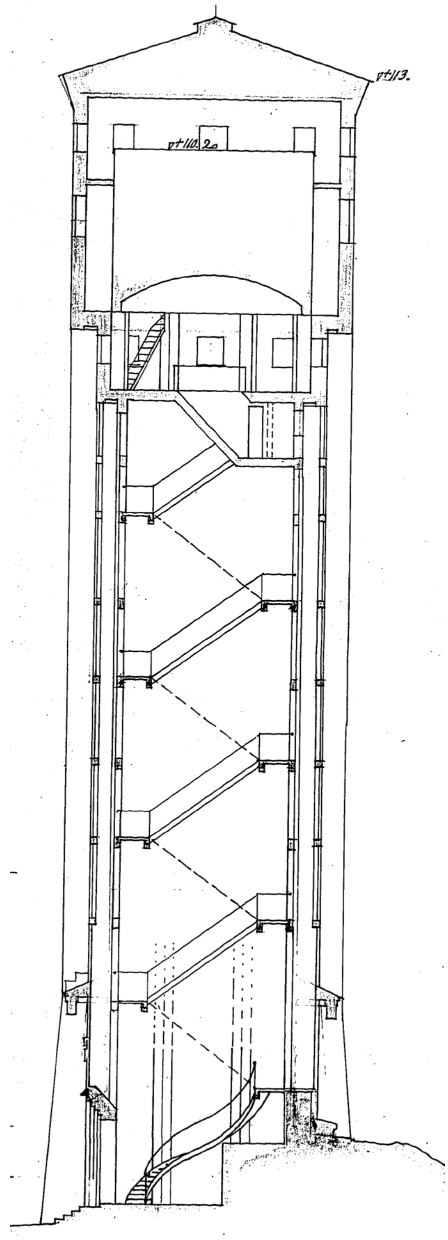
(Source: Photos taken by author)

LUNDEN'S WATER TOWER AS BUILT



Main Facade

(Drawing 4. Source: Stadsbyggnadskontoret, Gothenburg)

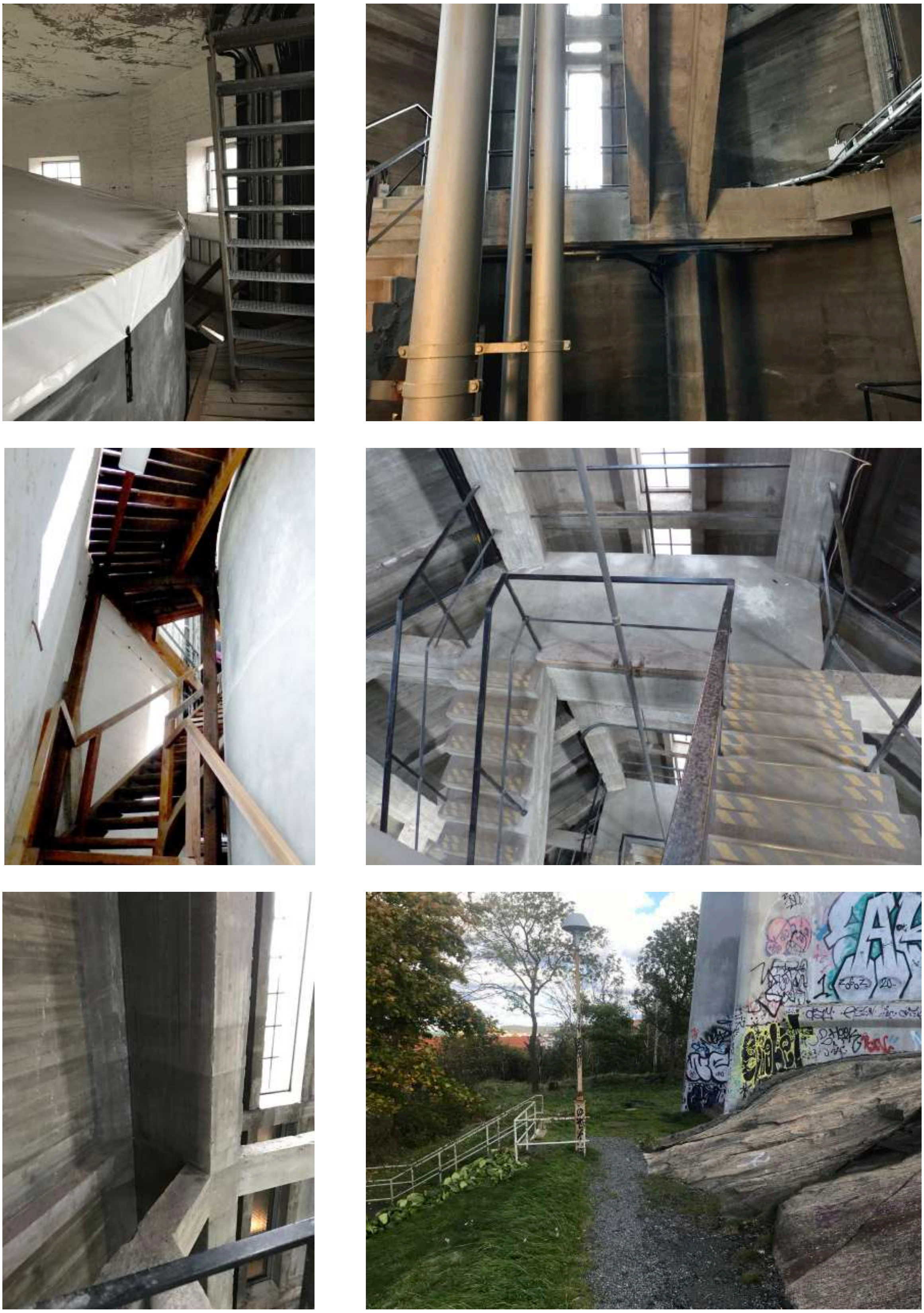


Section VII

(Drawing 5. Source: Stadsbyggnadskontoret, Gothenburg)

These drawings and photographs show how concrete structural elements form the architectural identity of the Lunden's water tower, both indoor and outdoor.

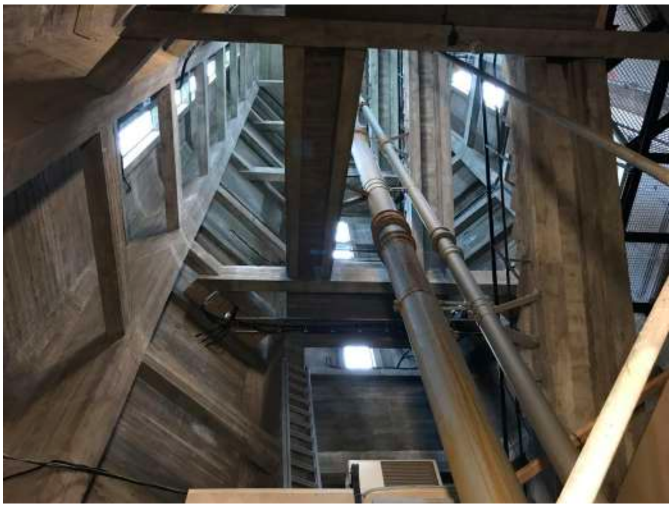
LUNDEN’S WATER TOWER AS BUILT

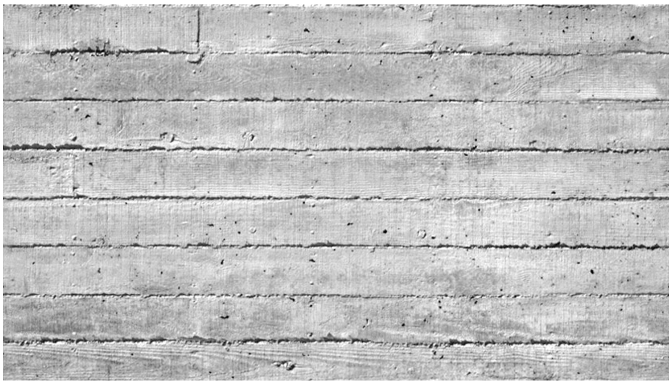


(Source: Photos taken by author)

CONCEPT

The water tower in Lunden reflects the identity of an industrial structure, typically characterized by its somewhat harsh appearance. This is evident through the massive concrete supports, narrow longitudinal windows, and the narrow, elongated concrete stairs, all contributing to a sense of austerity in contrast to the notion of soft, flowing water.





The concept aims to design architectural interventions that transform the inner space of the tower into a place of contemplation and insight bridging the past and present, and a moment of enlightenment amidst light and darkness.

This is achieved by accentuating concrete as the original building material and a pivotal element of the Lunden water tower's architectural identity.

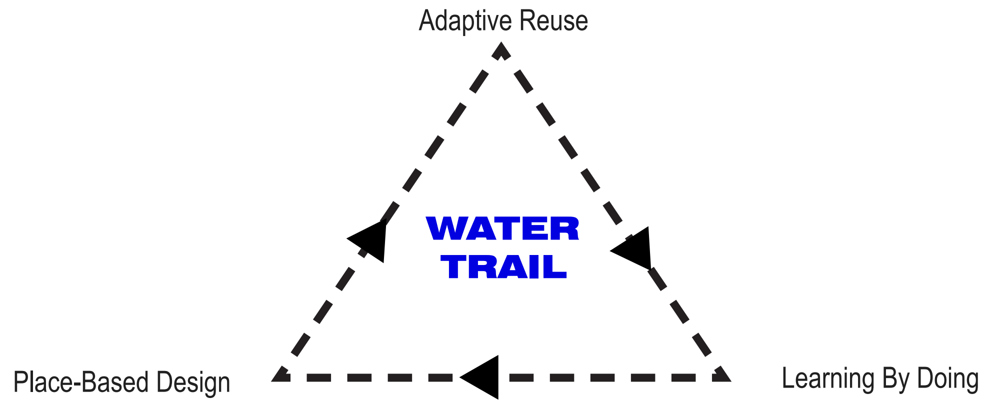
Inspiration for this design concept is drawn from the essence of the site and the natural and architectural elements surrounding the tower, as well as from the historical issue of potable water scarcity in the area previously.

In 1894, the Alelyckan water station commenced operations in Gothenburg, underscoring the necessity of pumping water to maintain balanced pressure in the city's water system. This marked a pivotal moment for the Lunden neighborhood, which previously lacked access to a clean, potable municipal water supply due to its elevated position. Recognizing the increasing demand in the area, the construction of a water tower became imperative at the turn of the 20th century.

By harmonizing history with site characteristics, such as existing pathways, clarifies the design concept. This involves architecturally activating these pathways by integrating them into the water tower and designing a water path guiding visitors to the top of the Lunden's water tower, where the water reservoir is housed.

(Source: Photos taken by author)

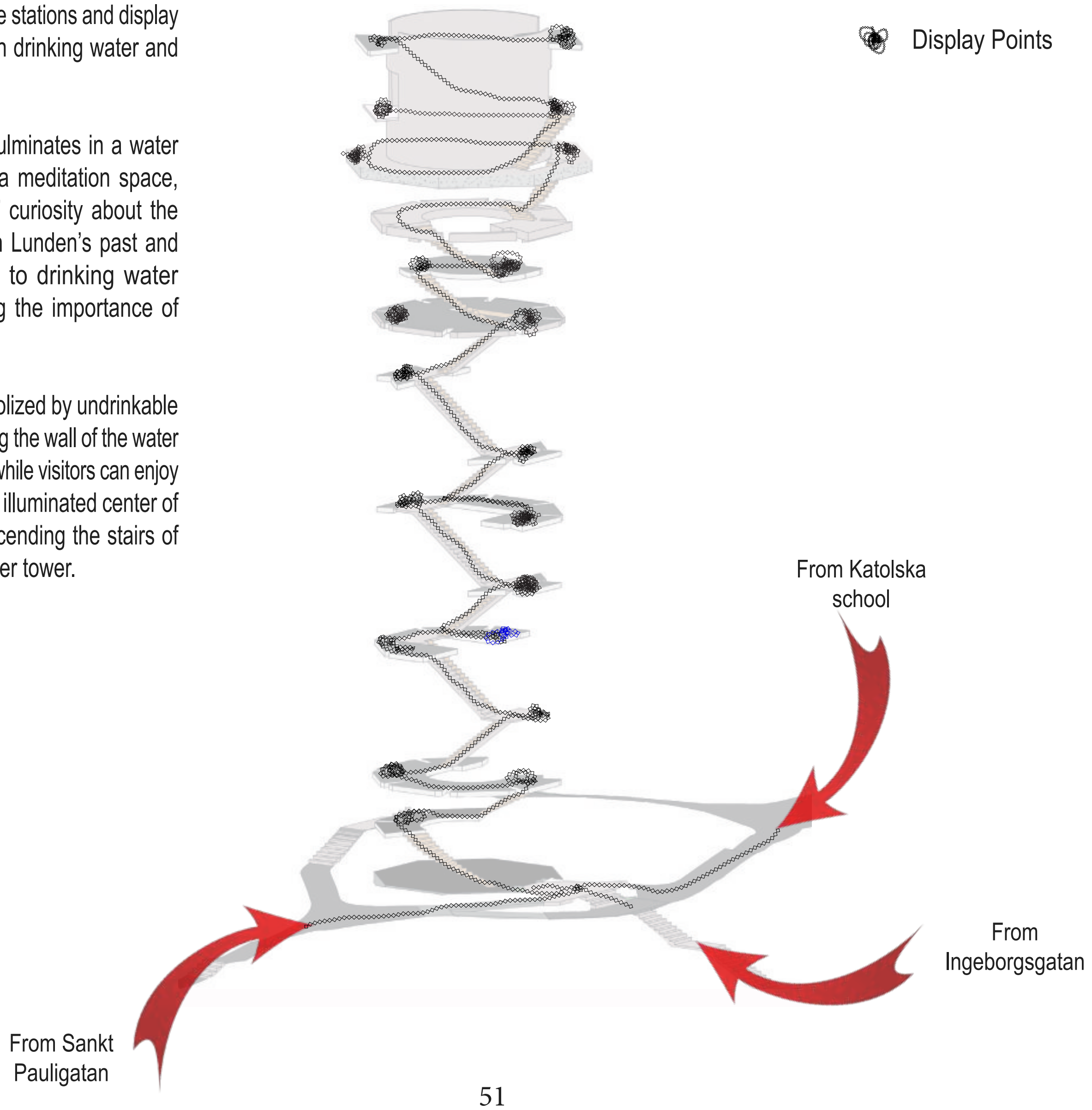
CONCEPT



En route, there are stations and display points focused on drinking water and its preservation.

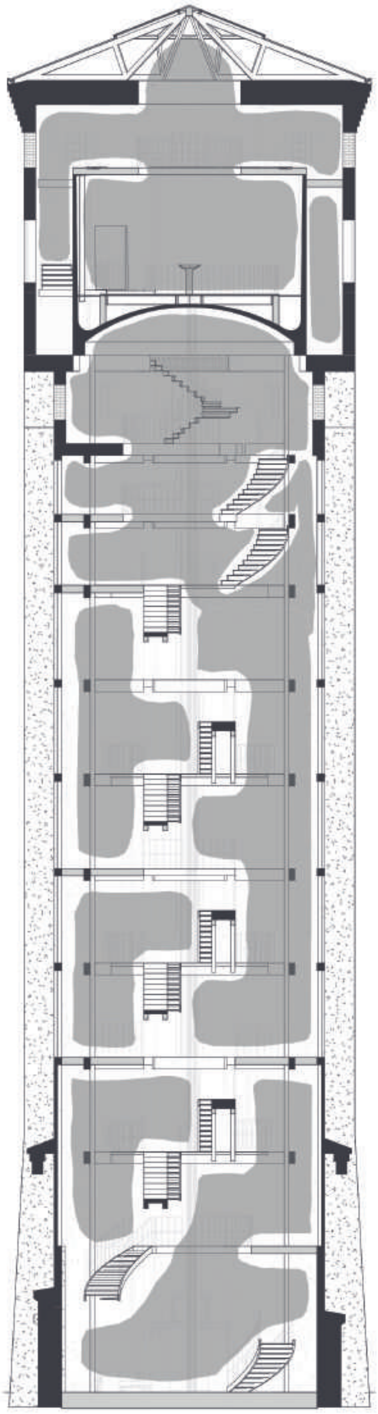
The water trail culminates in a water tank serving as a meditation space, arousing visitors' curiosity about the contrast between Lunden's past and present related to drinking water and emphasizing the importance of preservation.

The past is symbolized by undrinkable water flowing along the wall of the water tank in darkness, while visitors can enjoy fresh water in the illuminated center of the tank after ascending the stairs of the Lunden's water tower.



CONCEPT

This design presents an opportunity for creative drinking water display while enabling the public to explore the Lunden's water tower from within, examining its architectural and structural components. Achieving this involves opening up the interior and incorporating display corners across different levels, all within standards that uphold the tower's industrial identity and historical significance while captivating exploration enthusiasts.



The section shows how the internal volume is created by using this concept

(Original design of Lunden's water tower)
(Source: Unknown)

(Transformation Proposal)

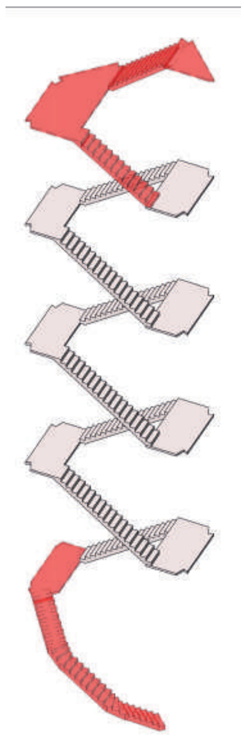
NEW SITE


W.C
Existing Trail
Existing Trail
New Trail
N
0
10
20
40
SCALE 1:500

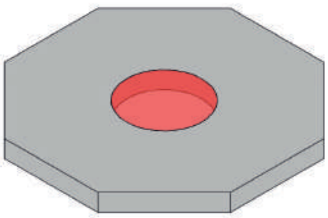
ARCHITECTURAL INTERVENTIONS

Architectural elements for demolition:

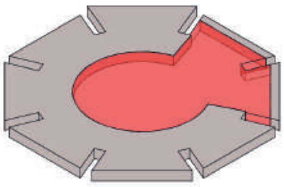
A -The red staircases on the ground, eighth, and ninth floors are not suitable for use due to their excessively high risers.



