07

CHAPTER SEVEN

TECHNICAL EXPLORATION

(PART 1 - SYSTEM DATA)

7.1
SUMMARIZED WATER TREATMENT METHOD

The contaminated water is treated as it makes its way through the various dams, channels, troughs, wetlands and river systems incorporated into the spine of the design of the facility. Various dynamic self-replenishing remediation methods, leveraging of the natural and observed adapted biome of the area will be utilised throughout the facility. These include the use of heavy metal algae water treatment (incorporating onsite sericulture elements), phytoremediation and dam and wetland settling processes.
The untreated water is stored in a detention dam that serves both as a retardation of flow in rainy season surge periods, and as the source of base flow to the system in the dry season. The amount of water entering the facility is controlled by a measured release of water from the detention dam through a water flow meter. The flow of the water is reticulated through a network of channels, coarse screen filtration, grit chambers and then into the primary stage of treatment - the algae treatment troughs.

This treatment system methodology involves the water moving through a rotational algae biofilm unit. The algae grows on a revolving biofilm which incorporate various forms of heavy metal retentive algae, such as the indigenous mining algal strain -microbial Ulothrix sp. Post the required cycle in the algae troughs the water proceeds to flow into a constructed wetland. The wetland contains a network of several plants acting as a secondary treatment through filtration and phytoremediation processes. Once the remediated water has filtered through the wetland network, it proceeds to flow into a storage dam which overflows into the river network. Other processes incorporated into the water treatment includes:

- The shredding of the biofilm into the anaerobic bio-digester when it reaches the point of saturation.
-The occasional harvesting of the depleted phytoremediation plants and the related entering of these into the anaerobic bio-digester. .
- The removal of the sludge from the anaerobic bio-digester from the site and related off site incinerated according to environmental regulations. The heavy metal separation from the ash post incineration and the related treatment as hazardous waste.

7.2

SYSTEM DATA FOR WATER TREATMENT

The following systems data influences the technical resolution of the design:

1. Volume of industrial effluent
2. Size of the detention dam
3. Size of contaminated water canal through the facility
4. Size of individual algal troughs
5. Data for production of biofilm
6. Size of the anaerobic bio-digester
7. Storage reservoir for treated water
8. Rainwater harvesting from roof surfaces and user's water demand

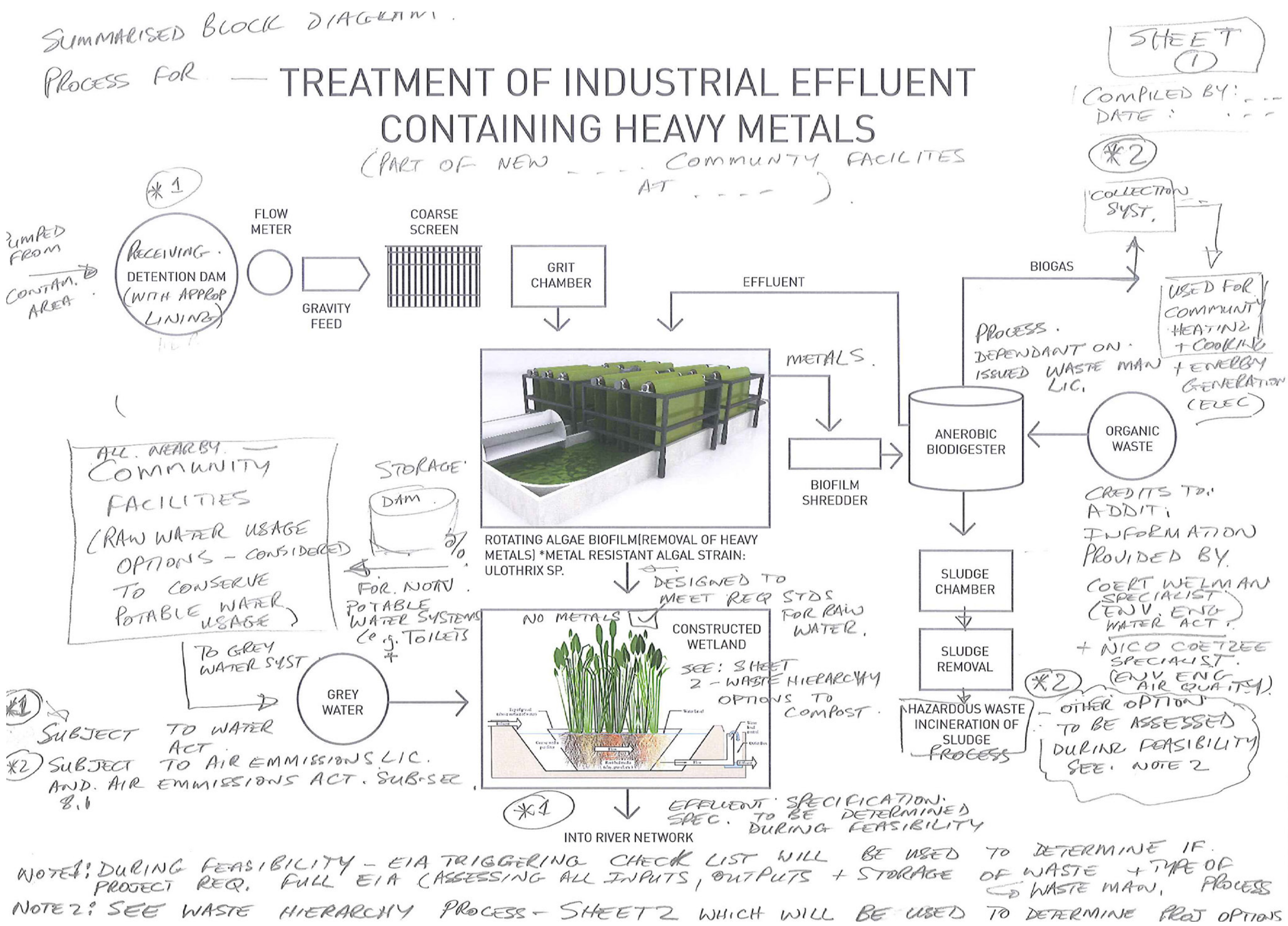
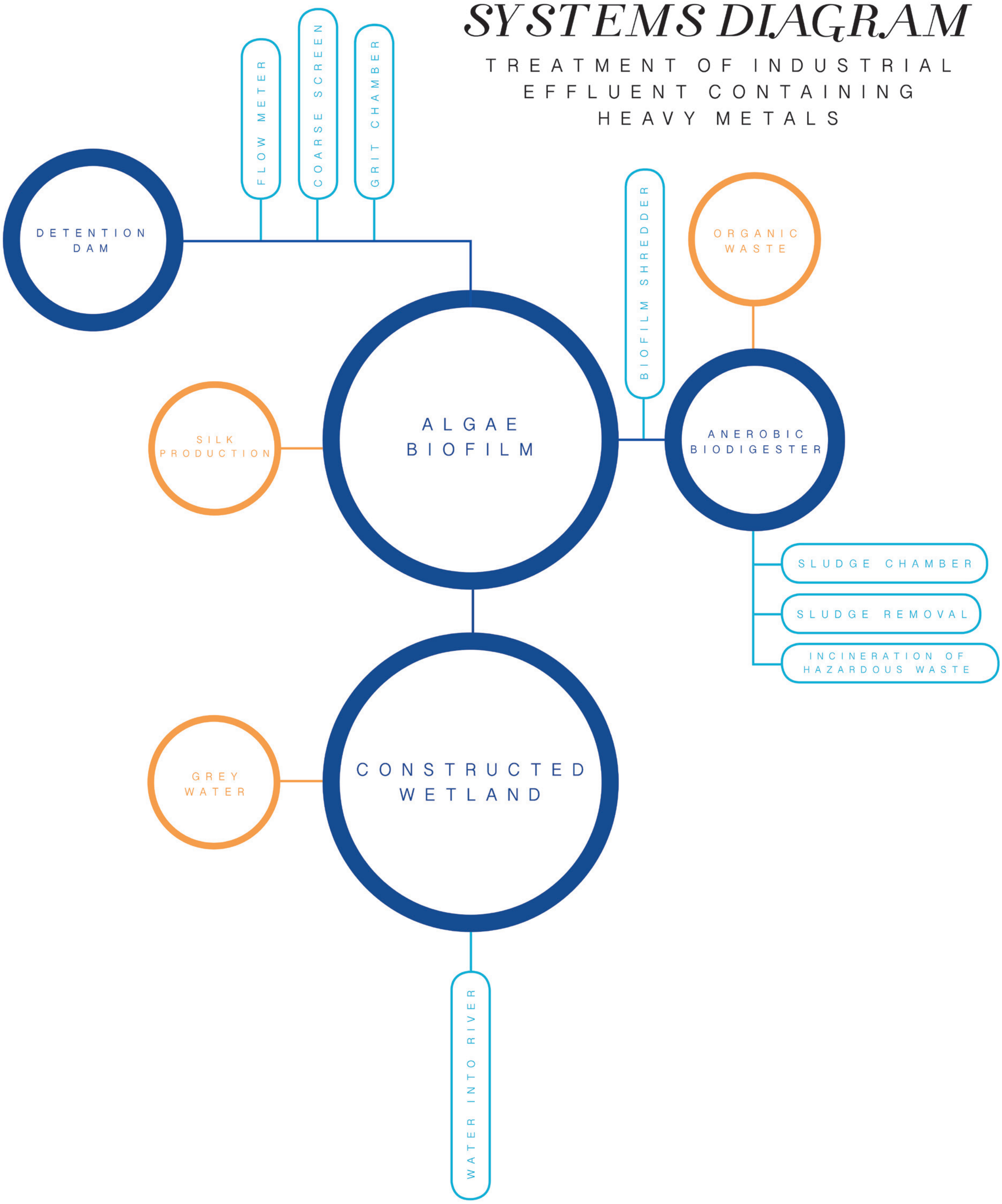


Figure 7.1: Treatment Diagram edited by environmental specialists.
(Welman, Coetzee, Grala, 2016)

NATURAL SYSTEMS DIAGRAM

TREATMENT OF INDUSTRIAL EFFLUENT CONTAINING HEAVY METALS



7.2.1
THE VOLUME OF INDUSTRIAL EFFLUENT

The water flow and existing canal infrastructure was measured on site and the following formulas were used to determine the constant flow of industrial effluent:

Velocity= distance / time
Cross sectional area of the water= width x depth
Volumetric Flow = velocity x cross sectional area of the water.
This data shows that 397, 1 m^3 enters the site every day.

The understanding of the volume of water is crucial for the design of the contaminated water canal through the facility, algae system and constructed wetland.

Figure 7.2: Industrial effluent entering the site on a daily basis. (Author,2016)

7.2.2
SIZE OF DETENTION DAM

The detention dam plays a vital role in the effectiveness of the treatment system. The base flow of industrial effluent is 397.1m^3 per a day. During high rainfall the Rietspruit canal will collect run-off from the surrounding areas which will dilute the contaminated water with storm water run-off. The implementation of the detention dam is crucial to retain the larger volume of untreated water after heavy rainfall. The detention dam has been introduced to store and regulate the amount of untreated water entering the facility.

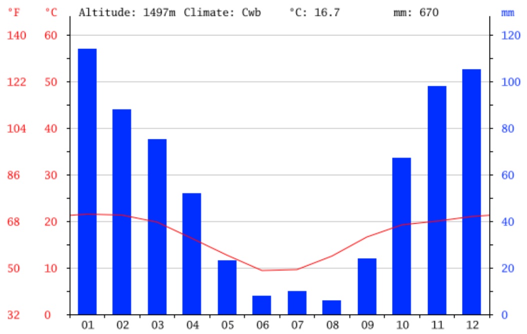


Figure 7.3: Annual rainfall graph (Climate-Data.Org,2016)

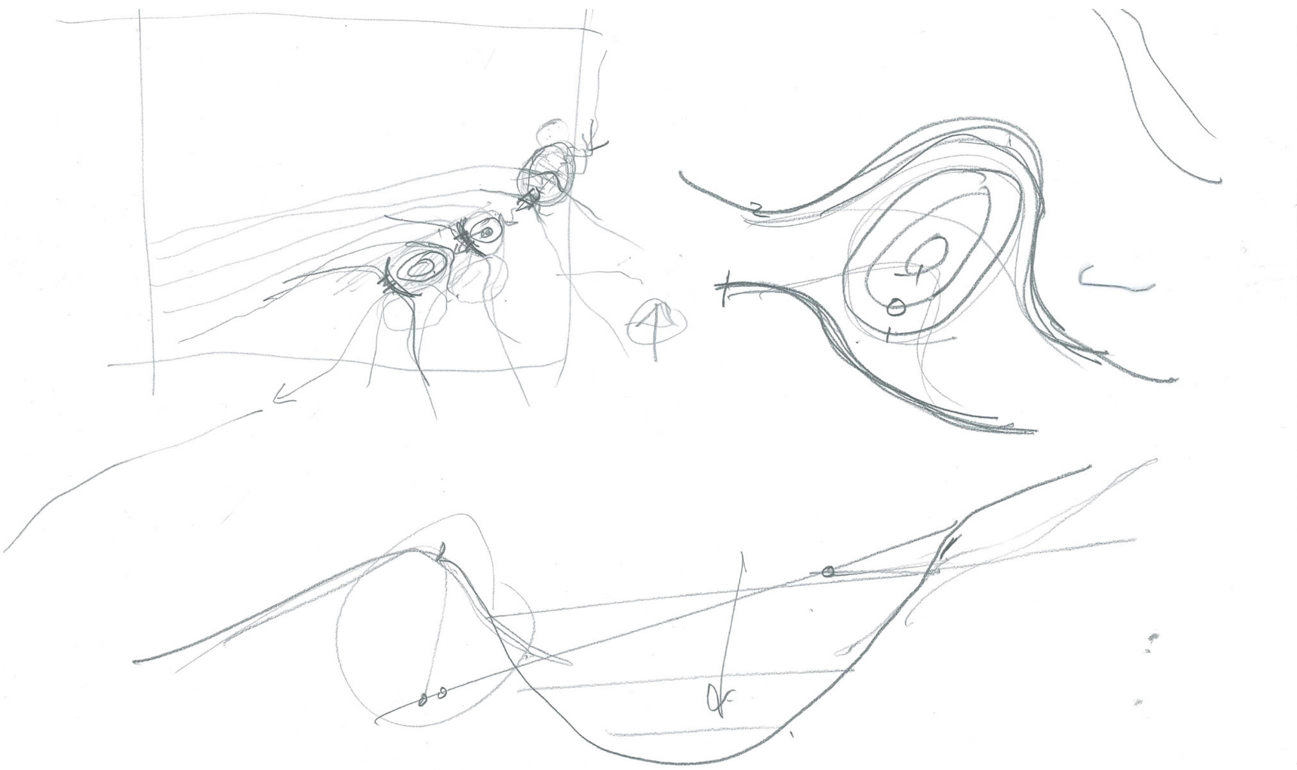


Figure 7.4: Conceptual sketch of detention dam. (Author,2016)

The rainfalls catchment area along the length of the Rietspruit canal has been estimated at 704,384m2, which includes a large portion of the industrial area. This area along with assumptions on the absorption and evaporation rate of the water in this catchment area has been used as the basis for the water volume and storage requirements estimates. A 50% absorption rate has been applied as well as 2-10% evaporation based on the temperature chart.
The size of the detention dam takes into consideration the volumes of water that can be processed by the facility, and the resultant calculation accounts for the dam volumes that have sufficient capacity to ensure the water will be gradually emptied during the dryer months of winter in preparation for the next rainy season, mitigating the cyclical nature of the processing requirement.
Calculations performed for annual rainfall management yielded the need for a a 7621m3 detention dam size. This is based on the assumption that the treatment facility is running at 90% capacity at 2.5 cycles per a day. The dam will require an automated flow meter which will release the required amount into the canal leading into the facility.

7.2.3
SIZE OF CONTAMINATED WATER CANAL

The canal transporting contaminated water through the building and into the algal systems needs to store 469.8m3 at maximum capacity. These canals feed water into the algal troughs network for the treatment process. These troughs are filled from the canal network and emptied into the respective wetlands. The canals need to supply sufficient water for the capacity of the treatment and hence the volume of the canal needs to allow for this capacity requirement. The entire length of the canal is 178m from detention dam to the last algal system.
The guideline for the canal size is 1.65m x 1.8m x 178m = 528.66m3, yet the canal will only be 90% full at all times which leaves it with a capacity of 475.79m3

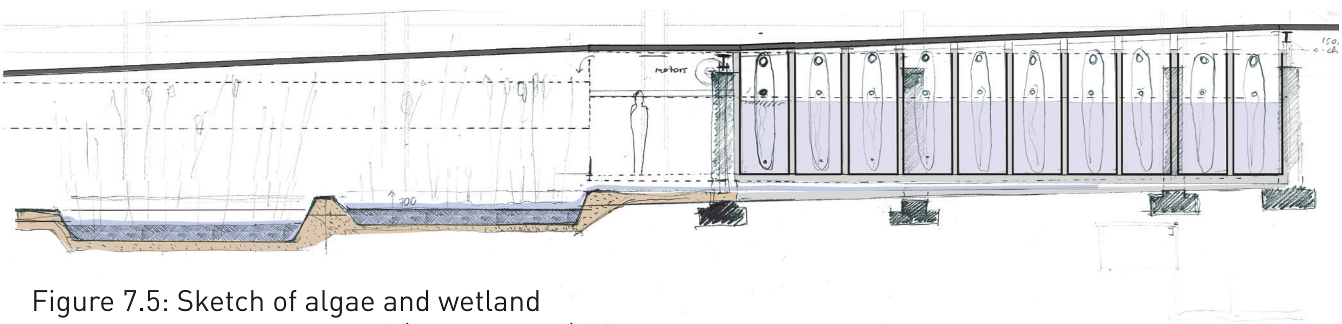


Figure 7.5: Sketch of algae and wetland system with walkway above. (Author,2016)