B -The red part of slab on the tenth floor to open space under the water tank, and the red part of slab under the existing roof to allow daylight in.

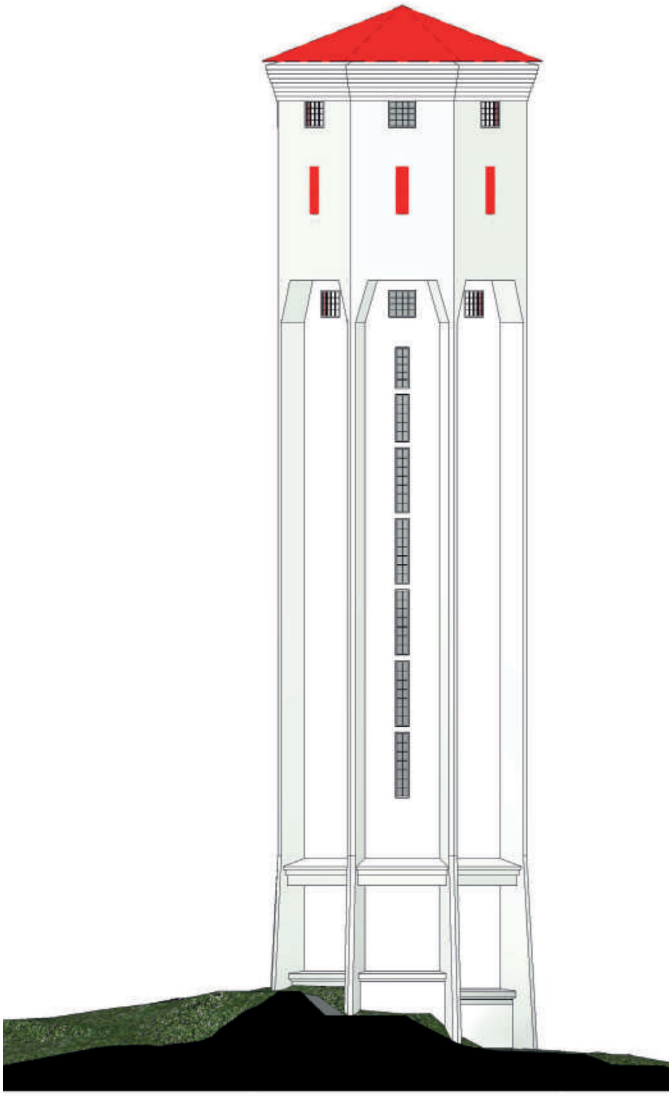


The slab under the existing roof.

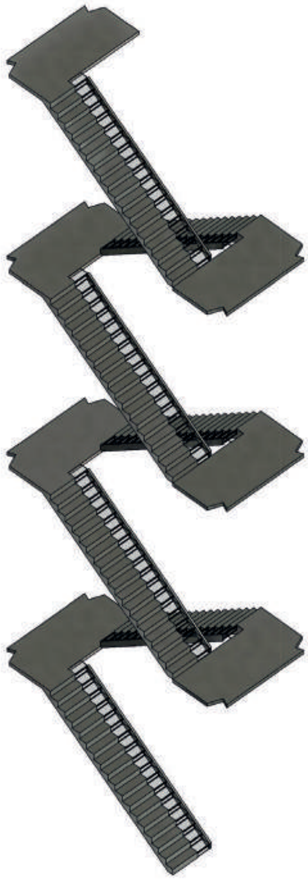


The slab under the existing water tank.

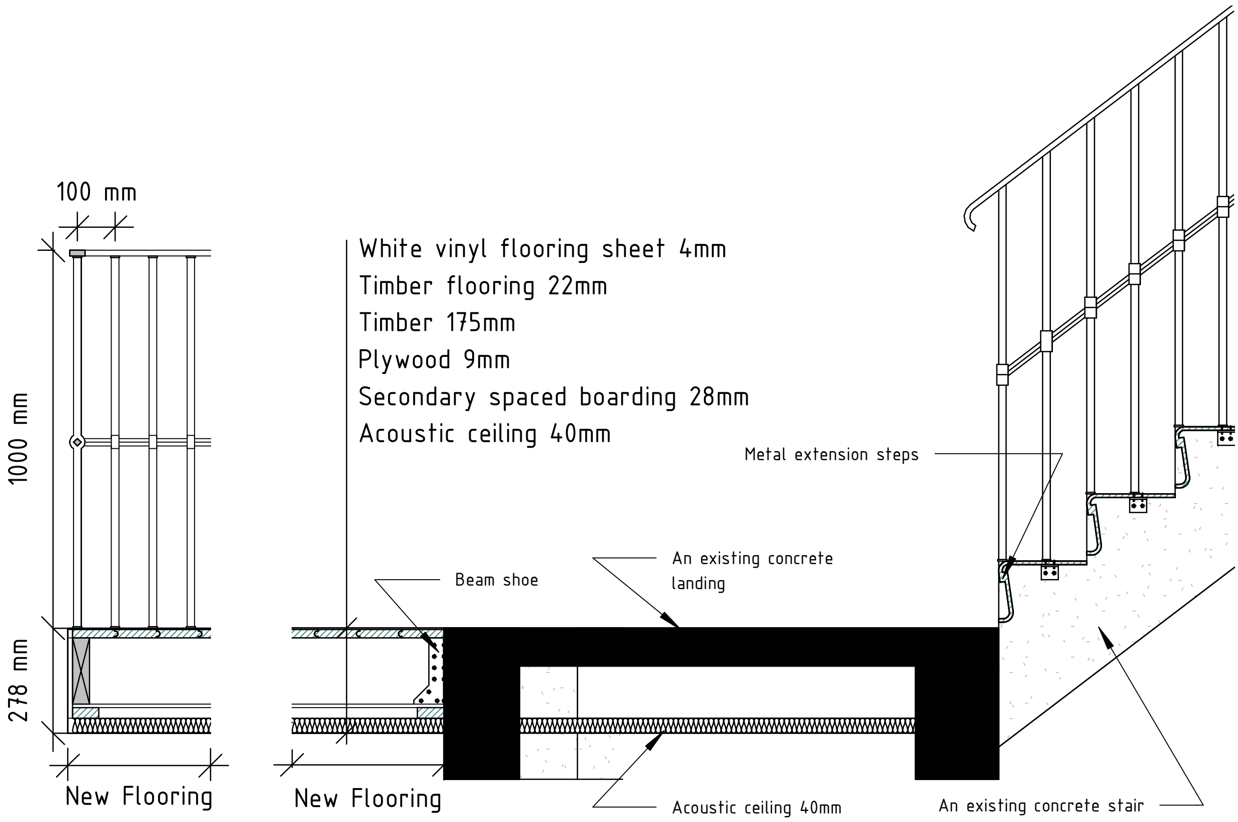
C -The red openings indicate the expansion of existing windows, as well as the replacement of the existing roof with a new one to let daylight in.



D -Extending the existing concrete staircases by adding a metal section, making them a total of 1200mm in width.



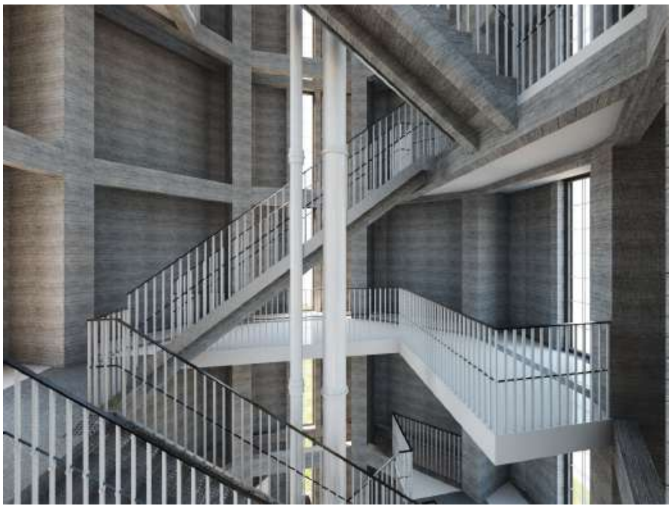
The design concept for the railing revolves around repurposing the existing structure, incorporating vertical metal elements for enhanced protection, all while employing the same manufacturing technique.



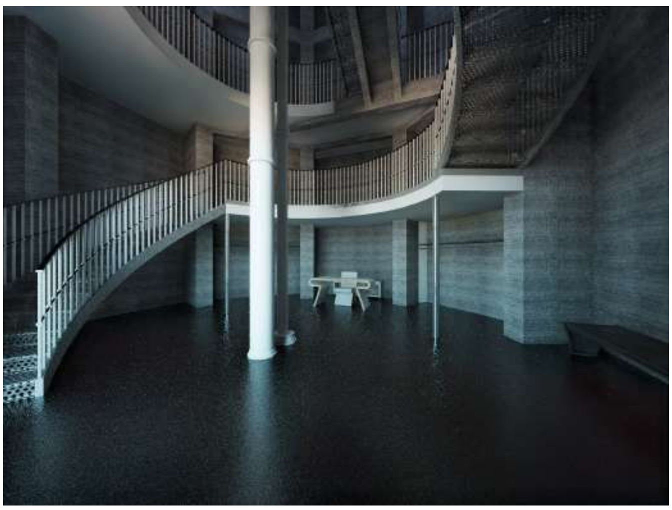
ARCHITECTURAL INTERVENTIONS

E -Opening in the water tank to allow visitors access to its interior (meditation room).

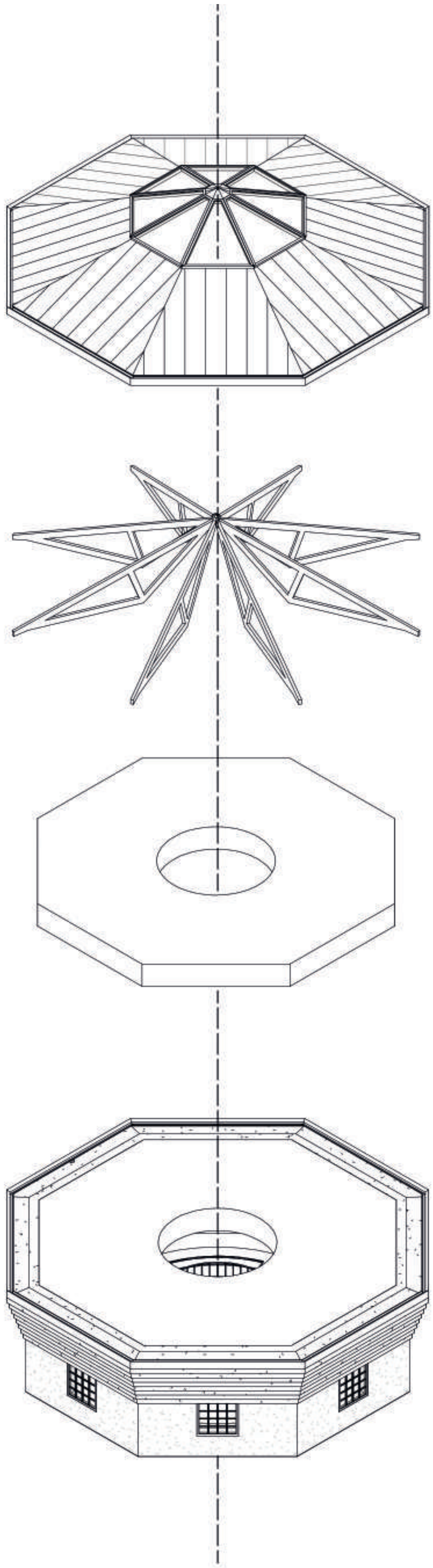
F -Adding balconies to the internal space that serve as display corners.

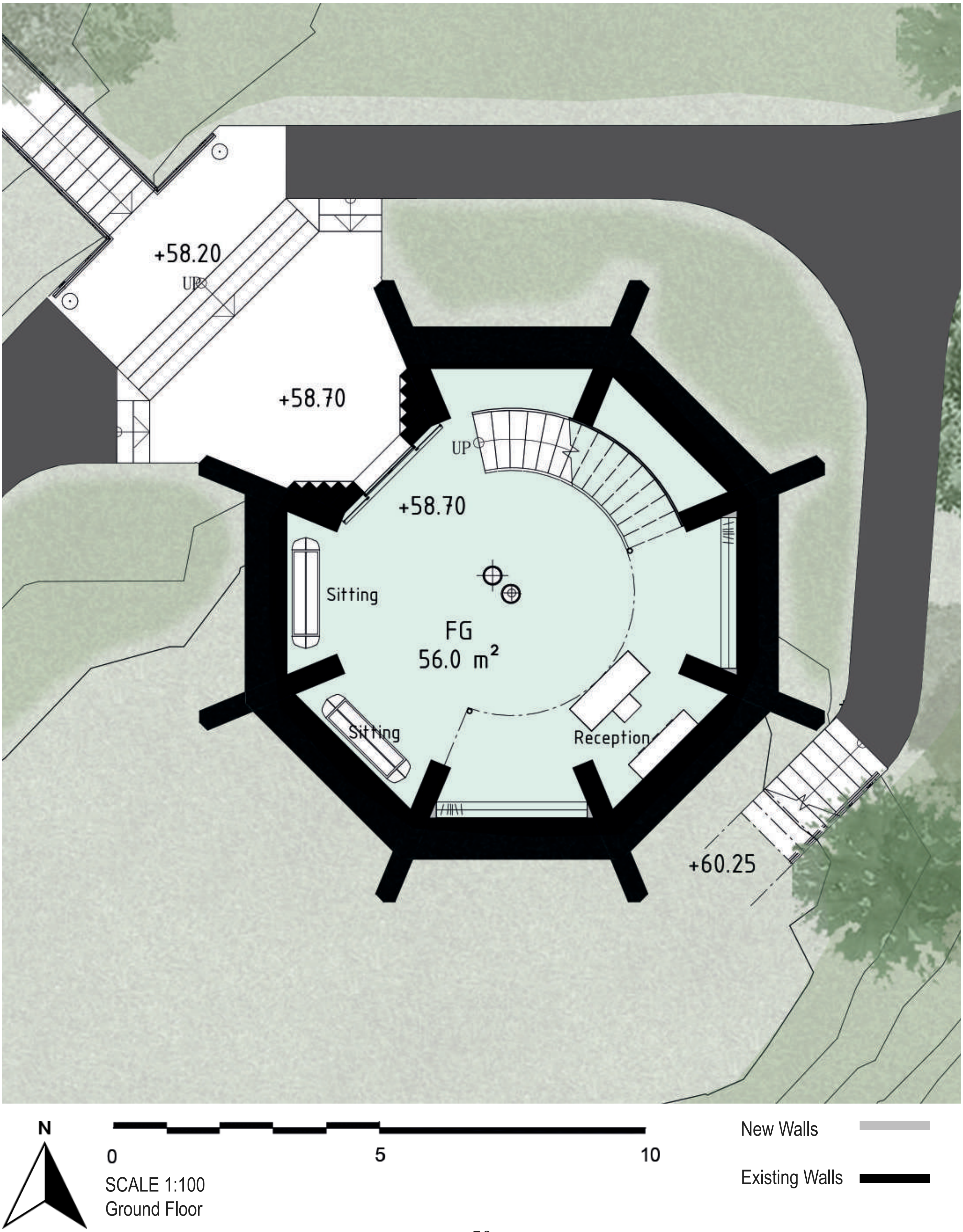


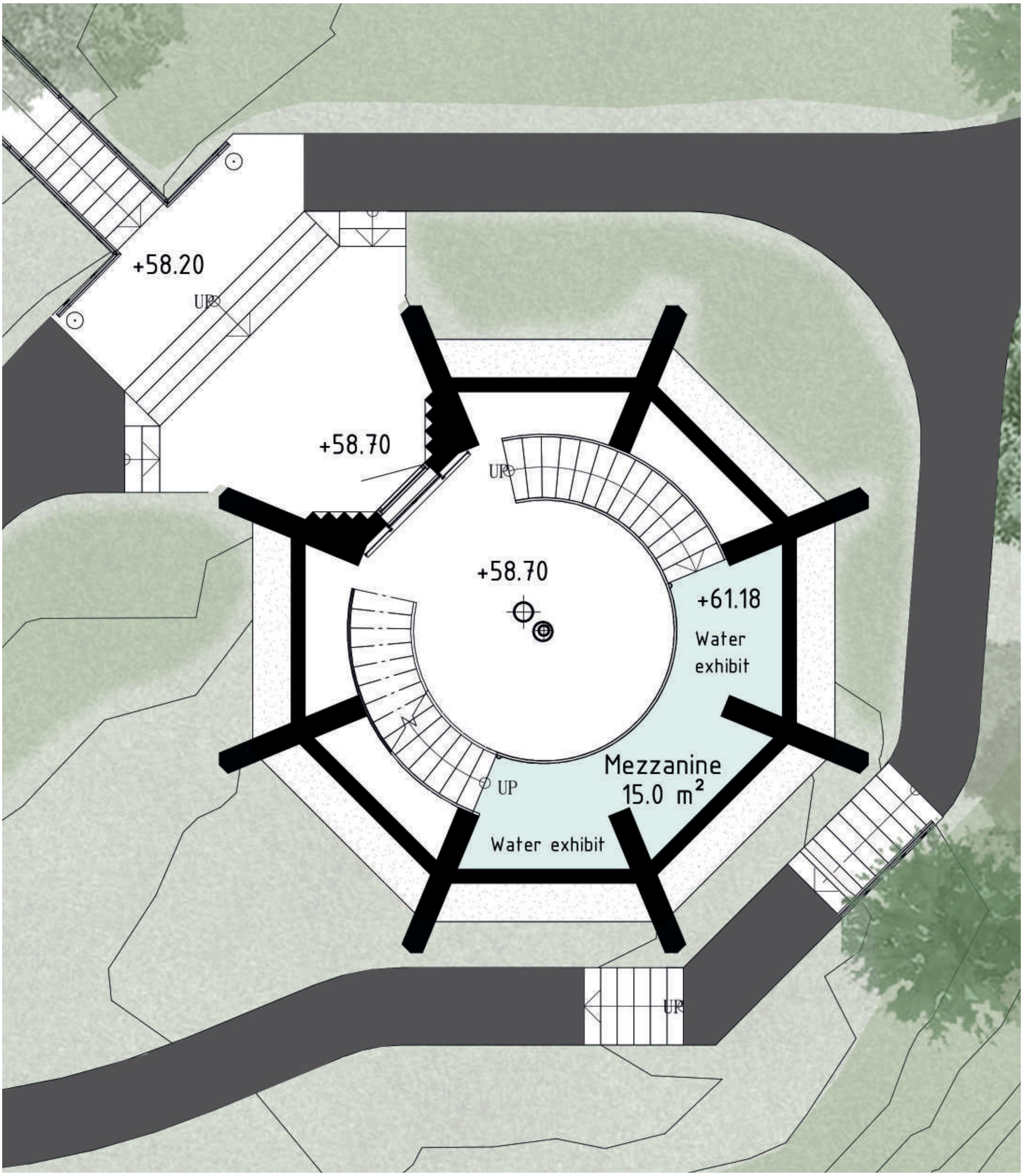
G -Adding metal staircases instead of those that were removed.