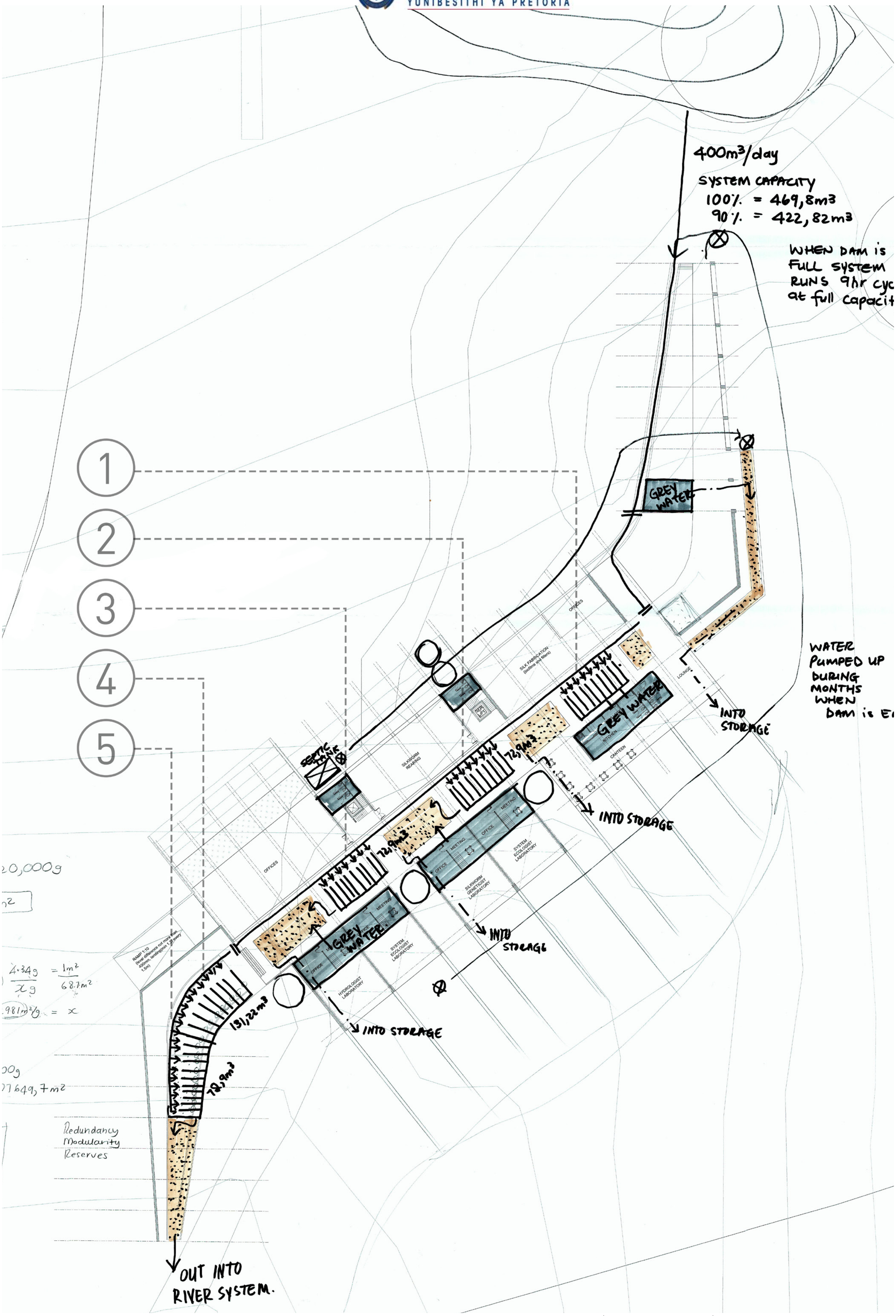


Figure 7.5: Algae and wetland treatment system. (Author,2016)

7.2.4
SIZE OF INDIVIDUAL ALGAL TROUGHS

The algal system as a whole is made up of 5 sub-systems which contain individual troughs respectively. The algal system has a total capacity of 400.6 m3 at 90% capacity. The facility is designed to complete 2.5 cycles in a normal day. It is assumed that the canal will fill and empty at 18 minutes respectively. The contaminated water will remain in the troughs for 9 hour cycles before being released into the constructed wetland. The facility is anticipated to run continuously with stoppages only for preventative maintenance and replacement of the biofilms. The facility has been designed with, 10% additional capacity as well as margin for factoring in normal anticipated down time. Taking these into account the facility is anticipated to be able to process the effluent base flow as well as the annual average rainfall with ease. It is anticipated that with this correct management of the cyclical rainfall the algal trough network will be able to process the full volume of detention dam in the dry season allowing it to be empty in time for the next high rainfall season.

7.2.5
DATA FOR BIOFILM PRODUCTION

Amount of biofilm medium required:
There are 55 biofilms. Each biofilm requires two lengths of 2.5 x 5m of silk or 25m2. 55 x 25m2=1375m2 of silk fabric is required for the algae processes to be working at full capacity.

Production yield of sericulture:
The 900dfl yields 360,000 cocoons/120 kg every 16-22 days, the amount of time required for the silkworm to grow and spin its cocoon. 1kg of silk fabric requires 3000 cocoons and 4.34 grams = 1m2 of silk (Planet trading, 2016: Online)

This yields 27,649m2 of silk fabric production every 16-22 days. The algae treatment system requires 1375m2 of silk at full capacity, therefore 27,649m2 can provide for 20 treatment cycles every 16-22 days. Is the yield is sufficient as biofilms are only removed once the algae biofilm reaches saturation, on average 4-5 days.

7.2.6
SIZE OF ANAEROBIC BIO-DIGESTER

The Chemical Forum states that a single digester of 3150m3 can treat 50,000 ton/year or 136.9 ton/day of organic waste. The processing requirement of this facility is estimated at a maximum of 1 ton/day. This would require a bio-digester with a capacity of 23m3. (Chemical Forum, 2016: Online)

Volume of cylinder = $\pi/4 \times d^2 \times h$
With a diameter of 4m and height of 1 meter:
1 digester = 12.6m3
2 digesters = 25.1m3 (8.5% overdesign)

A total waste yield of 1 ton/day will be assumed which will include bio-degradable biofilms, solid human waste, silkworm waste as well as all organic kitchen waste. The two bio-digesters will allow for management of waste and production of biogas.

7.2.7
STORAGE RESERVOIR

The Chemical Forum states that a single digester of 3150m3 can treat 50,000 ton/year or 136.9 ton/day of organic waste. The processing requirement of this facility is estimated at a maximum of 1 ton/day. This would require a bio-digester with a capacity of 23m3. (Chemical Forum, 2016: Online)

Volume of cylinder = $\pi/4 \times d^2 \times h$
With a diameter of 4m and height of 1 meter:
1 digester = 12.6m3
2 digesters = 25.1m3 (8.5% overdesign)

A total waste yield of 1 ton/day will be assumed which will include bio-degradable biofilms, solid human waste, silkworm waste as well as all organic kitchen waste. The two bio-digesters will allow for management of waste and production of biogas.

7.2.8
RAINWATER HARVESTING

The facility's clean water daily demand is calculated at 1.14m3 (Annexture D). The water management plan involves harvesting rain water for activities which require clean water. According to the According to the calculation in Annexure C, the facility will require rainwater storage for the winter months of June, July and August. 62.93m3 will need to be stored during the high rainfall periods to ensure the facility has clean water all year round. There is an excess of 774.67m3 during the months of September to May. 7 x 10000L water tanks will be needed for storage for the winter months.

07

CHAPTER SEVEN

TECHNICAL EXPLORATION

(PART 2)

7.3
TECHNICAL INTENTION

"In many ways, the environmental crisis is a design crisis. It is a consequence of how things are made, buildings are constructed, and landscapes are used. Design manifests culture, and culture rests firmly on the foundation of what we believe to be true about the world. Our present form of architecture is derived from design knowledge incompatible with nature's own." (Littman, 2009:40)

The technical intention of this dissertation is rooted in an understanding of resilience rather than sustainability. Natural systems, that restore, regenerate, and replace conventional methods which deplete resources. Regenerative thinking recognizes our connection to the natural world and re-establishes the relationship between man and nature, moving away from the worldview that the earth and its resources are ours to exploit.

The technical focus of this dissertation is the removal of heavy metals from the industrial effluent from the nearby industry and the supportive spaces that make the remediation process possible and provide community development opportunities for the township of Bophelong.

7.4
ARCHITECTURE THAT HEALS

The technical exploration intends to answer the research question stated in chapter 1 of this dissertation: "How can architecture be constructed to intercept and create a condition which sustains the healing of a contaminated environment and its people?"

The technical exploration has been divided into the following categories:

1.The base structure
2. The building as an extension of the landscape
3. The primary steel structure
3.The contaminated water canal
4. The algae and wetland system
5.The continuous roof
6. The spine's covering
7. Internal walls

7.4.1
MATERIAL PALLET

The approach to the material selection for the construction of the facility builds on the idea of preserving the earth's non-renewable resources. The design intends for steel off-cuts to be incorporated and the by product of the steel making process, flyash will be added to the concrete work. All the materials are to be supplied by the local industries. Raw materials and recycled bricks have been selected for their durability and low impact on the environment.

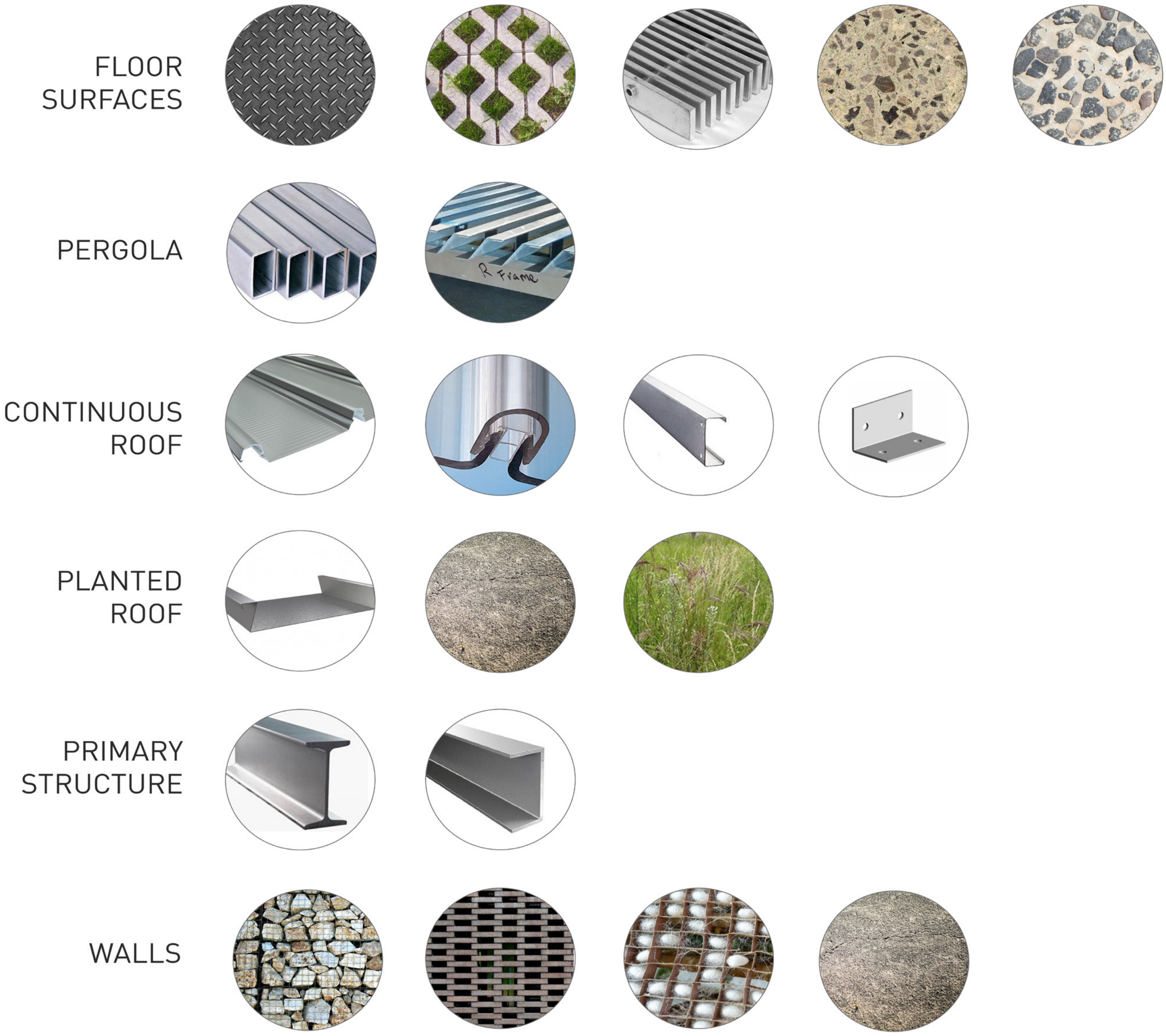
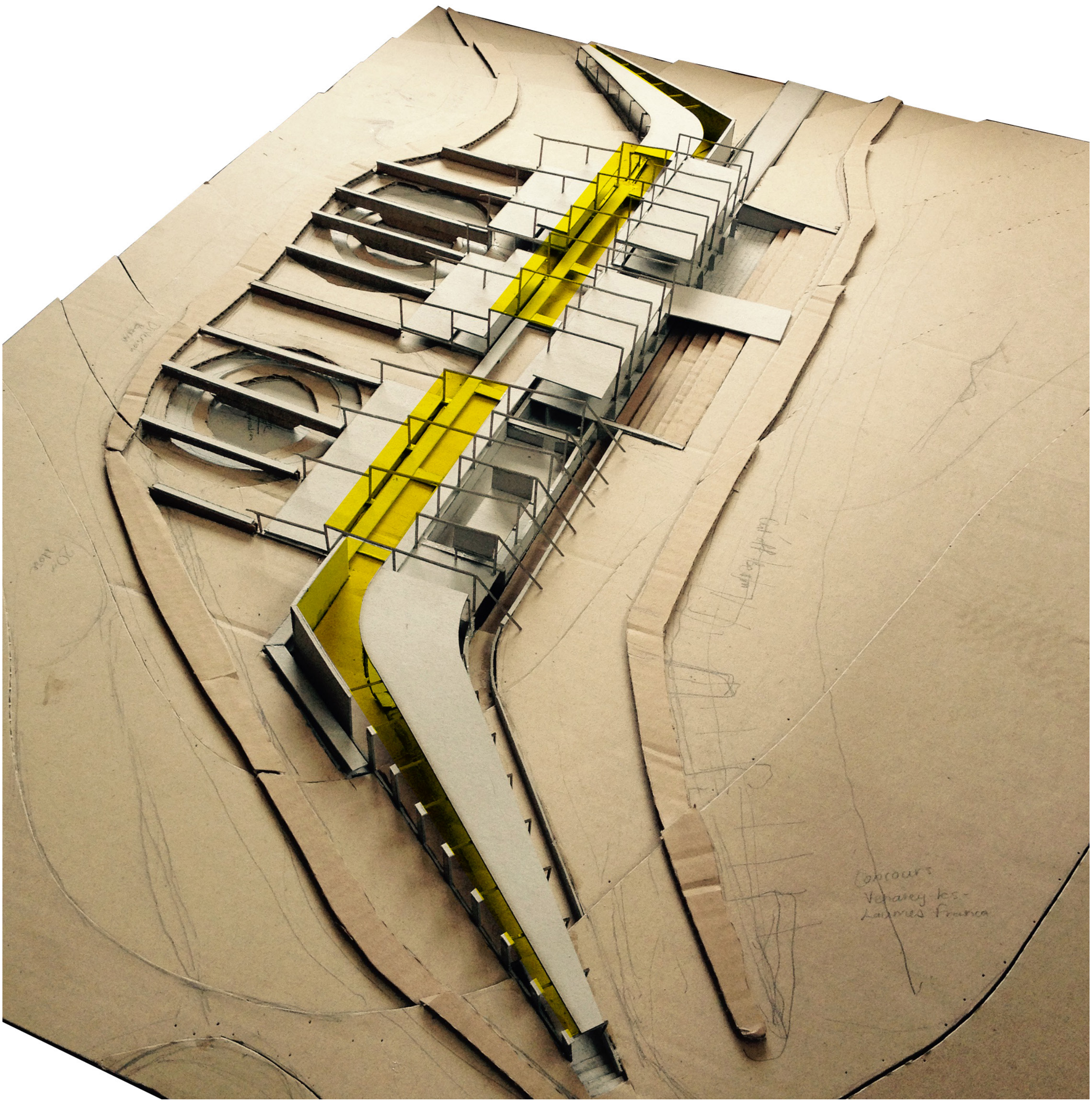


Figure 7.7: Materiality for low impact and durability. (Author,2016)

7.4.2

THE SPINE

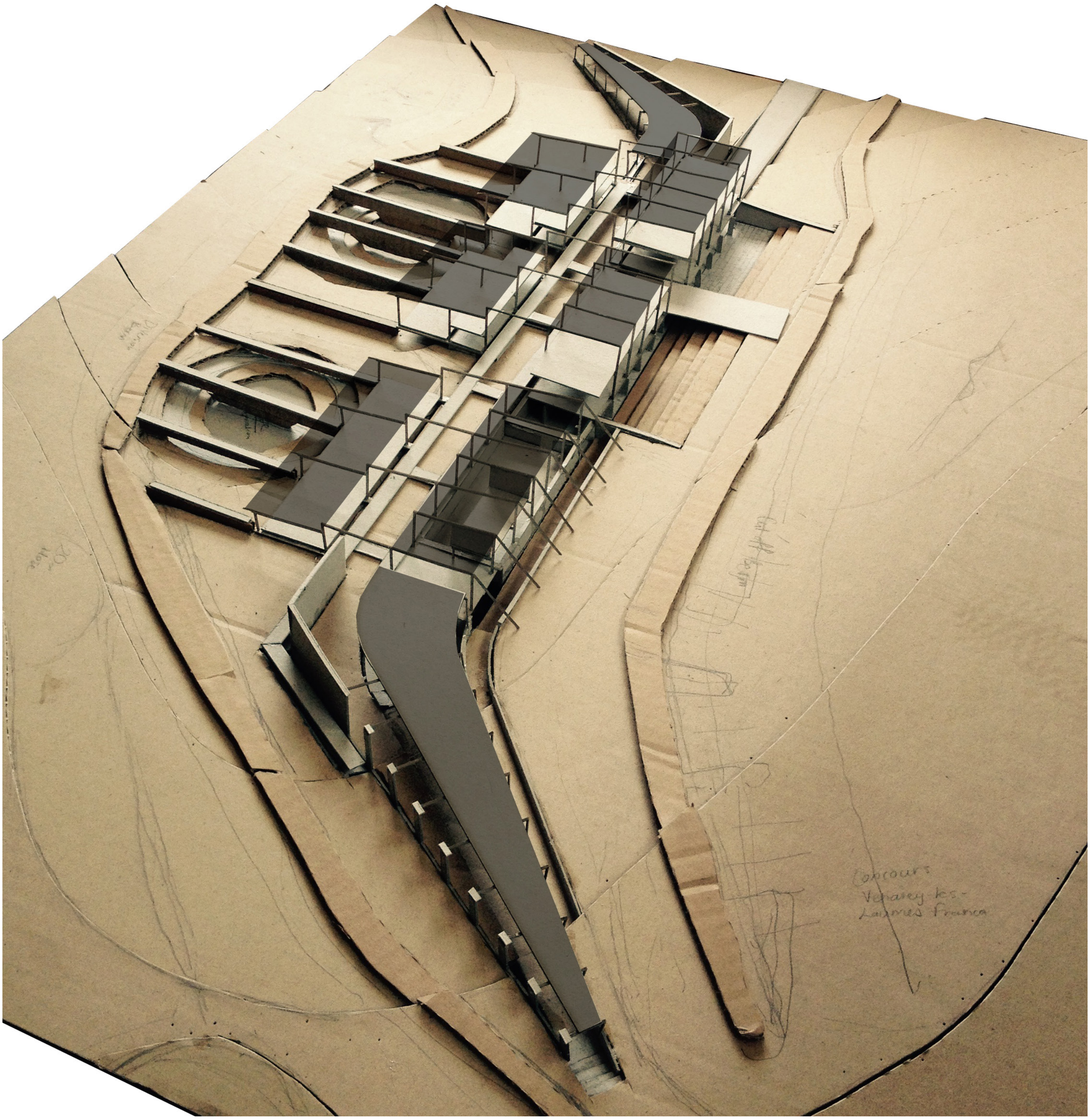
The spine of the building can be seen as a series of continuous spaces which run between the formal roofs covering on either side. The nature of these spaces are open to the elements, allowing sun and rain in, yet in some places the rhythm changes to a more protective covering to suit the function below, yet the concept of light entering the spaces below remains consistent. Where necessary the translucent sheeting is covered by a pergola which is the host of vines and creeper to shade the spaces beneath during the summer months. In winter the leaves will fall improving the overall performance of the facility.