H -Replacing the old roof with new one to allow daylight in.




+58.20
UP
+58.70
UP
+58.70
Sitting
FG
56.0 m²
Sitting
Reception
+60.25
N
0
5
10
SCALE 1:100
Ground Floor
New Walls
Existing Walls



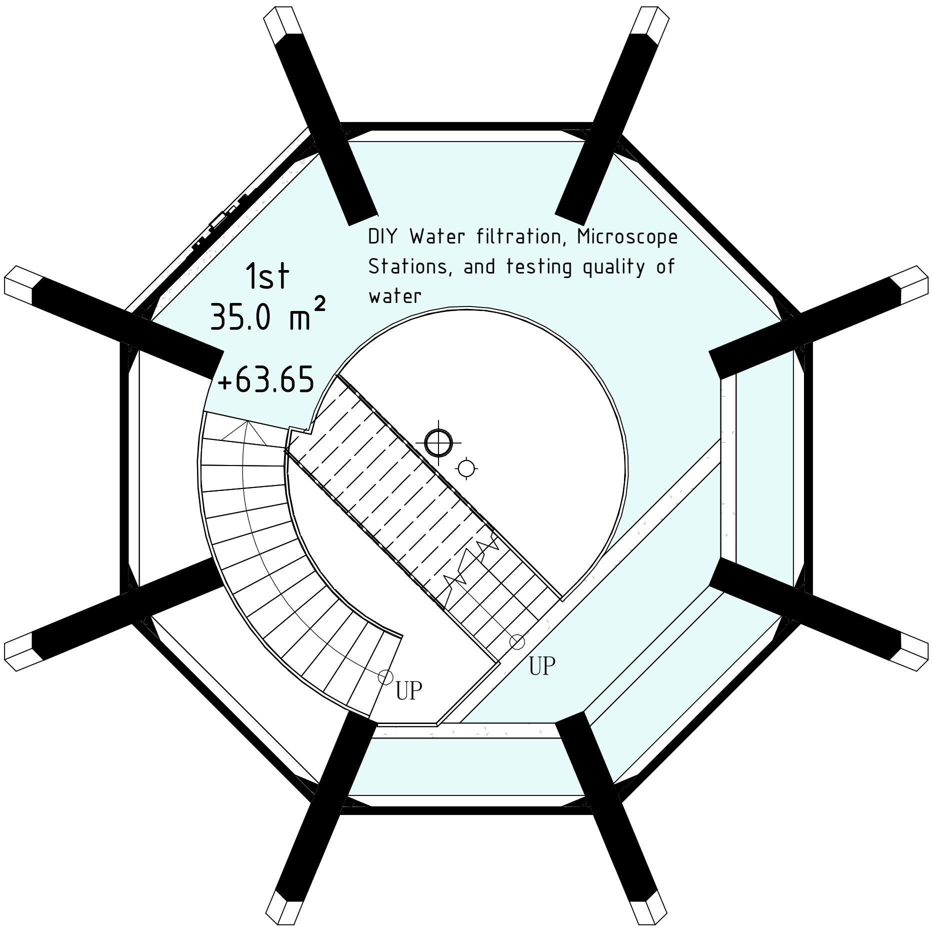
N

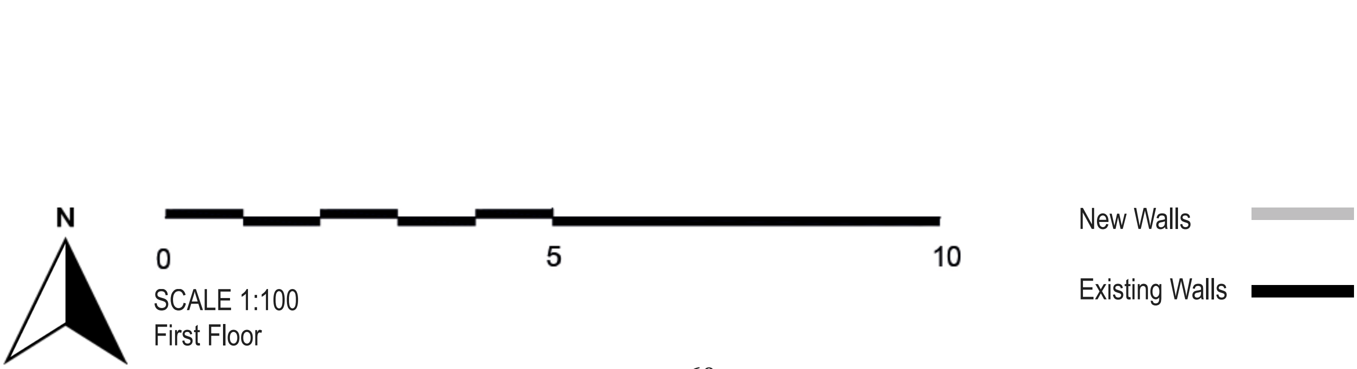
0 5 10

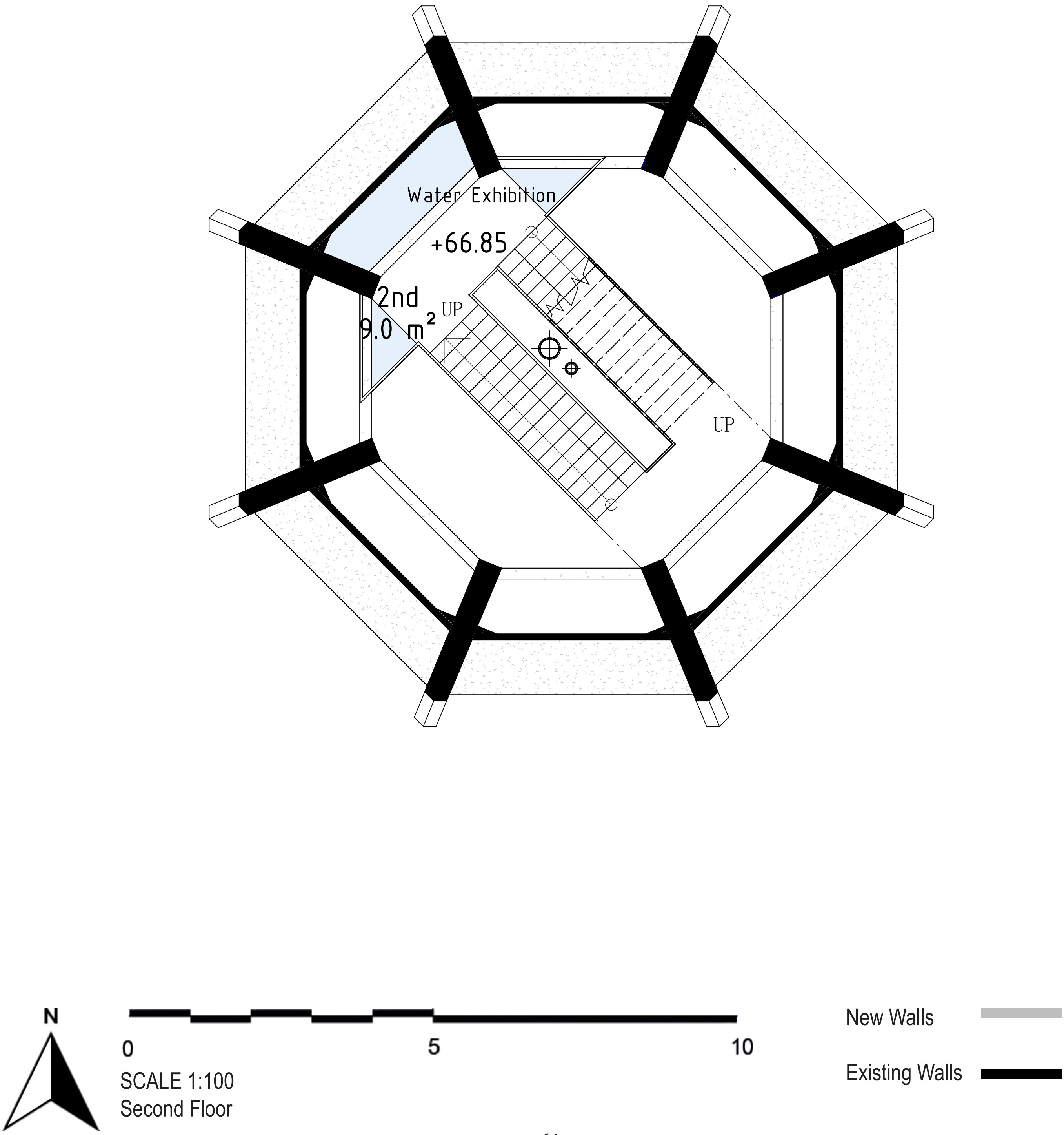
SCALE 1:100
Mezzanine Floor

New Walls

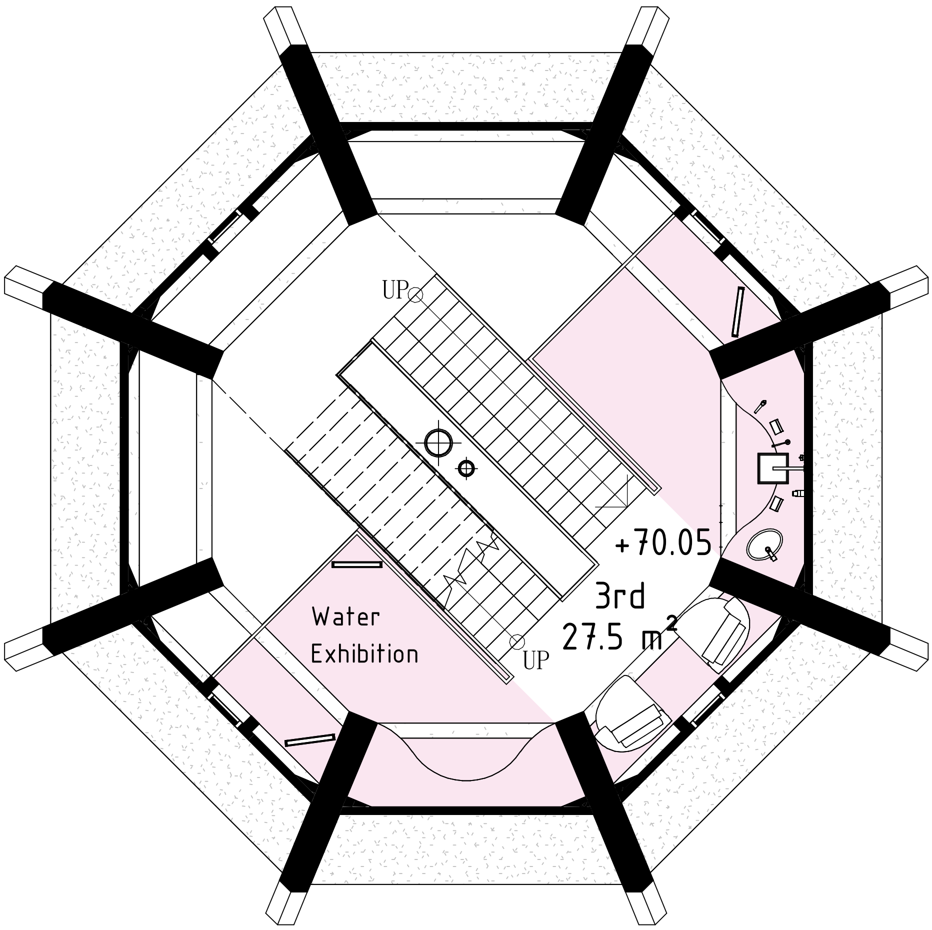
Existing Walls


DIY Water filtration, Microscope
Stations, and testing quality of
water
1st
35.0 m²
+63.65
UP
UP


N
0
5
10
SCALE 1:100
First Floor
New Walls
Existing Walls



SCALE 1:100
Second Floor



N

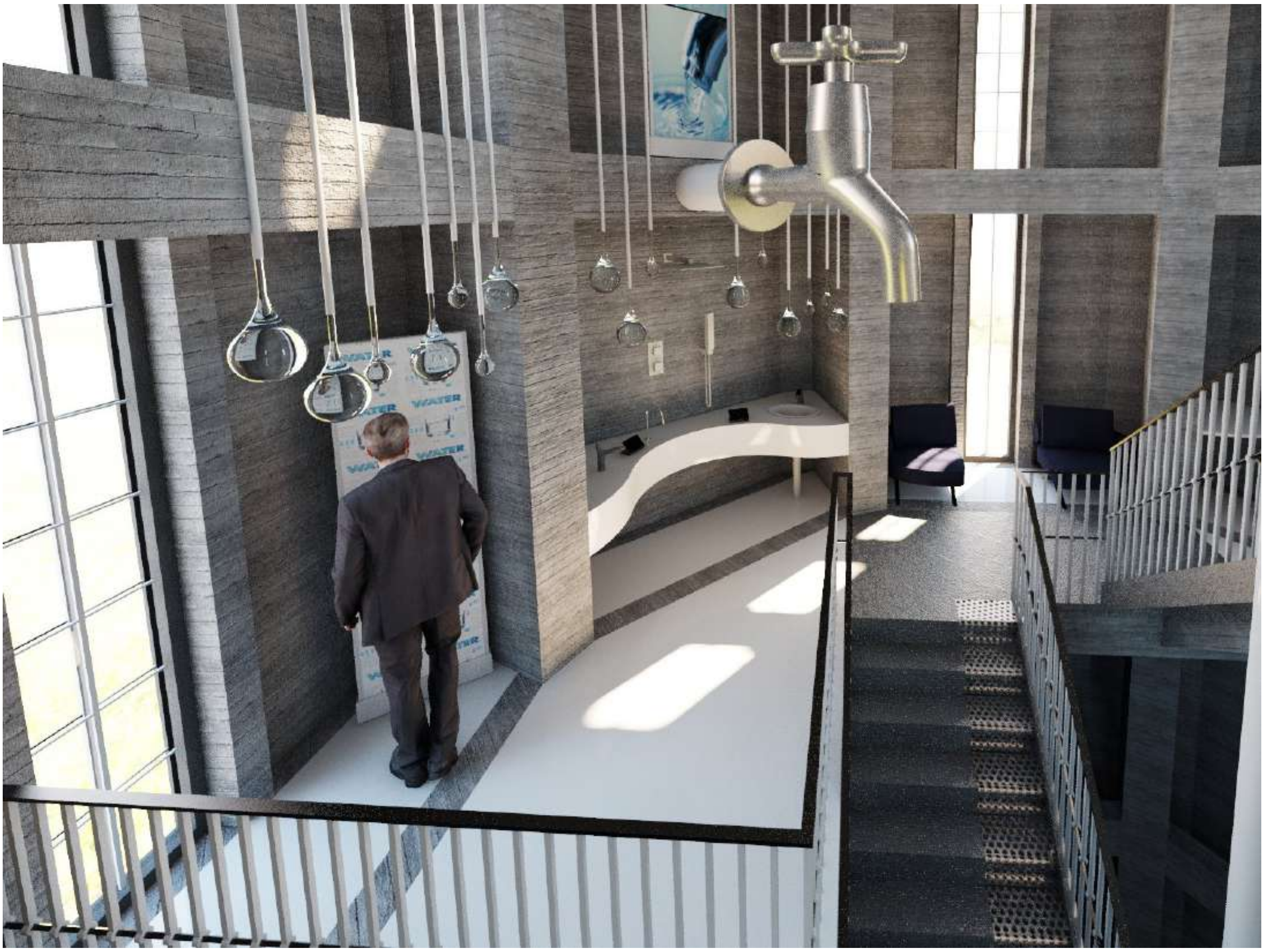
0 5 10

SCALE 1:100
Third Floor

New Walls

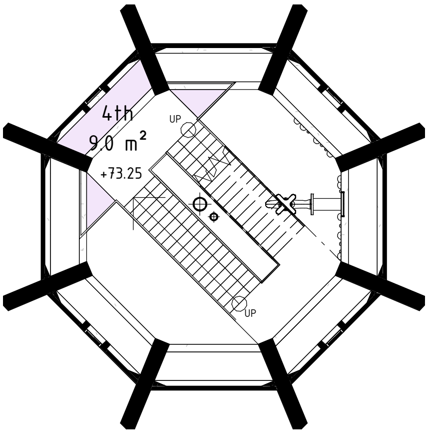
Existing Walls

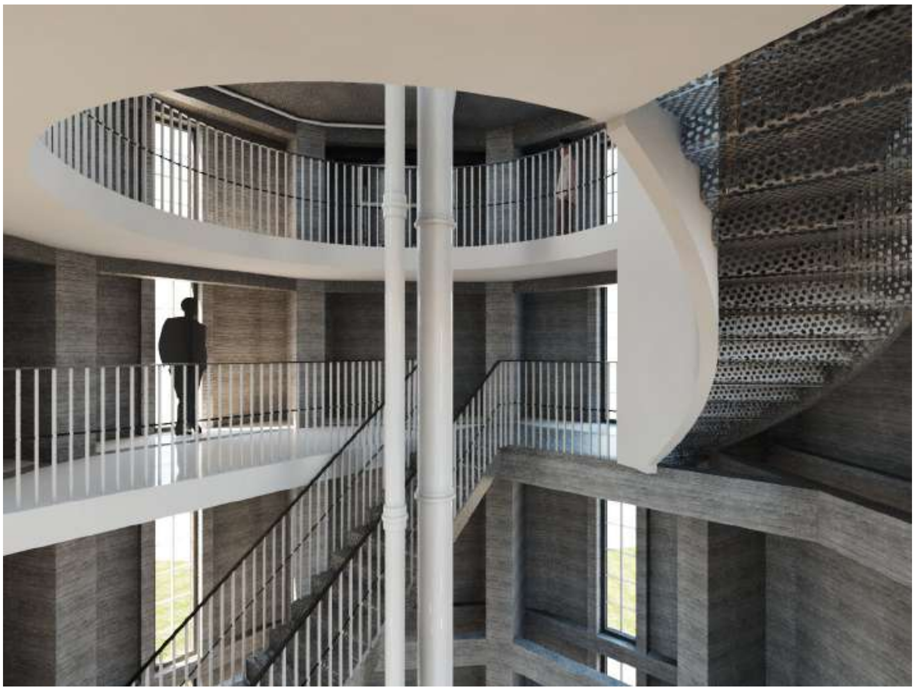
PLANS



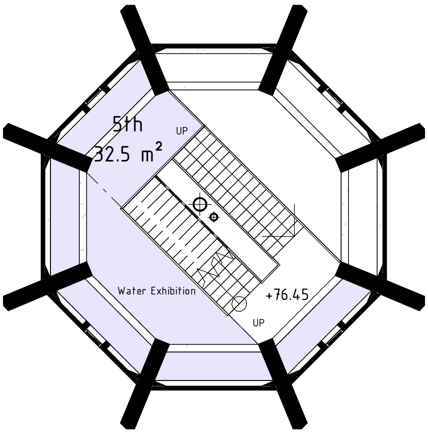
The visualization shows how the display corner could be situated within a balcony on the third floor.
The huge antique water faucet tells visitors how these styles of faucets wastewater while modern faucets with sensors save water.