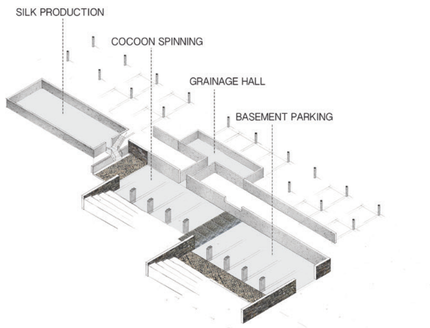
7.4.3
THE CONTINUOUS ROOF

The planted steel roof covers the exhibition hall and auditorium. All the supportive processes and production are situated between the beginning and the end of the roof. The rearing halls, biofilm fabrication, canteen and laboratories are all covered by conventional metal sheeting.

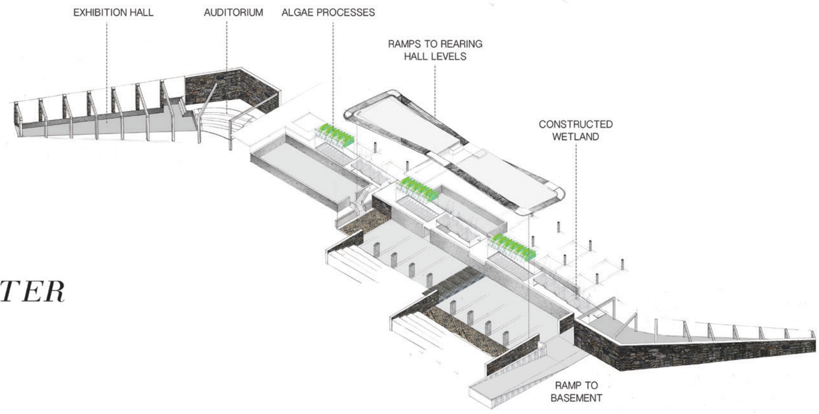
The planted steel roof continues back into the landscape which ends the cycle of the removal of heavy metals by releasing the water back into the river system.



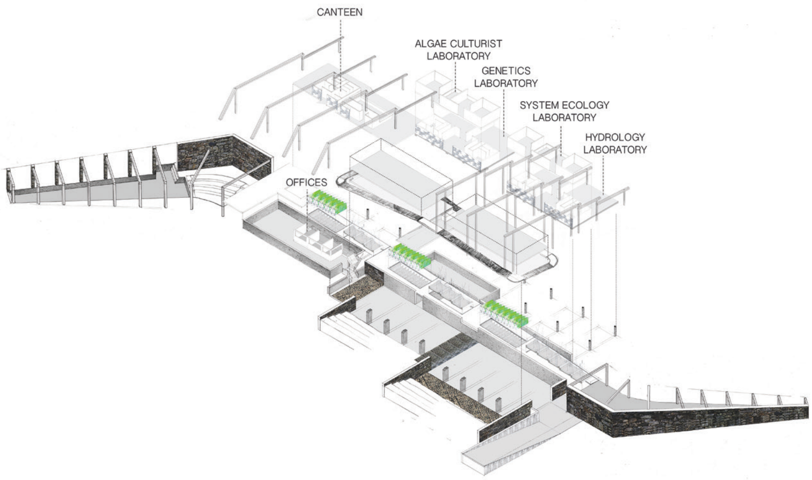
1 *BASE STRUCTURE*



2 *FLOW OF RAMPS & WATER*



3 *STEEL STRUCTURE*



7.4.4
THE BASE STRUCTURE

The solid base is constructed as the most permanent layer of the intervention's structure. This includes the concrete columns, retaining walls and concrete piles.

Approximately 20% of the site's natural landscape has been previously disturbed. The portion of the facility which is built below natural ground level is zoned according to the disturbed areas. The retaining walls are constructed on the transition edge between the wetland area and disturbed landscape. The retaining walls create the void for the insertion of the algae and wetland systems. The gabion walls retaining walls are constructed to create the terrace landscape to the basement level of the facility. The grainage hall which requires a damp, dim environment has been included within the base structure.

The concrete columns and retaining walls become the base for the steel frame envelope of the building. The concrete piles are used due to the buildings placement on the edge of the low lying wetland basin. The intention is for the existing wetland to be disturbed as little as possible.

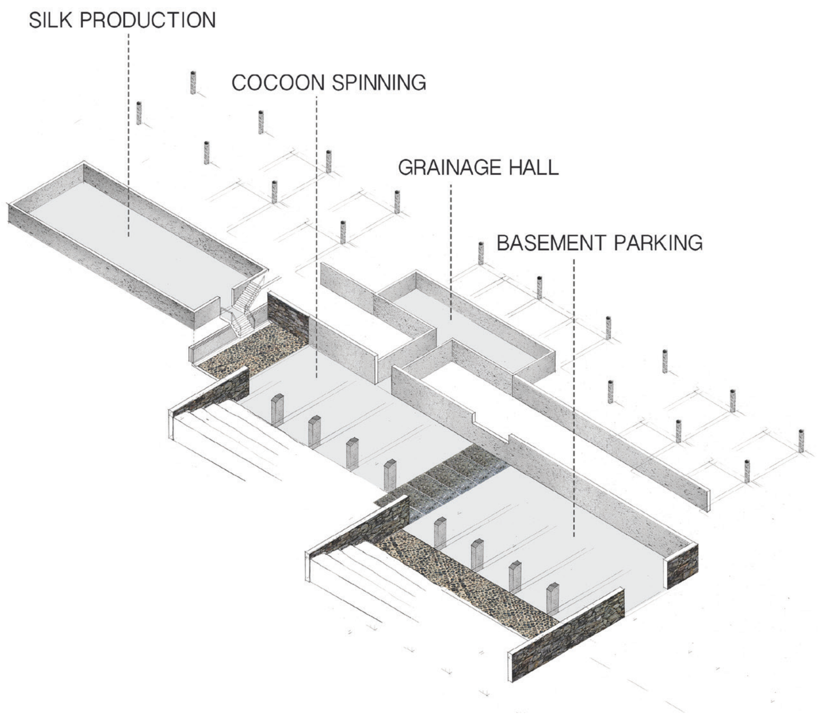


Figure 7.8: The base structure. (Author,2016)

7.4.5

BUILDING AS AN EXTENSION OF THE LANDSCAPE

The concept of man and nature led to the healing infrastructure as an extension of the earth constructed to include natural materials on site. The gabion walls are included for its characteristic of permability to encourage a natural habitat to develop within and around the facility. The plants and organisms found on site will grow and move through the rocks to create a natural habitat within the facility. The tapered walls become the structure to which the steel frames are fixed.

The roof covering of the spaces created by the tapered walls was iterated extensively in the design development. A roof planted with the soweto highveld grass will be the appropriate iteration to express the facility as a sensitive development in the natural landscape. The technical resolution of planted roof includes a steel frame @2meter intervals with bondlok as permanent shuttering for 135mm of concrete for a load of 17.1kn/m^2. Sandy soil weight ranges from 5-15kn/m^2. (Typical soil properties, 2016:online)

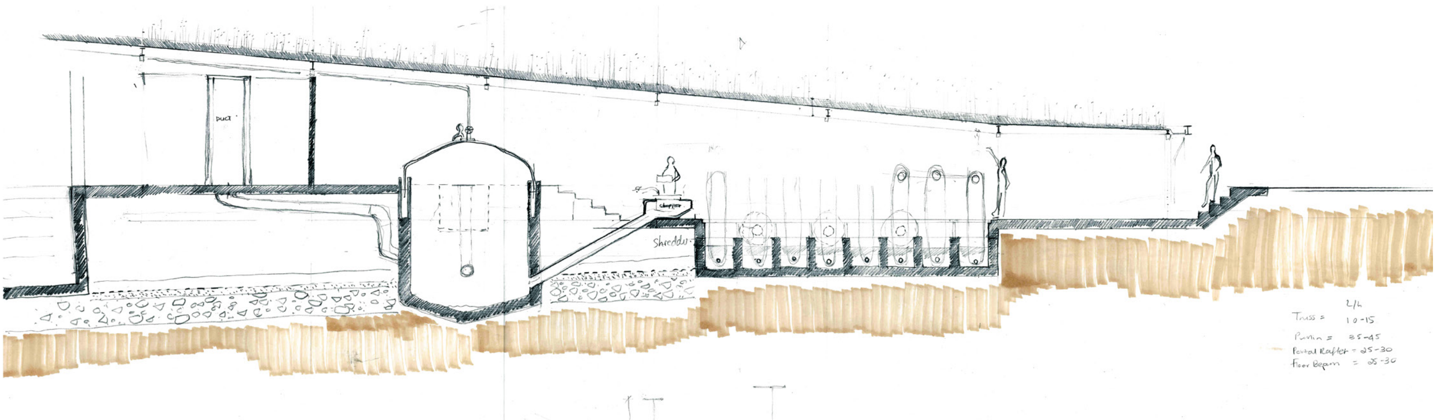


Figure 7.9: Planted roof and tapered gabion walls. (Author,2016)

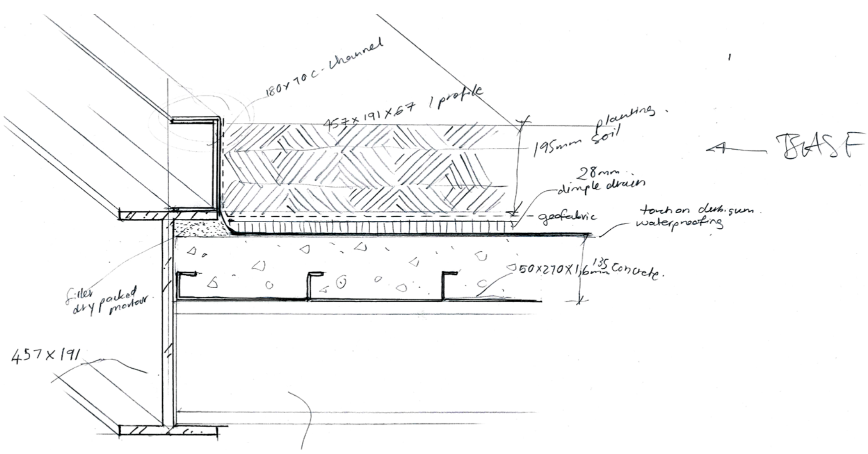
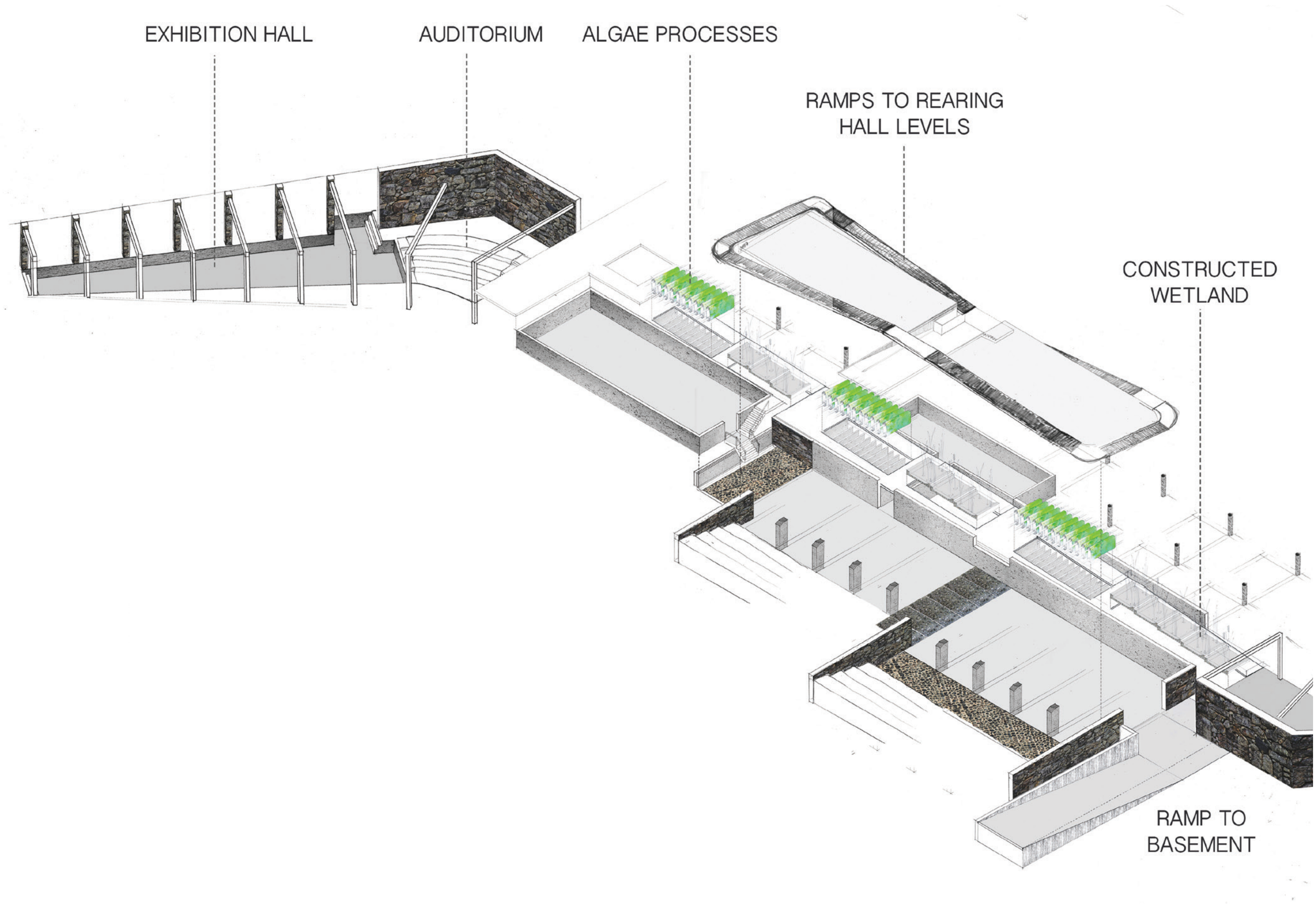


Figure 7.10: Planted steel roof detail. (Author,2016)



7.4.4

RAMPS & WALKWAYS

The route through the facility is connected with a continuous walkway that follows the gradient of the site and flow of the water. The walkway is detailed to be raised above the treatment processes to allow visitors to view the activities. The walkway covered with mentis grating allows the flowing water to be experienced and seen without compromising saftey.

The rearing hall has a continuous ramp within its perimeter - connecting the top and bottom level. The ramps have been placed within the envelope of the building for the movement of the insects through their life cycle. The ramps double up as an efficient method to remove waste.

7.4.6
STEEL STRUCTURE

Steel construction's adaptable and deconstructive nature is ideal for the primary structure of the facility which requires large volumes and open spaces . The steel frame is fixed to the base structure's columns and retaining walls. 230 x 85mm parallel flange c-channels are fixed to a 203x133x30mm I-profile. The Bondlok composite flooring system is fixed to 203x133x30mm I-profile joists @2000mm intervals.

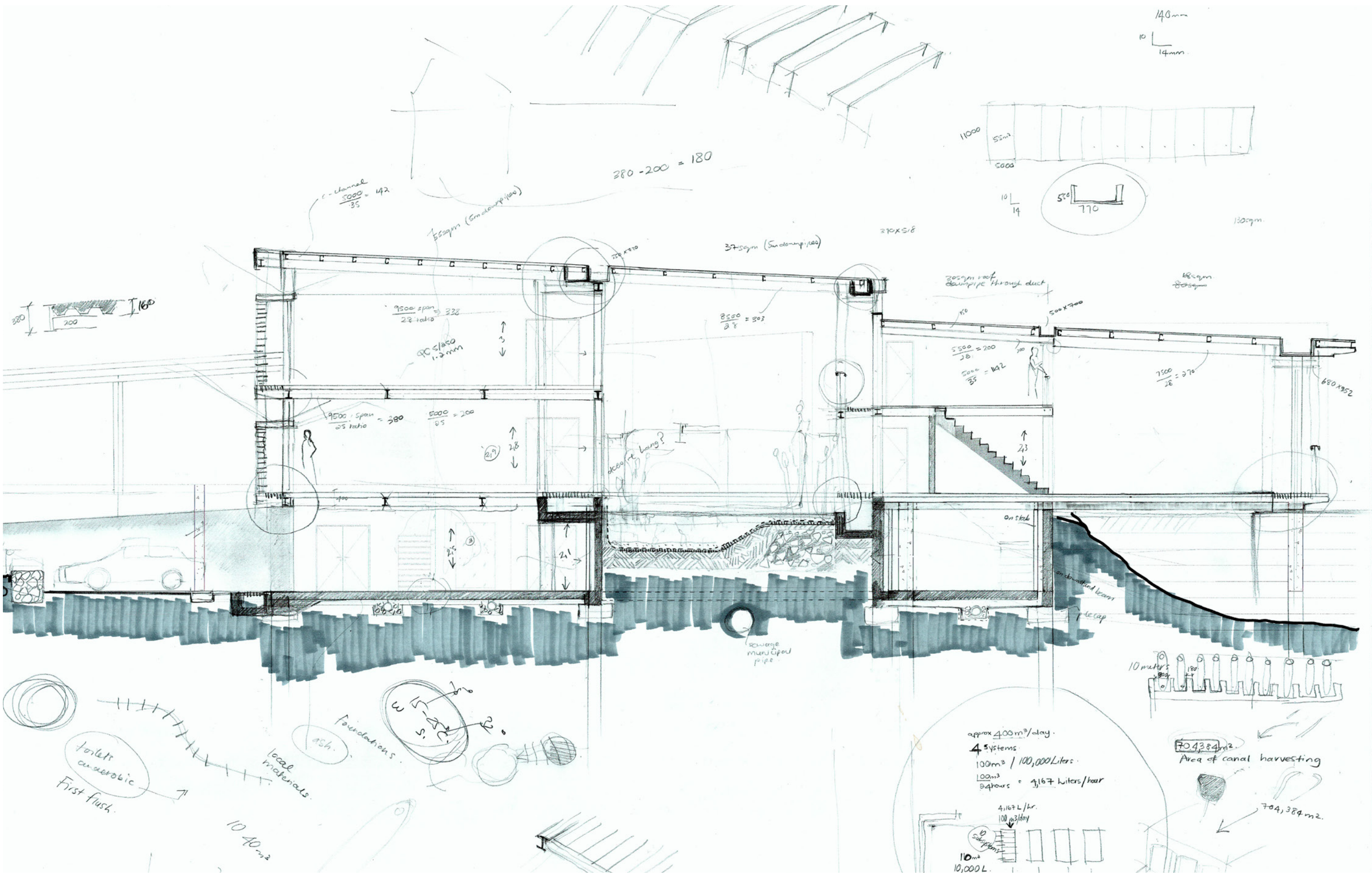


Figure 7.10: Section with base structure and steel frame. (Author,2016)