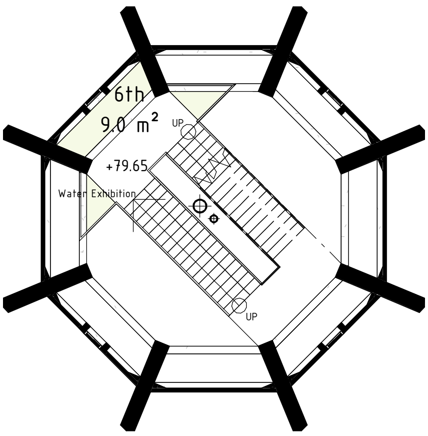
PLANS





(Illustration shows the 9th floor under the water tank)





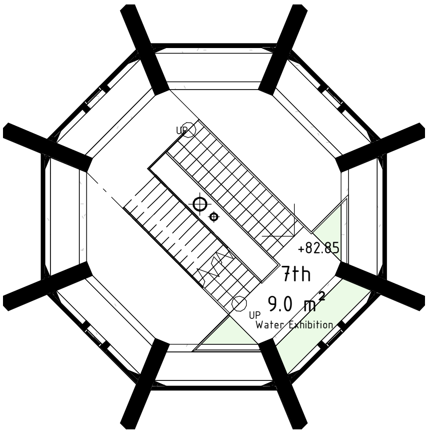
(Illustration shows the 10th floor under the water tank)

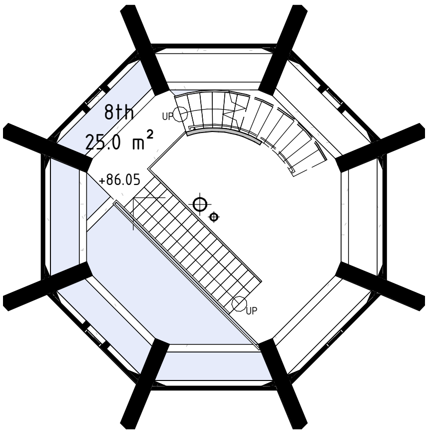
0 5 10

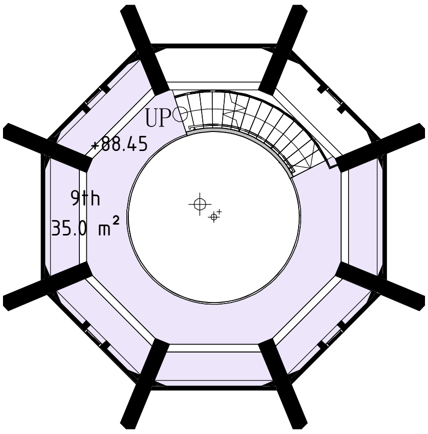
SCALE 1:200
4th, 5th,6th Floor

New Walls

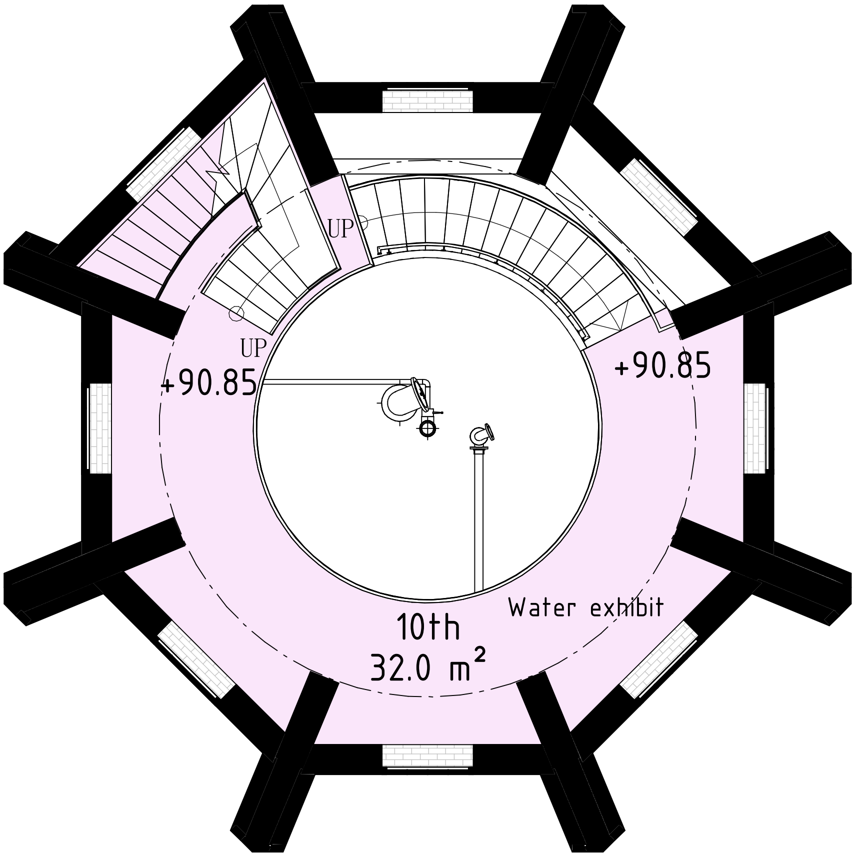
Existing Walls



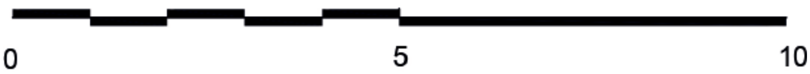




SCALE 1:200



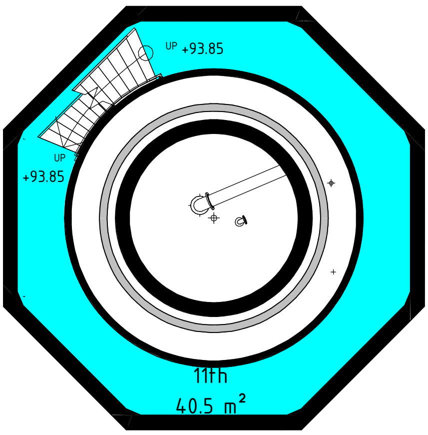
Tenth Floor (The floor directly below the water tank)



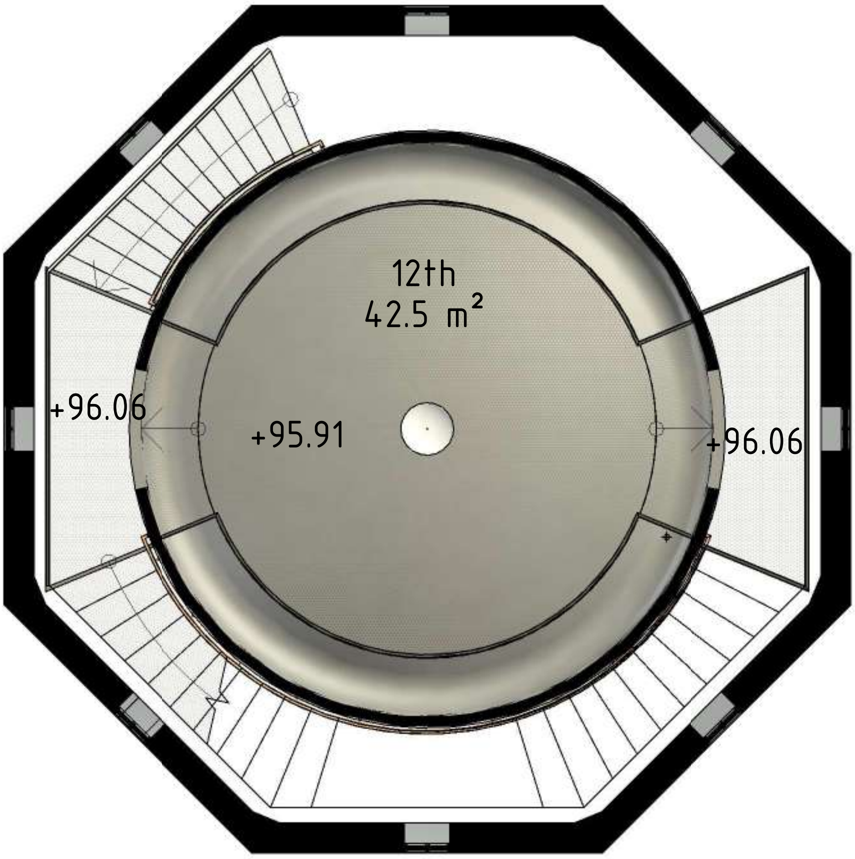
SCALE 1:100
7th, 8th, 9th, and 10th Floor

New Walls

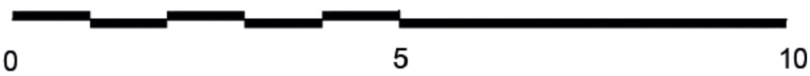
Existing Walls



SCALE 1:200



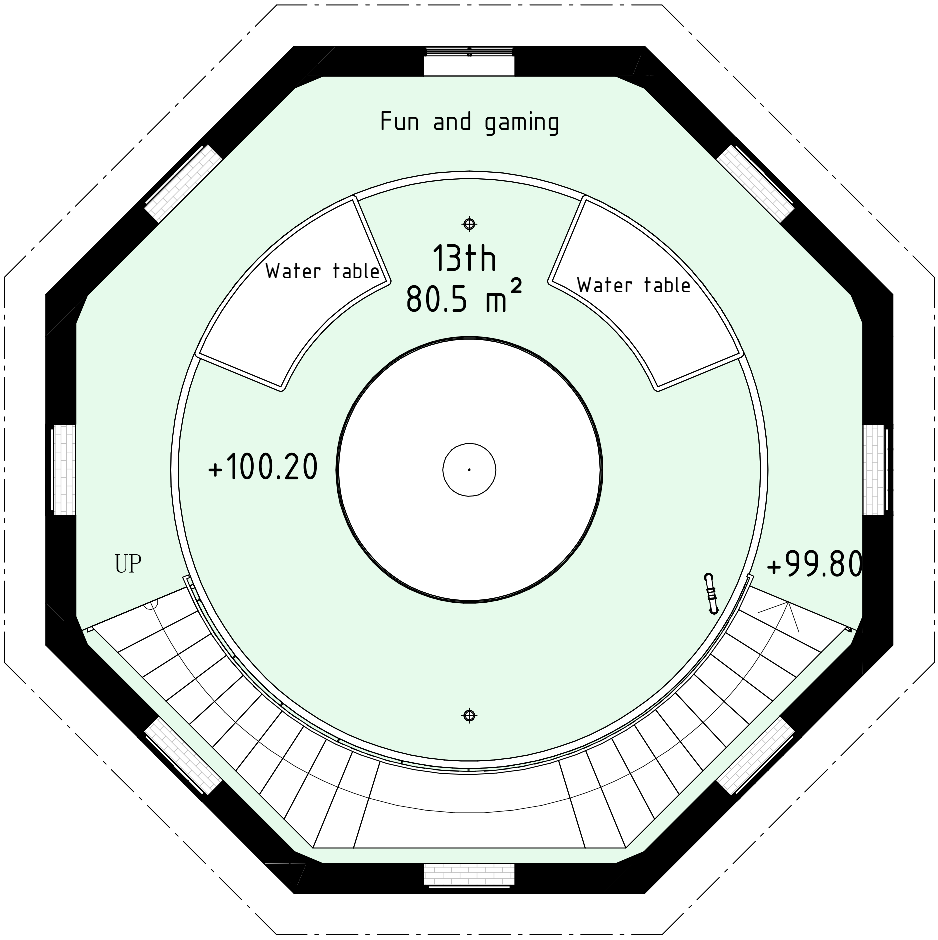
Meditation Room



SCALE 1:100
11th, and 12th Floor

New Walls

Existing Walls

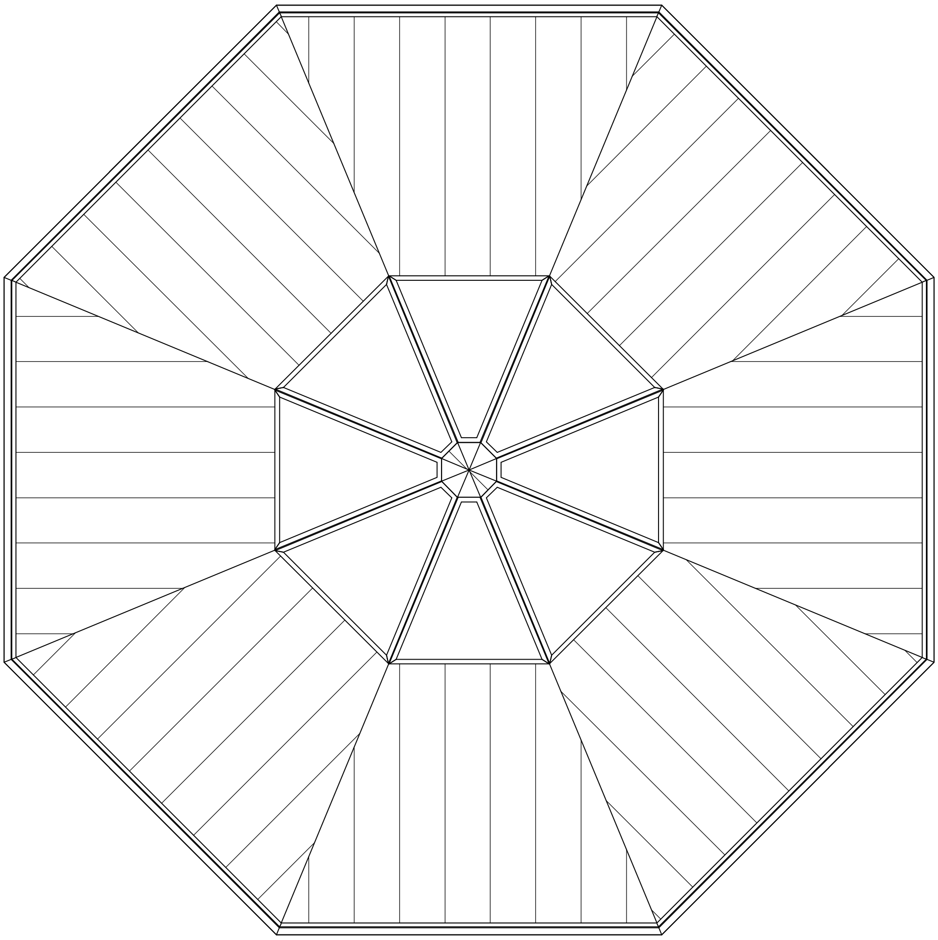


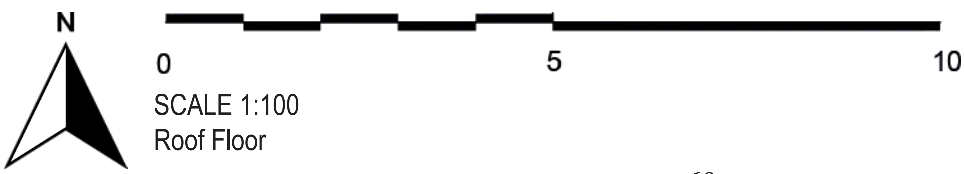
A level is designed to be a place of fun and observation.

SCALE 1:100
Thirteenth Floor

New Walls

Existing Walls



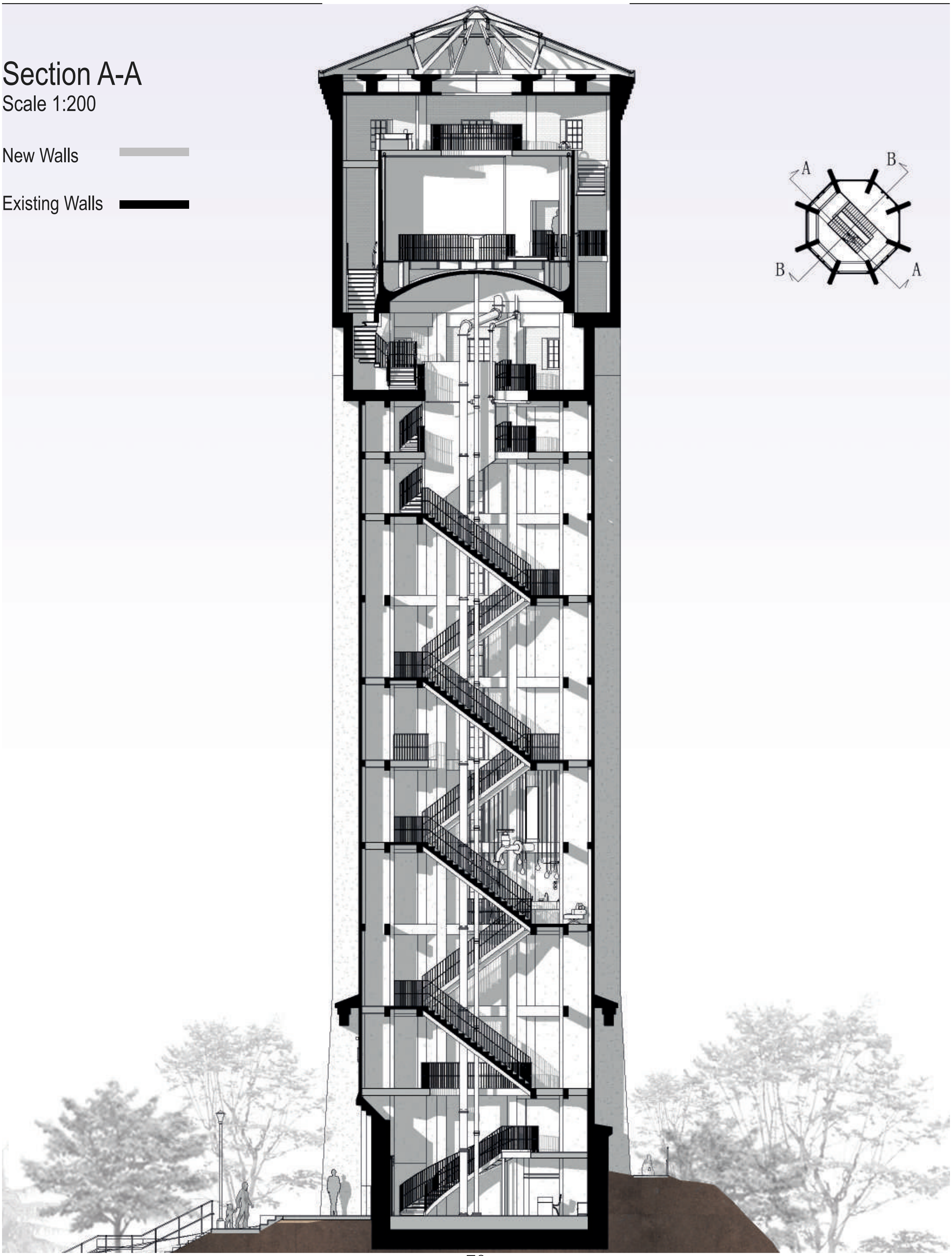


SCALE 1:100
Roof Floor

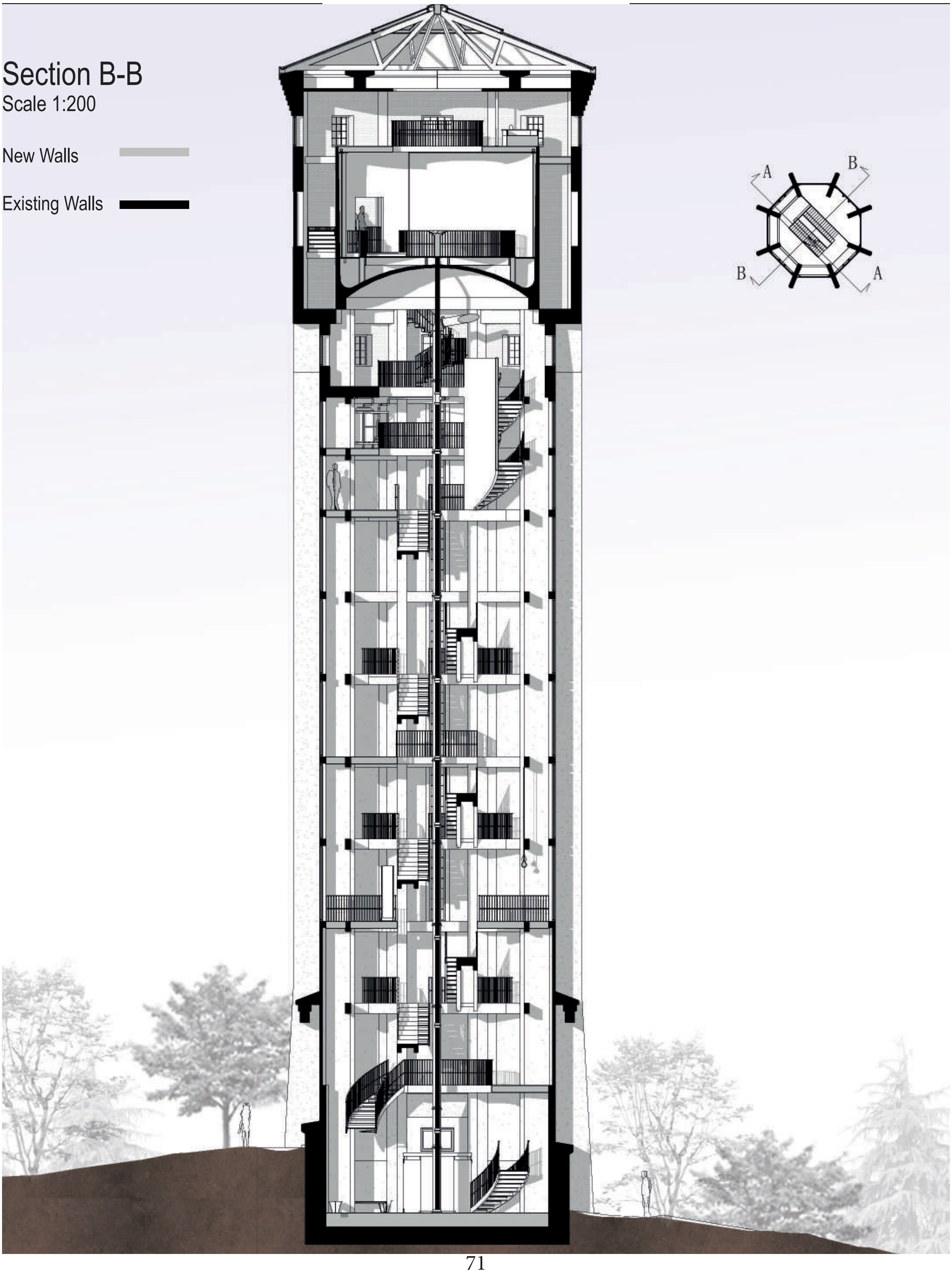
New Walls

Existing Walls

SECTIONS

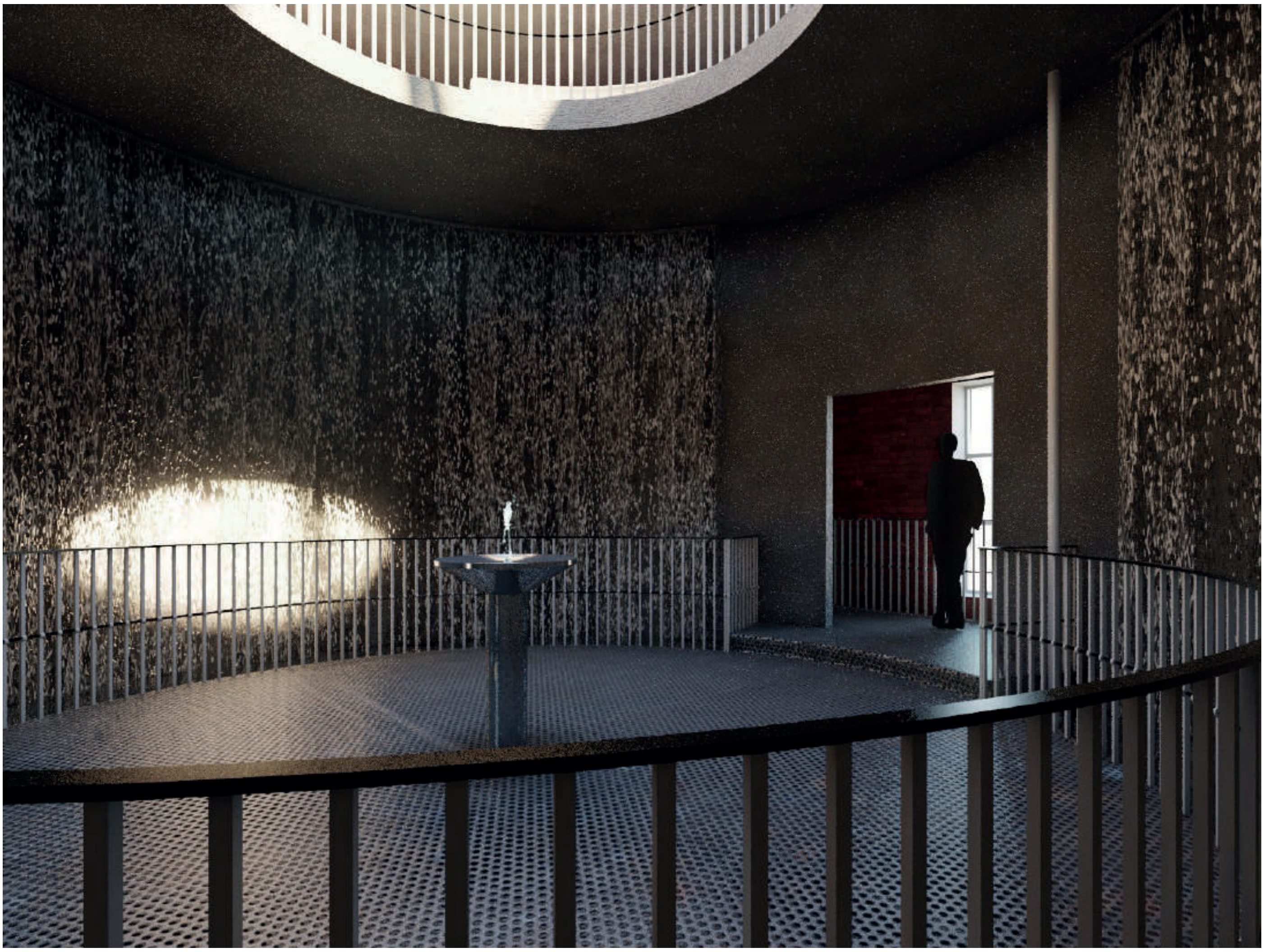


SECTIONS



MEDITATION ROOM

The idea is to transform the water tank located on the twelfth floor into a space for contemplation bridging the past and present of the Lunden neighborhood.

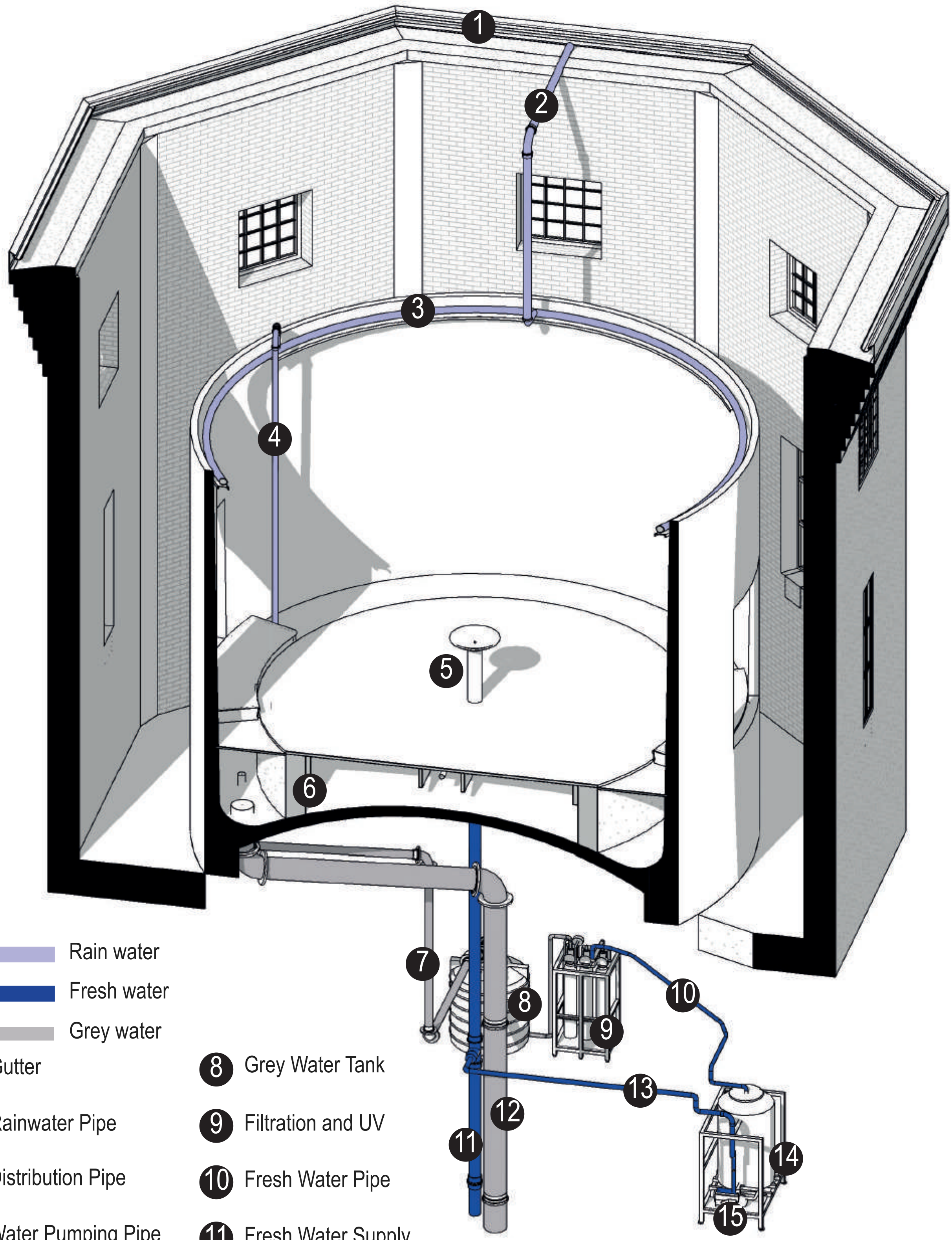


(Illustration inside the meditation room)

When visitors arrive at the meditation room (formerly a water tank), they may feel fatigued from climbing the stairs of the water tower. They will have then the opportunity to drink fresh water from the fountain situated in the center of the meditation room. Meanwhile, non-potable water (rainwater) will flow from the sides of the water tank's wall, cascading into a pool located at the bottom.

The sound of non-potable water flowing, combined with the act of drinking fresh water, will leave a lasting impression on visitors, prompting a moment of insight and contemplation regarding the importance of preserving drinking water. This idea makes water tangible to visitors and brings them closer to Lunden's past.

MEDITATION ROOM



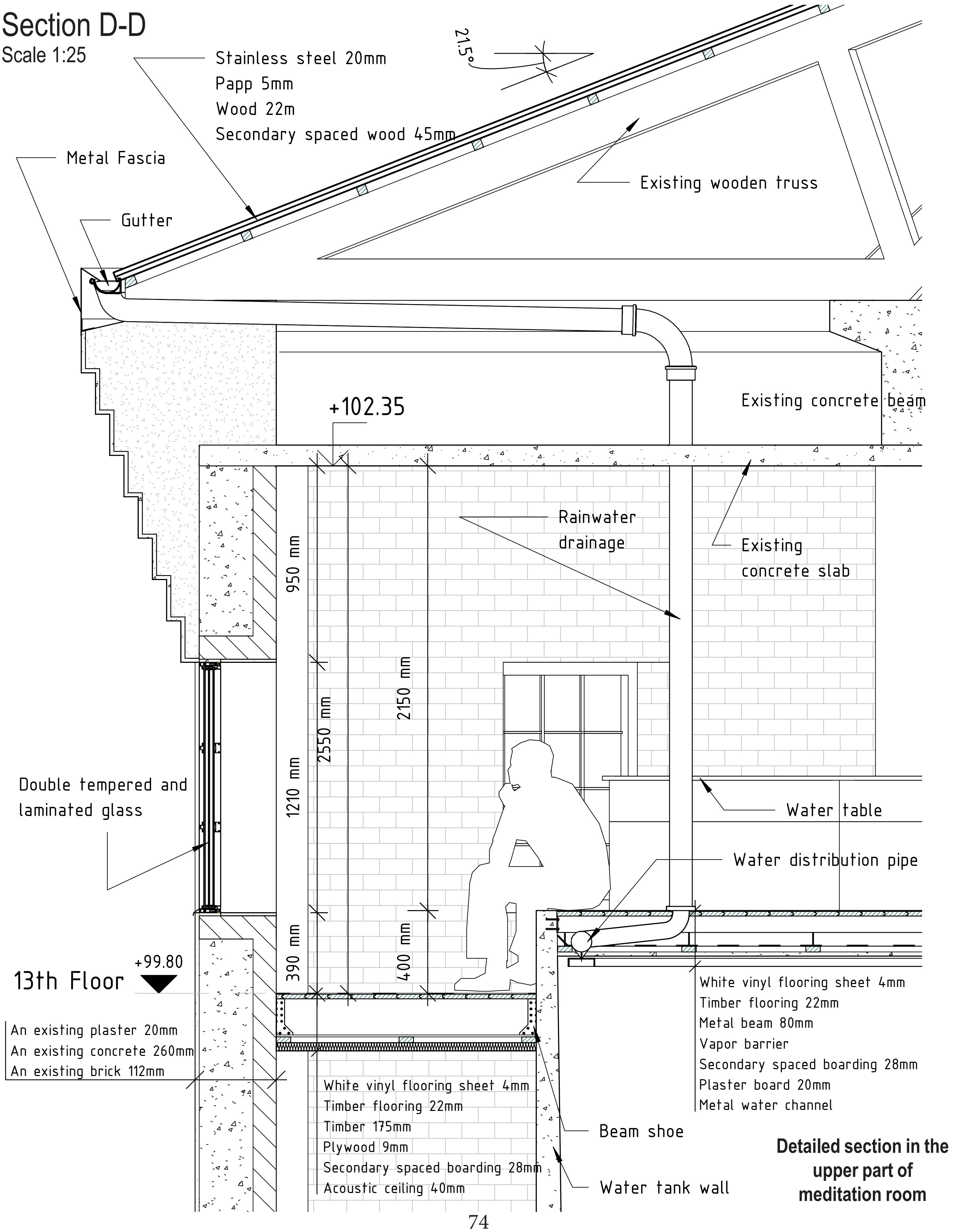
- Rain water
- Fresh water
- Grey water

1. Gutter
2. Rainwater Pipe
3. Distribution Pipe
4. Water Pumping Pipe
5. Fountain
6. Pump
7. Grey Water Pipe
8. Grey Water Tank
9. Filtration and UV
10. Fresh Water Pipe
11. Fresh Water Supply
12. Grey Water Drainage
13. Fresh Water Pipe
14. Fresh Water Tank
15. Pump

3D section shows components of water harvesting and purification system.