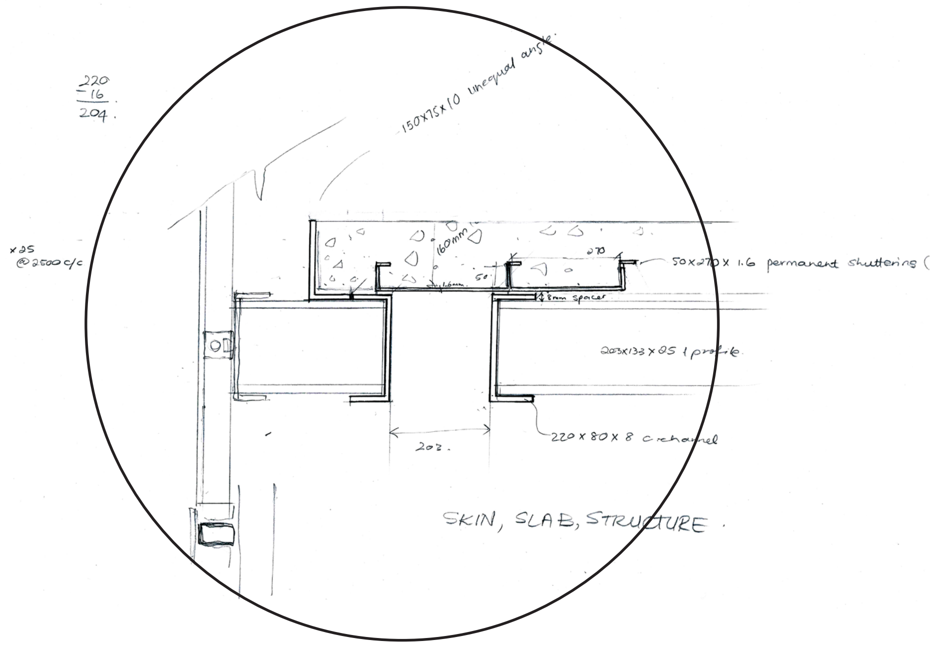


Figure 7.11: Bondlok fixed to I-profile joist (Author,2016)

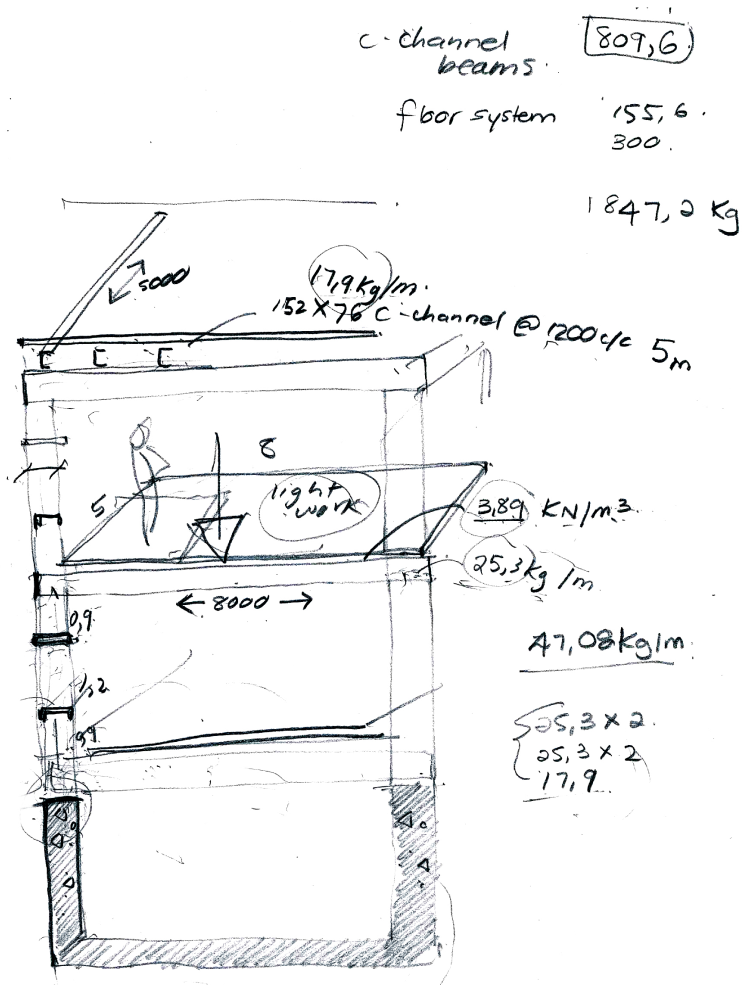


Figure 7.12: Sizing of steel structure. (Author,2016)