Section D-D

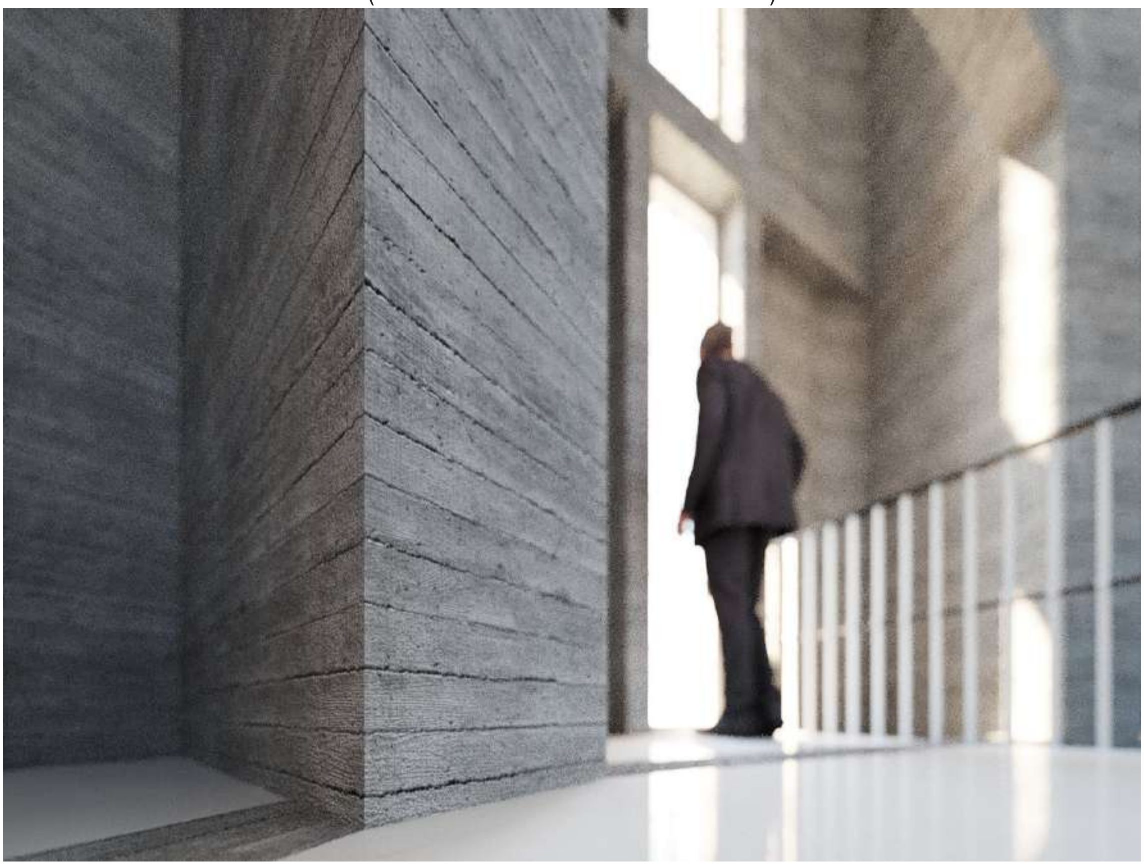
Scale 1:25



Detailed section in the upper part of meditation room

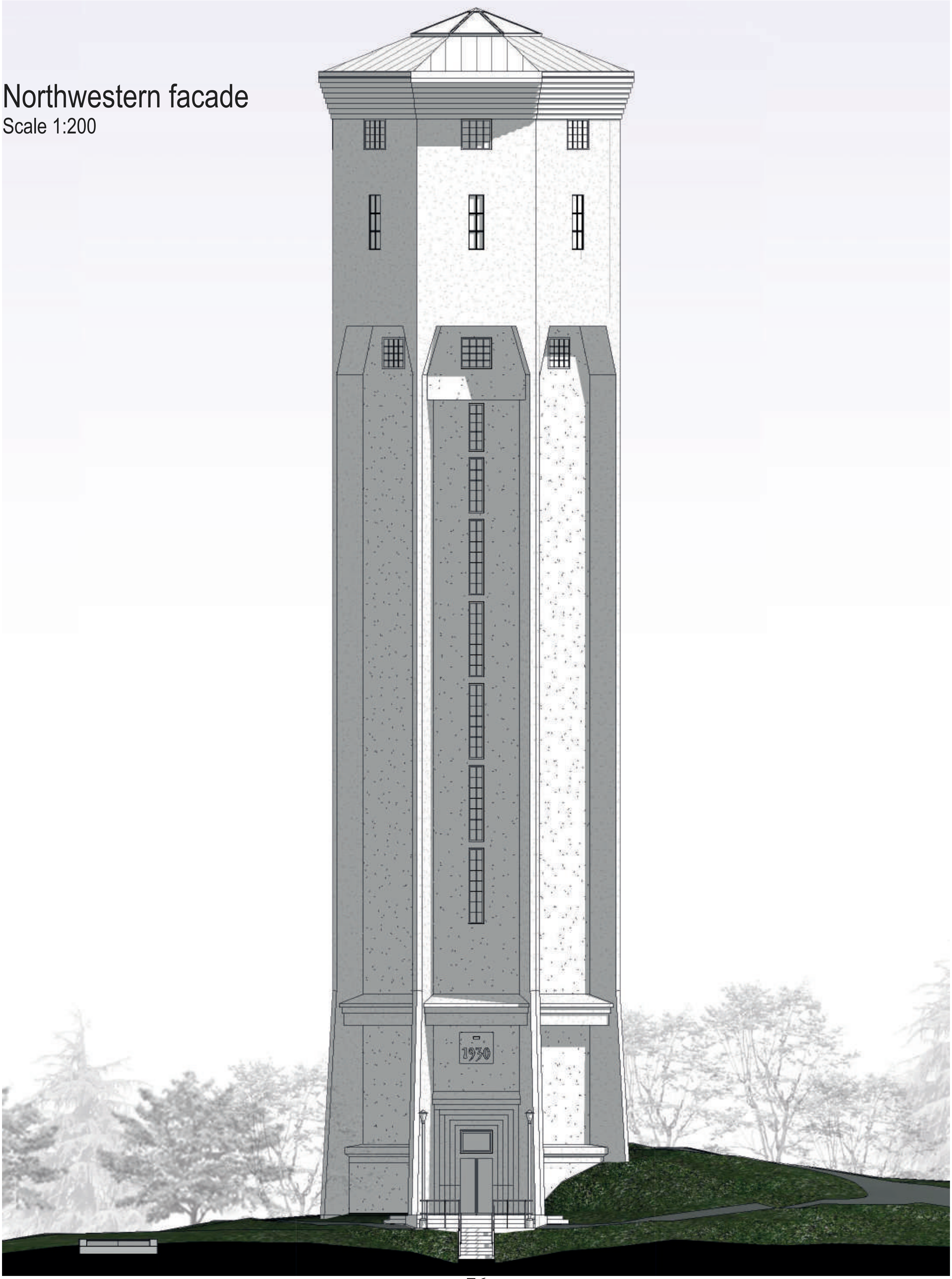
MEDITATION ROOM

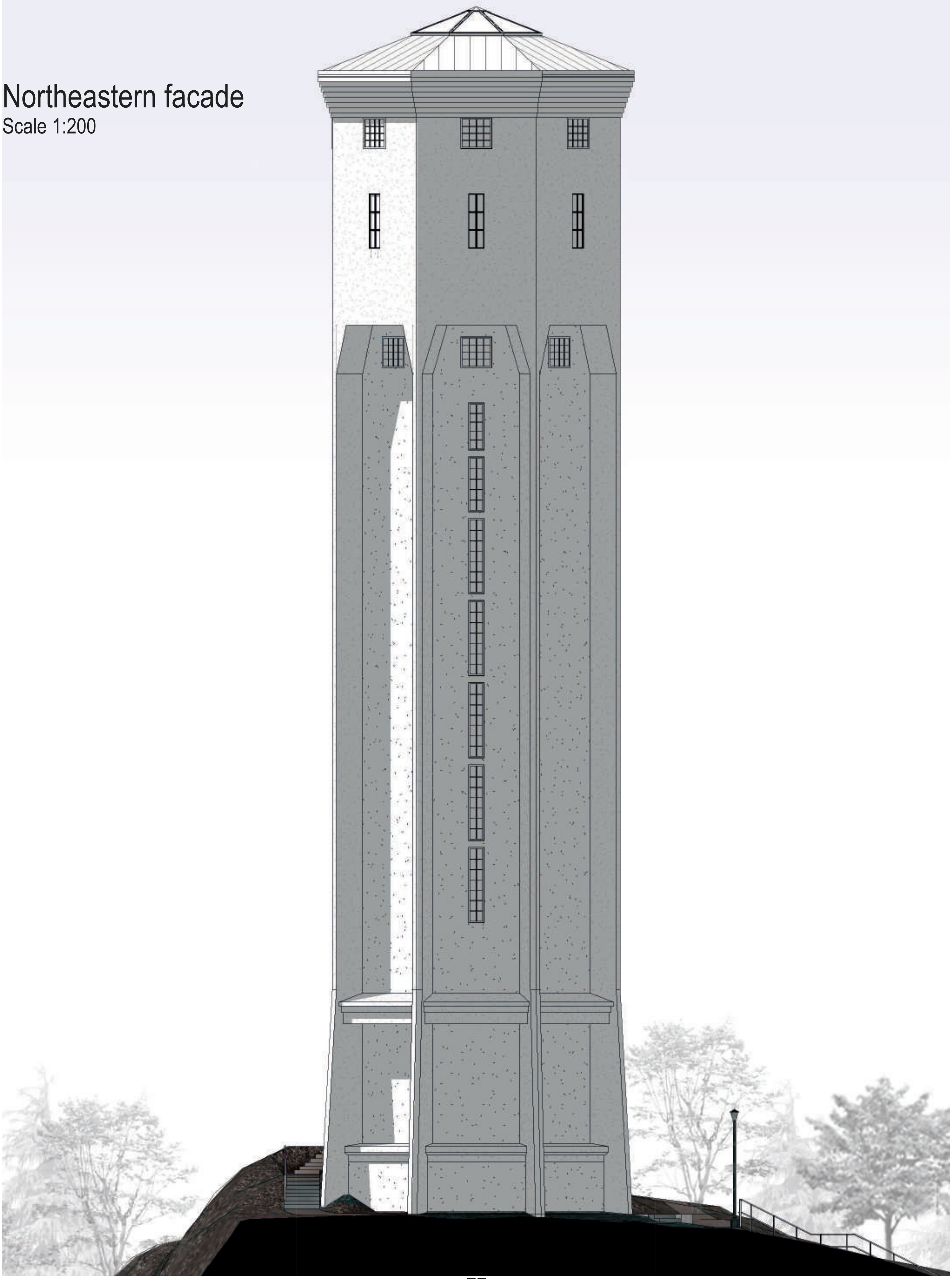
(Illustration inside the meditation room)



(Illustration shows the concrete as an original building material)

Northwestern facade
Scale 1:200

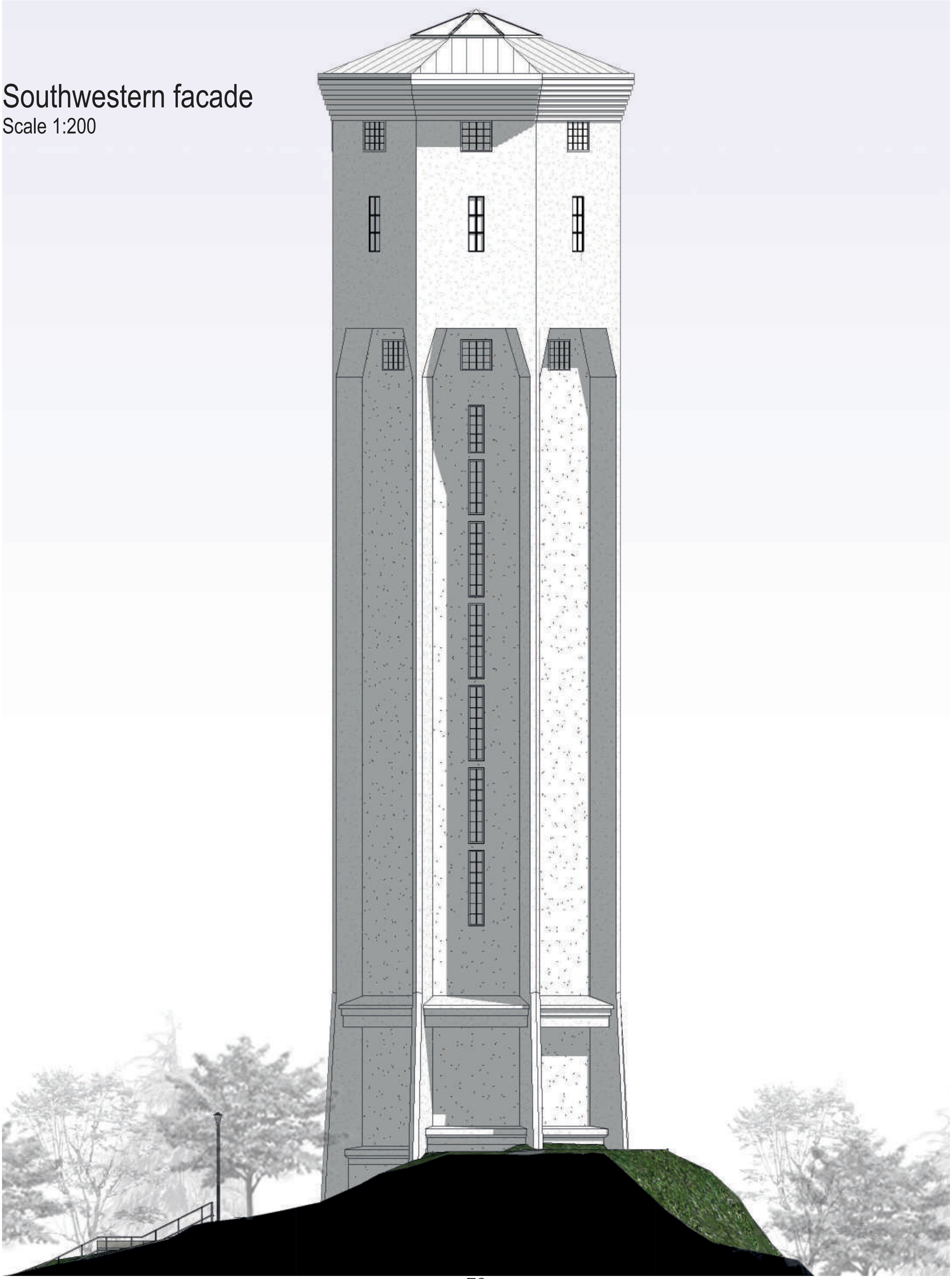



Northeastern facade
Scale 1:200

FACADES

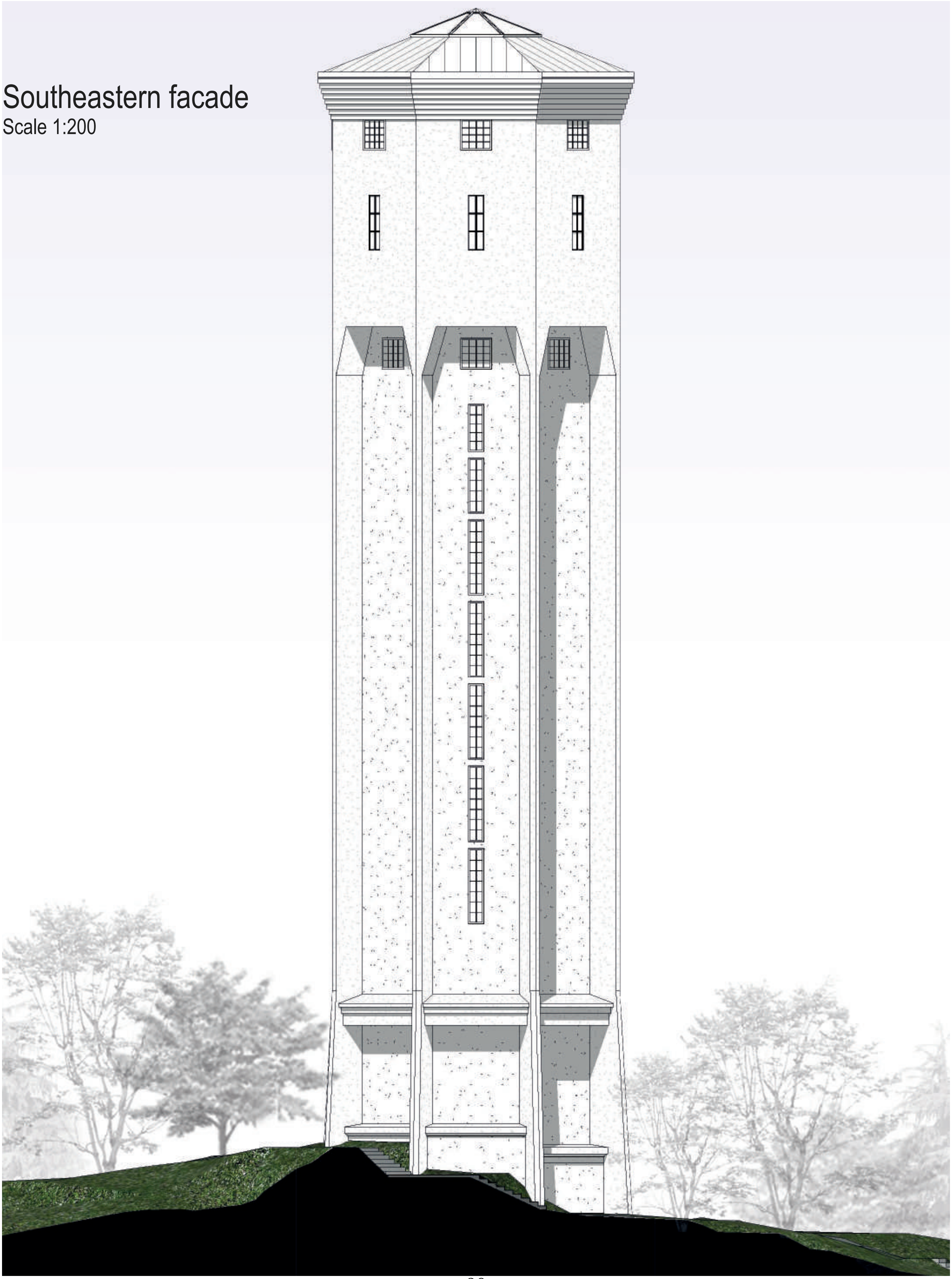
The aim is to preserve the facades as built, but there is a requirement to renew the existing windows by adding two layers of tempered and laminated glass.

FACADES

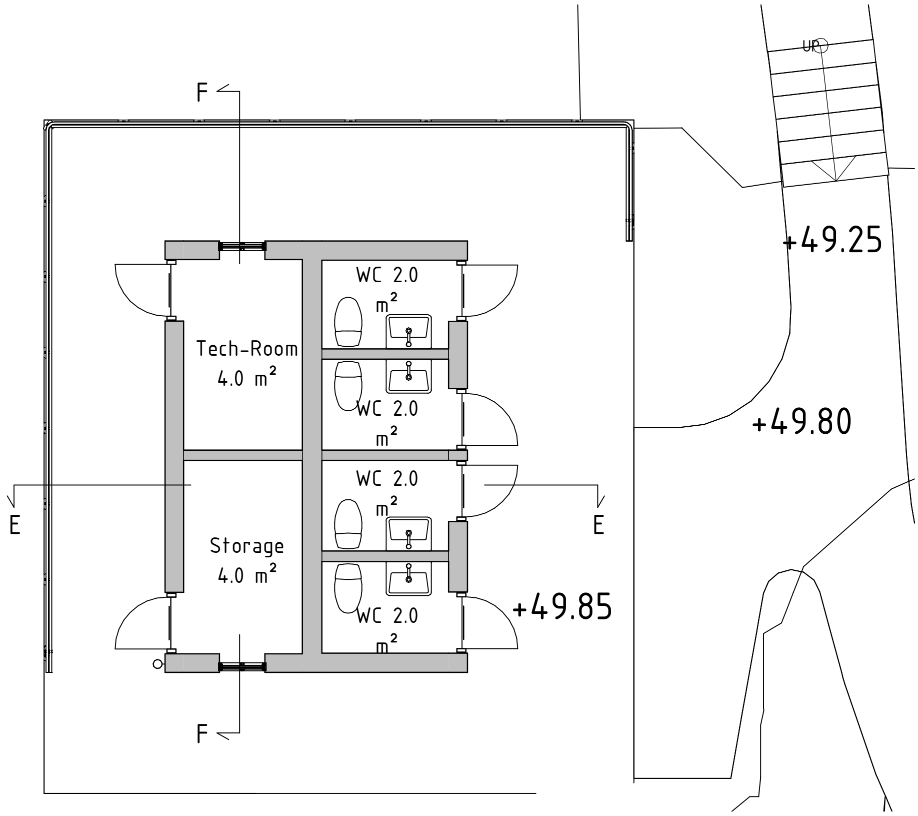


Southwestern facade

Scale 1:200


Southeastern facade
Scale 1:200

TOILETS BUILDING



N

0 5 10

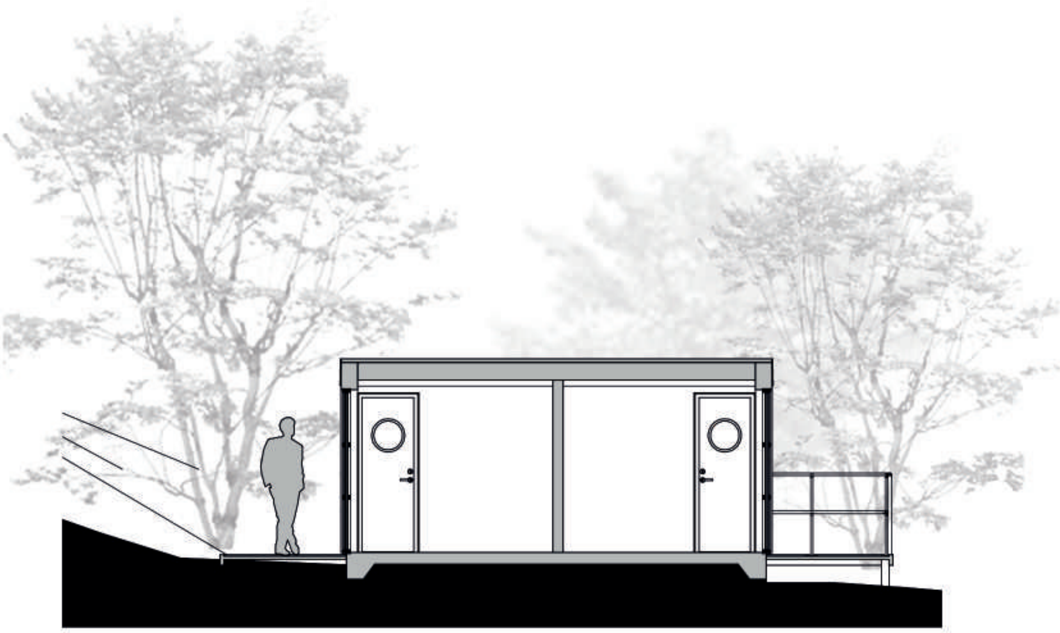
SCALE 1:100
Ground Floor

New Walls

Existing Walls

TOILETS BUILDING

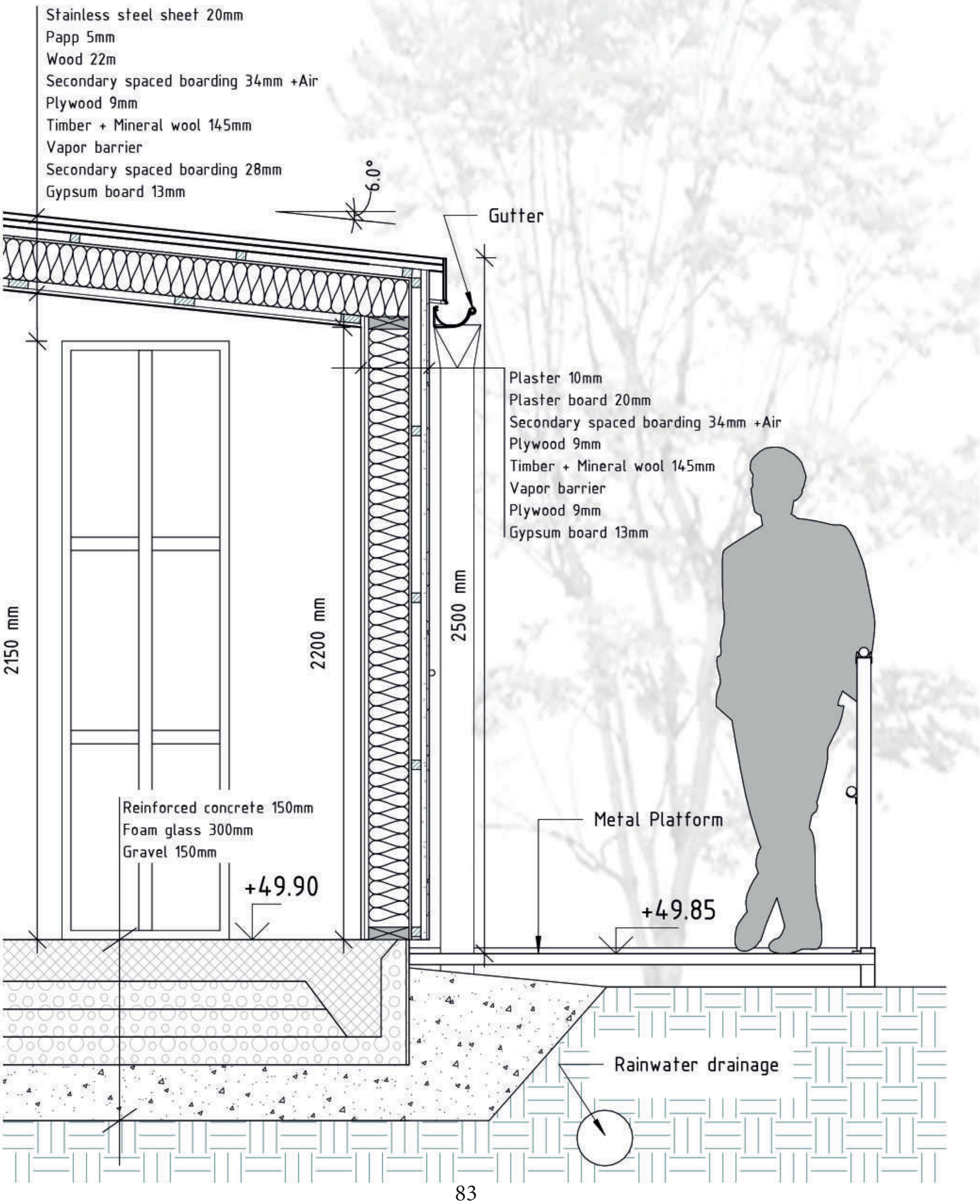
Section E-E



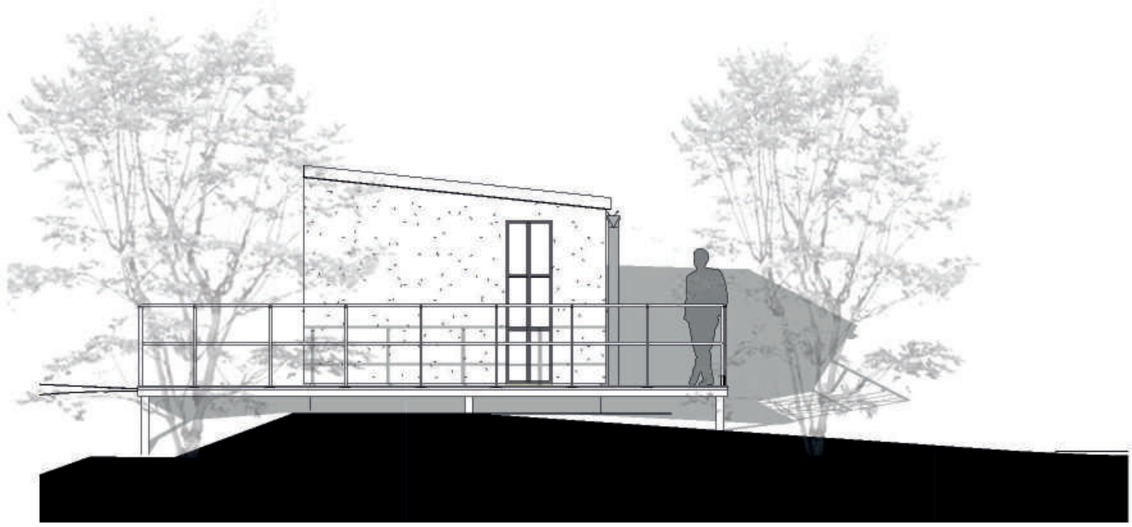
Section F-F

SCALE 1:100
Sections

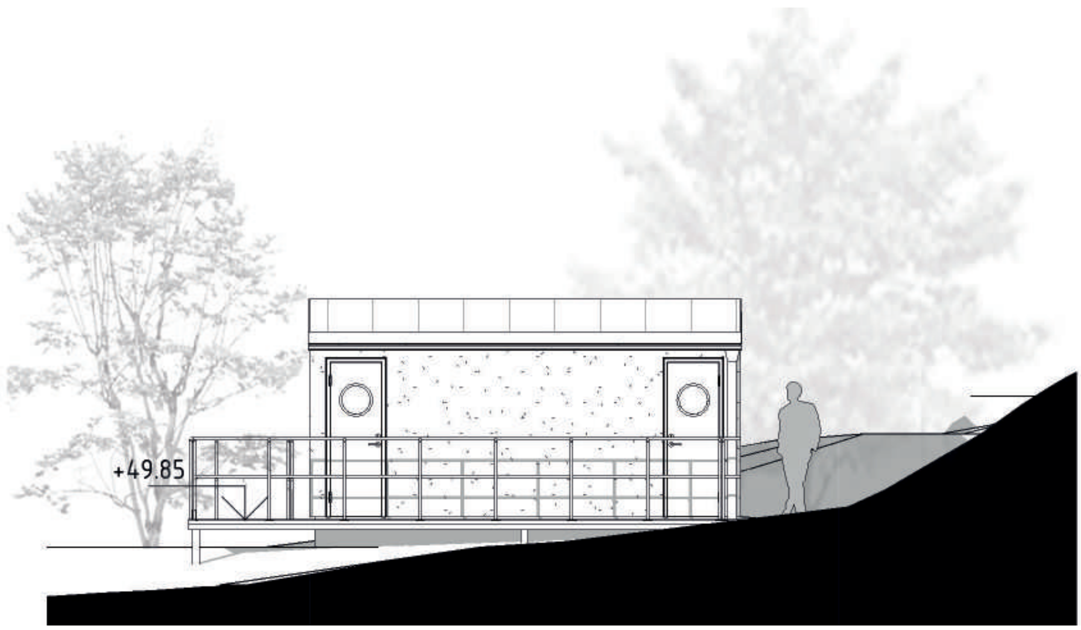
Detailed Section
Scale 1:20



TOILETS BUILDING



Northeastern facade



Northwestern facade

0 5 10

SCALE 1:100
Facades

New Walls

Existing Walls

TOILETS BUILDING

Southwestern facade

Southeastern facade

0 5 10

SCALE 1:100
Facades

New Walls

Existing Walls

VI. CONCLUSION

DISCUSSIONS AND CONCLUSION

Working on this thesis leads to the emergence of a series of research questions that are central to the topic, such as:

Could transforming Lunden's water tower into an educational center focused on water conservation and sustainability enhance the architectural and heritage value of the tower in the long term?

What is the environmental impact of this conversion process?

What are the challenges facing the implementation of such a project, and how can they be overcome?

Heritage values.

During the course of researching this thesis, I have come to realize the complexity of this topic. It has become evident that transforming the Lunden's water tower, as investigated in this thesis, does not deviate significantly from its original function as a place where water flows.

Thus, converting it into an educational center focused on water conservation and sustainability aligns well with its structural and architectural elements, despite encountering structural limitations that hinder free utilization of interior spaces.

The research process has explored ideas that do not necessitate large spaces and can be incorporated into the recruitment and utilization of space.

The design methodology outlined in the proposal of this thesis delineates the factors and principles essential for preserving the tower's architectural identity as a significant and renowned landmark in Gothenburg.

Therefore, the architectural interventions proposed in this thesis do not affect the identity of the water tower; instead, they emphasize the importance of its preservation.

Environmentaal impact.

Hence, we conclude that there is an urgent need for designers to collaborate with specialists to establish design principles that effectively serve the project's objectives. This collaboration is crucial for ensuring comprehensive consideration of all the diverse aspects that must be taken into account in this project.

The objective of reusing an existing structure is to diminish the necessity for new construction, thereby conserving resources and diminishing associated environmental repercussions such as energy consumption, raw material extraction, and waste generation.

However, this does not imply that emissions are nonexistent in such cases. Certain reuse endeavors involve demolition work, material transportation, and installation of new infrastructure, consequently generating waste necessitating specialized treatment. This results in short-term environmental impacts. Furthermore, the ongoing operation of the center itself entails continuous energy consumption and emissions.

Nevertheless, this repurposing effort contributes to heightened awareness regarding water conservation and sustainability practices, fostering positive behavioral changes among visitors that can positively impact the local environment.

DISCUSSIONS AND CONCLUSION

Implementation challenges.

Transforming the Lunden's water tower into an educational center focused on water conservation and sustainability entails several implementation challenges:

1-Structural Integrity:
Assessing the structural integrity of the tower is essential, yet it is not addressed in this thesis. Adapting the structure to accommodate exhibitions and interactive displays while ensuring its stability poses a significant challenge.

2-Accessibility:
Implementing the project while maintaining the architectural integrity may present challenges in ensuring accessibility. The design concept aims to minimize architectural interventions, potentially impacting accessibility standards and compliance with safety regulations and fire codes.

3-Cost:
The thesis does not address the cost implications of the project. However, the proposed design emphasizes minimal architectural interventions to reduce implementation costs.

These challenges can be addressed through collaboration among project stakeholders, including active engagement with the local community in decision-making processes. By fostering cooperation and involvement, stakeholders can collectively overcome obstacles and ensure the successful realization of the project.

Conclusion.

Given the historical and cultural significance of Lunden's water tower, tackling this thesis presents challenges, as any architectural modifications during the repurposing process must be meticulously considered to preserve the tower's architectural integrity.

Certain architectural prerequisites may prove difficult to incorporate into the tower, such as ensuring its usability during winter. This necessitates insulation, raising concerns about thermal bridges, potentially hindering visitors from fully experiencing the tower's architectural and structural elements, particularly its reinforced concrete, a fundamental building material.

(The proposal presented in this thesis is founded on seasonal operating schedules).

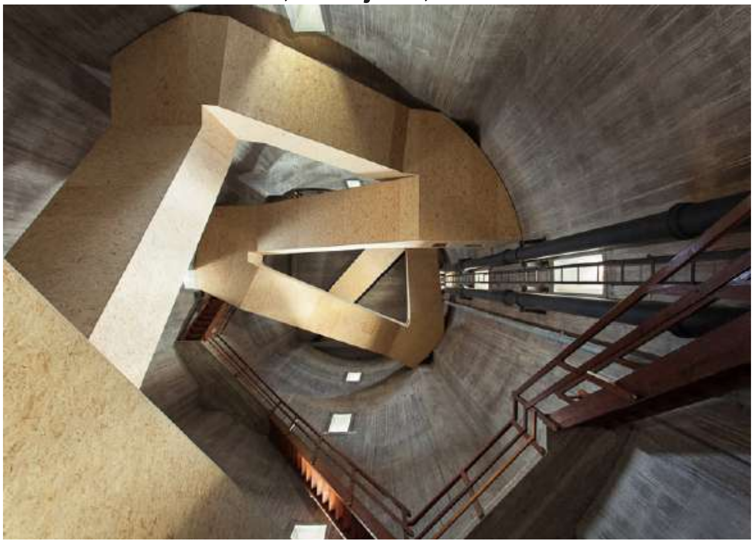
Lunden's water tower lacks sufficient internal space as originally constructed. This limitation restricts architects from having ample freedom to address it, as the structural elements occupy a considerable portion of the internal space. The tower boasts numerous architectural features that contribute to its identity, making it challenging to disregard them. This is why the proposal is particularly cautious when considering demolition aspects.

The design proposal focuses on drinking water and the imperative of its conservation. Consequently, it revolves around water displays that prompt visitors to explore methods of preserving drinking water, such as filtration processes, water recycling, and rainwater collection. The research has determined that the design of the water purification center, tailored to accommodate the daily water usage volume within the tower, aligns with the project's objective. This objective is to heighten awareness regarding the importance of water conservation, especially in drinking water, and underscore the necessity of showcasing this system to visitors.

Building upon prior studies and research and aligning with proposals for the reuse of Lunden's water tower, it becomes evident that repurposing the tower as an education space to emphasize the importance of water conservation, particularly drinking water, resonates with the site's essence and accentuates its historical significance.

Lunden's water tower stands as a massive concrete edifice with robust structural features, demanding that architectural designers acknowledge and showcase them to visitors. This underscores to local authorities that the most fitting reuse scheme for this tower entails transforming it into a memorial and contemplative space bridging the past and present.

The Observation Point, Overijssel, Netherlands



An old water tower as located amongst the marshes of De Wieden, a national park in the Dutch Province of Overijssel, the decommissioned water tower provides a monumental landmark on the skyline. Zecc Architecten's task was to make the structure accessible to the public by transforming it into an observation point, and it has achieved that via a series of twisting staircases through the structure's center.

Water Tower Pavilion, Tiexi, Shen Yang, China.

This water tower is located on the campus of a dilapidated military factory. META-Project Studio designed this pavilion to preserve it as a fragmented memory of manufacturing history.

The renovated water tower forms an artistic intervention from the outside into the urban landscape, and from the inside it provides space for public activities. The work in the interior space aims to collect daylight and bring it into the tower.

Laredo Water Museum, Texas, USA.

The Laredo Museum is fun for the whole family as it fosters sustainable water use via interactive activities and educational displays on the water treatment process and the value of conservation.

The Laredo Water Museum, with it's over 30 exhibits, addresses critical issues related to: home, agricultural and industrial water usage; the history and consequences of drought; the pervasive problem of plastic waste in our waters; water-borne pathogens and contaminants; new technologies in water purification and their impact on third-world countries; and recycling, water conservation and environmental stewardship.

Clay Center for the Arts and Sciences, West Virginia USA.

The enormous water exhibit inspired by the local Kanawha River combines creativity and real-world science. The idea of the exhibit's design stems from the water flow when a simulated rain cloud is cascading overhead. The water travels down through a wheel and enters a hydroelectric dam.

The sophisticated electronic system engages visitors, who control the water's flow through the dam and use trial and error to explore its effect on the amount of power generated to light up a model town.

Children operating the dam have fun using their imagination while witnessing the science behind local power generation. It is playful, creative, and exciting as it explores how water works in the real world.

REFERENCES

Books:

1- Gleick, P. H. (2014). " The world's water: The biennial report on freshwater resources". Washington, DC: © Island Press, 2000 M Street NW, Suite 650, Washington, DC 20009.

2- Hunt, R., & Boyd, I. (2017). "New design for old buildings". Newcastle, U.K.: © RIBA Publishing, 2017.

3- Novak, C.A., Van Giesen, G.E., DeBusk, K.M. (2014). "Designing rainwater harvesting systems: Integrating rainwater into building systems".New Jersey, USA.: © John Wiley & Sons, Inc., Hoboken, 2014.

4- Wong, L. (2016). "Adaptive reuse : Extending the lives of buildings". Berlin, Germany: © Birkhäuser Verlag GmbH, Basel, 2017.

5- Lynch, K. (1960). " The Image of the City". USA: © 1960 by the Massachusetts Institute of Technology and the President and Fellows of Harvard College Twentieth Printime. 1990

6- Dewey, J. (1998). "Experience and Education". West Lafayette, Indiana, USA: © Kappa Delta PI an International Education Honor Society in Education.

7- Dean, D. (1994). "Museum Exhibition: Theory and Practice". New York, USA: © Routledge 11 New Fetter Lane, London EC4P 4EE.

8- Rönnbäck, K. (2017). "The Sink as a Source: Safeguarding the Raw Water Source of Gothenburg, Sweden,1860–1980". Gothenburg, Sweden: © White Horse Press.

9- Douet, J. (2013). " Industrial Heritage Re-tooled: The TICCIH Guide to Industrial Heritage Conservation". London and New York: © Routledge Taylor & Francis Group.

10- Stratton, M. (2000). " Industrial Buildings: Conservation and Regeneration". London: © E & FN Spon 11 New Fetter Lane, London EC4P 4EE, Taylor & Francis Group.

11- Hein, C. (2020). " Adaptive Strategies for Water Heritage: Past, Present and Future". Gewerbestrasse, Switzerland: © Springer Nature Switzerland AG.

Reports & Articles:

1- Bullen, P.A., & Love, P.E.D. (2011). "Adaptive reuse of heritage buildings", Structural Survey, Vol. 29 No. 5, pp. 411-421.
www.emerald.com/insight/content/doi/10.1108/02630801111182439/full/pdf

2- Foster, G. (2019). "Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts", ScienceDirect, Vol. 152.
www.elsevier.com/locate/resconrec

3- Jonsson, K., & Nordström, K. (2017). "Kulturmiljöunderlag, Lundens vattentorn", Museum of Gothenburg city,
https://samlingar.goteborgsstadsmuseum.se/carlotta/web/image/blob/1229210/Kulturmilj%C3%B6rapport%202017_03.pdf

4- Lönnroth, G., Ander, H., Lundgren,M., Lönnroth, G., Bankel, L., Westergren, S., Lönnroth, G., Rydvall, G., Nord, L., & Carlefred, K. (1999).
" Kulturhistoriskt värdefull bebyggelse i Göteborg" Götoborgs Stad, Vol. 2(2), pp. 63-69.
https://goteborgsstadsmuseum.se/kulturmiljo/vardefull-bebyggelse/

5- Melton, P. (No date). "Buildings that last: Design for adaptability, deconstruction, and reuse", American institute of architecture,
https://www.aia.org/resources/6282663-design-for-adaptability-deconstruction-and

6- Miletto, M., Connor, R. Koncagül, E., Abete, V., Tonsini, M., Lobach, S., Imburgia, L. V., Thuy, L., Abete, V., Favilli, M., De Oliveira, M.L. C. M., Gallese, S., Harrigan, E. M., Bracaglia, B., Chiodini, L., Frascani, A., Brensacchi, M., Brugnami, T., Gioffredi, F., Alyami Mahdi, H., Chacón Labrador, D.F., & Chaves Pacheco, S. M.
(2023). " The United Nations world water development report 2023", The United Nations Educational, Scientific and Cultural Organization, © UNESCO 2023, ISBN 978-92-3-100576-3.
https://unesdoc.unesco.org/ark:/48223/pf0000384655

7- Rica, M., Biancalani, R., Marinelli, M., Ben Hamouda, G., & Chocholata, L. (2021). " Progress on level of water stress", Food and Agriculture Organization of the United Nations,
https://www.unwater.org/publications/progress-level-water-stress-2021-update

8- Aguirre,M.F., Alfadl, F., Anangnost,A., Anastasiadou, E., Baker, L., Baulo Darhanpe, H., Beji Kraiem, S., Boualwan, A., Dr. Chikada, T., Elefante, C., Elwany, M., Gamboa, C., Hasman, M., Hunziker, R., Itanola, M., Dr. Krawietz, S., Prof. Lamberts, R., Dr. Lematire, C., Martinez, V., Pouffary, S., Schwenk, S., Shapiro, I., Sims, cbo, D., Templeton, P., Viessmann, M. (2022). " 2022 Global Status Report for Buildings and Construction", © 2022 United Nations Environment Programme,
https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

9- Schielke, T. (2016). "When Droplets Create Space: A Look at Liquid Architecture", © ArchDaily, ISSN 0719-8884
https://www.archdaily.com/795388/when-droplets-create-space-a-look-at-liquid-architecture

10- Kaunisto, T., Latva, M., Christian J. Engelsen, C. J., Kloppenborg, S., Olivier Rod, O., GulbrandsenDahl, S. (2017). "Nordic drinking water quality: A Nordic Innovation project", European Drinking Water.
https://www.europeandrinkingwater.eu/fileadmin/edw/documents_links/MaiD_Report_1_final_11.9.2017.pdf

REFERENCES

Images & drawings:

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Webpages:

01-Univercity of Wisconsin-Madison. (May 2020). Experiential learning model. https://4h.extension.wisc.edu/resources/volunteer-resources/4-h-foundations/experiential-learning-model/

02-United States Geological Survey (USGS). By Water Science School (October 25, 2019). The distribution of water on, in, and above the Earth https://www.usgs.gov/media/images/distribution-water-and-above-earth

03-Meteoblue Weather Close To You. https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/gothenburg_sweden_2711537

04-Climate Data. https://en.climate-data.org/europe/sweden/vaestra-goetalands-laen/gothenburg-197/

05-Swedish Water. https://www.svensktvatten.se/fakta-om-vatten/dricksvattenfakta/

06-World Health Organization (WHO). https://www.who.int/

07-EUROWATER. https://www.eurowater.com/en

08-Jet Propulsion Laboratory, California Institute of Technology. https://www.jpl.nasa.gov/edu/learn/project/make-a-water-filter/

09-Green Product Awards. https://www.gp-award.com/en/produkte/water-filter

10-Rain King Purification Systems. https://rainkingsystems.com/

11-Science in School, The European journal for science teachers. https://www.scienceinschool.org/article/2008/nextgeneration/

12-United States Geological Survey (USGS). By Water Science School (October 25, 2019). The distribution of water on, in, and above the Earth.
https://www.usgs.gov/media/images/distribution-water-and-above-earth

13-Jake Services. https://www.plumbingbyjake.com/lake-havasu-az/free-home-water-test/

14-Jet Propulsion Laboratory, California Institute of Technology). https://www.jpl.nasa.gov/edu/learn/project/make-a-water-filter/

15-Ready Tribe. Retrieved from. https://www.readytribe.com/a-great-diy-way-to-build-a-water-filter/

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Projects References:

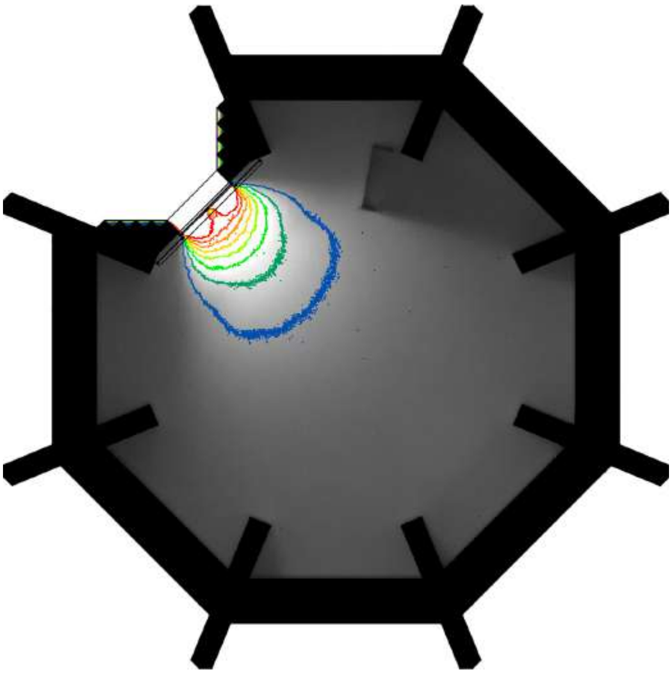
01-The Observation Point, Overijssel, Netherlands. https://www.dezeen.com/2014/05/02/viewpoint-sint-jansklooster-observation-point-staircases-zecc-architecten/
02-Water Tower Pavilion, Tiexi, Shen Yang, China. https://urbannext.net/water-tower-pavilion-renovation
03-Clay Center for the Arts and Sciences, West Virginia USA. https://www.bossdisplay.com/clay-center-for-the-arts-and-sciences-waterworks
04-Laredo Water Museum, Texas, USA. https://coredesignstudio.com/laredo-water-museum/

APPENDIX

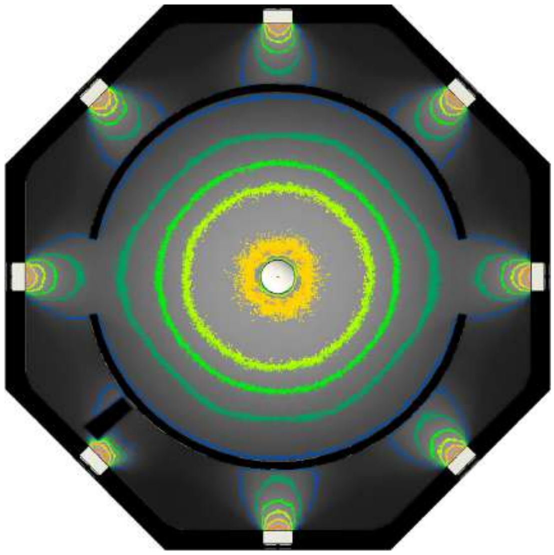
Daylight analysis:

This is the daylight analysis for ground, fourth, and twelfth floor by using VELUX program.

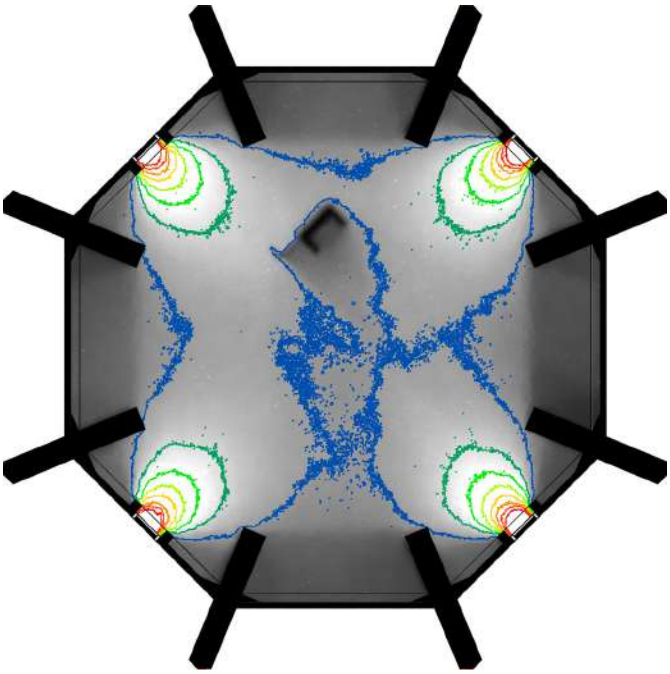
The result shows a favorable distribution of daylight across these floors, exemplified by this analysis indicating that the existing window openings adequately admit daylight. Hence, there is no necessity for additional openings in the water tower.



Ground floor



Twelfth floor



Fourth, floor

Daylight Factore Scale %

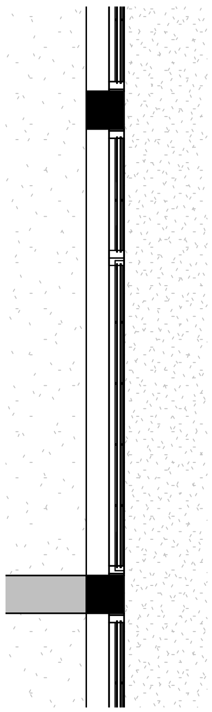
APPENDIX

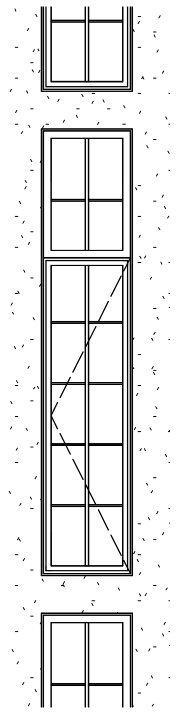
Emergency situations:

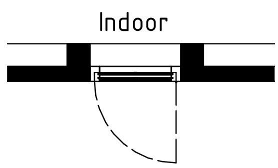
Several solutions and proposals have been attempted for escape stairs and ladders. However, a significant issue arises with some additions, such as opening escape doors on each floor at this height, which negatively impacts the facades and architectural elements that characterize Lunden's water tower. This problem is particularly pronounced when considering the addition of a metal staircase, as it would obscure the facade.

The escape plan is a crucial concern in the re-employment process, as it cannot be overlooked due to the tower's height. Therefore, one recommendation worthy of consideration is to make the current windows on the southwestern and southeastern facades openable for emergency escape when necessary.

Given the tower's location on a hill, the installation of a fixed crane adjacent to the tower may also be an urgent matter to facilitate rapid response during emergency evacuation scenarios.







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A New Contribution

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Sustainability
Gothenburg, Sweden 2024