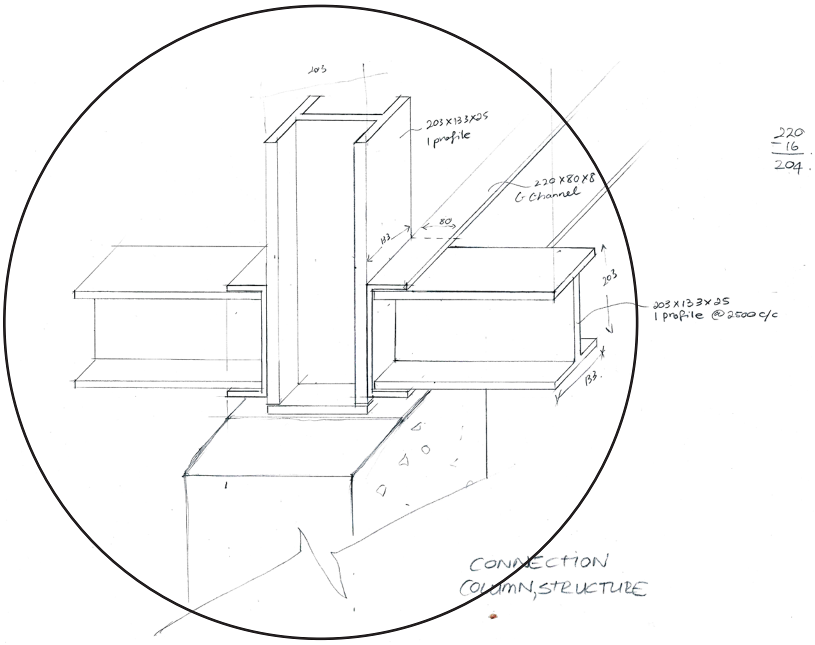
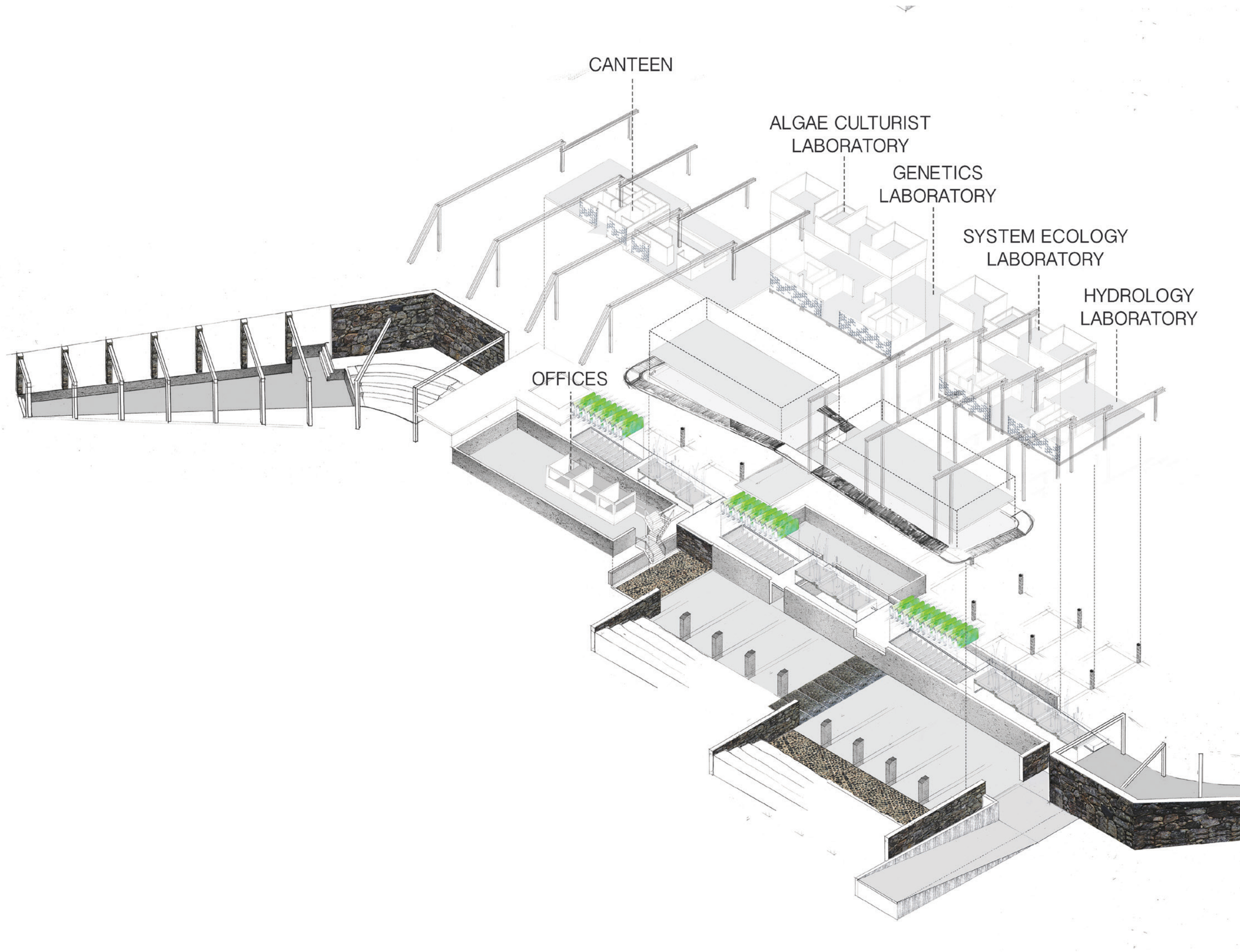
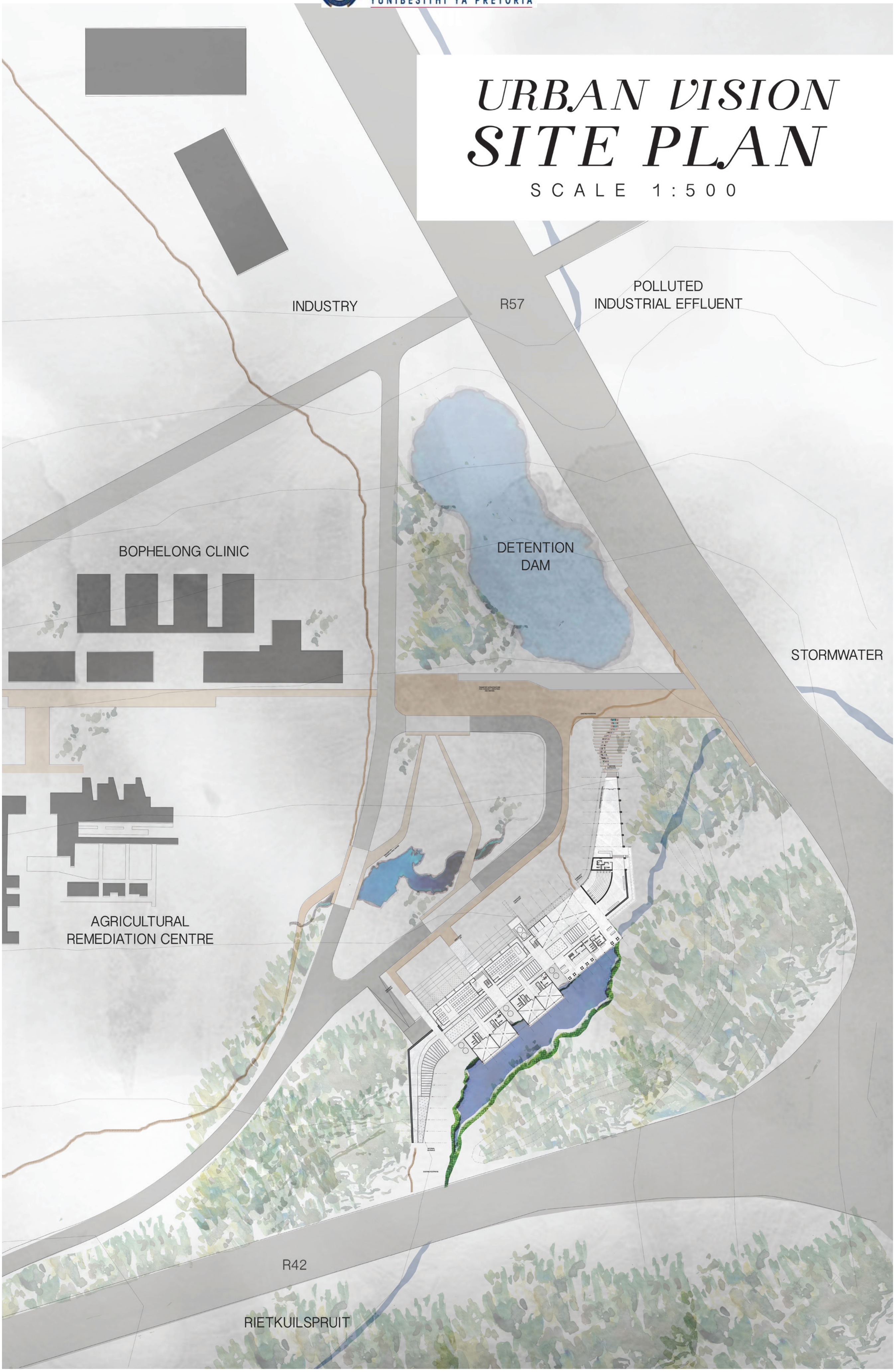


Figure 7.10: Typical steel connection (Author,2016)



FINAL PRESENTATION

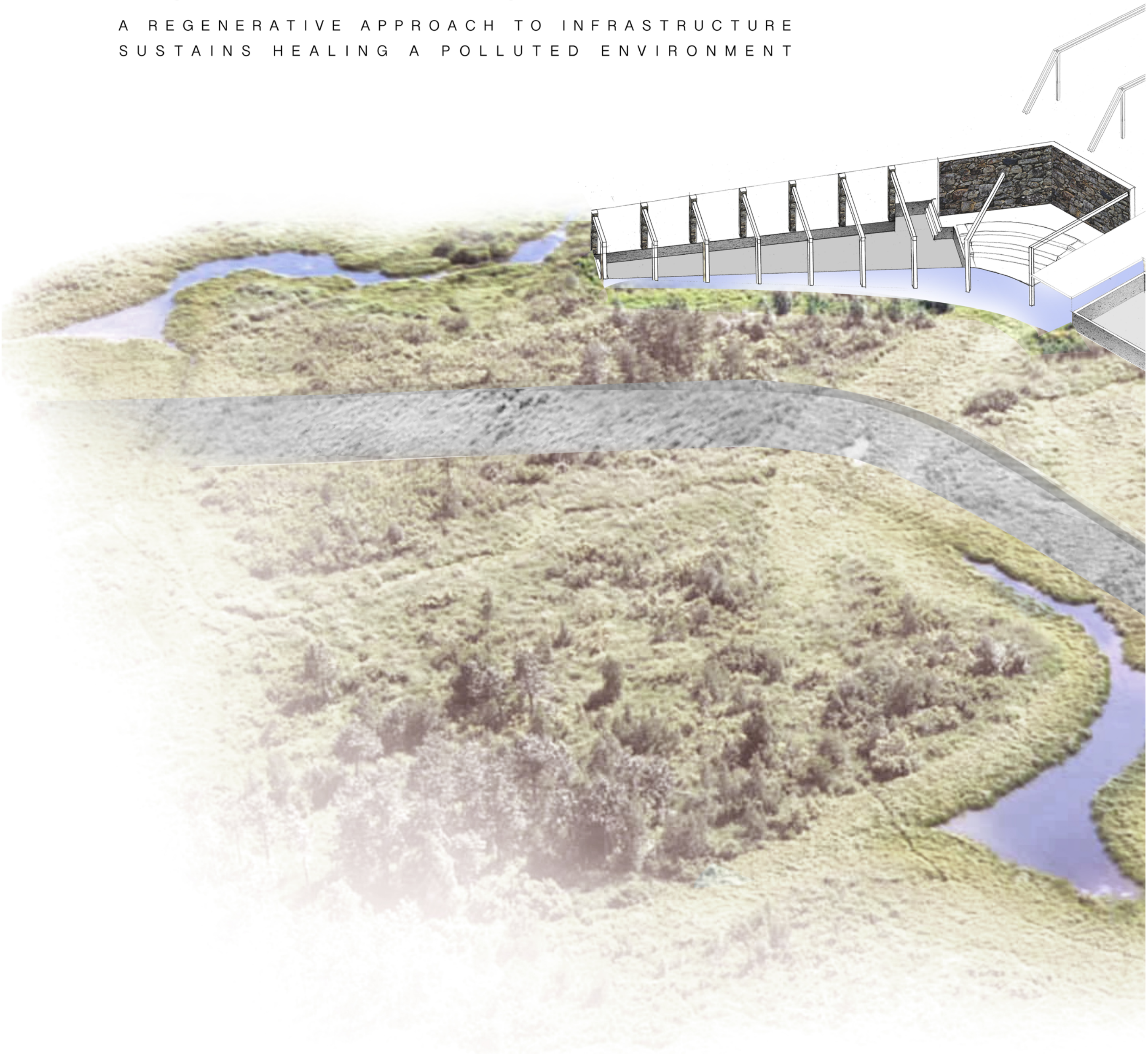
URBAN VISION
SITE PLAN
SCALE 1:500

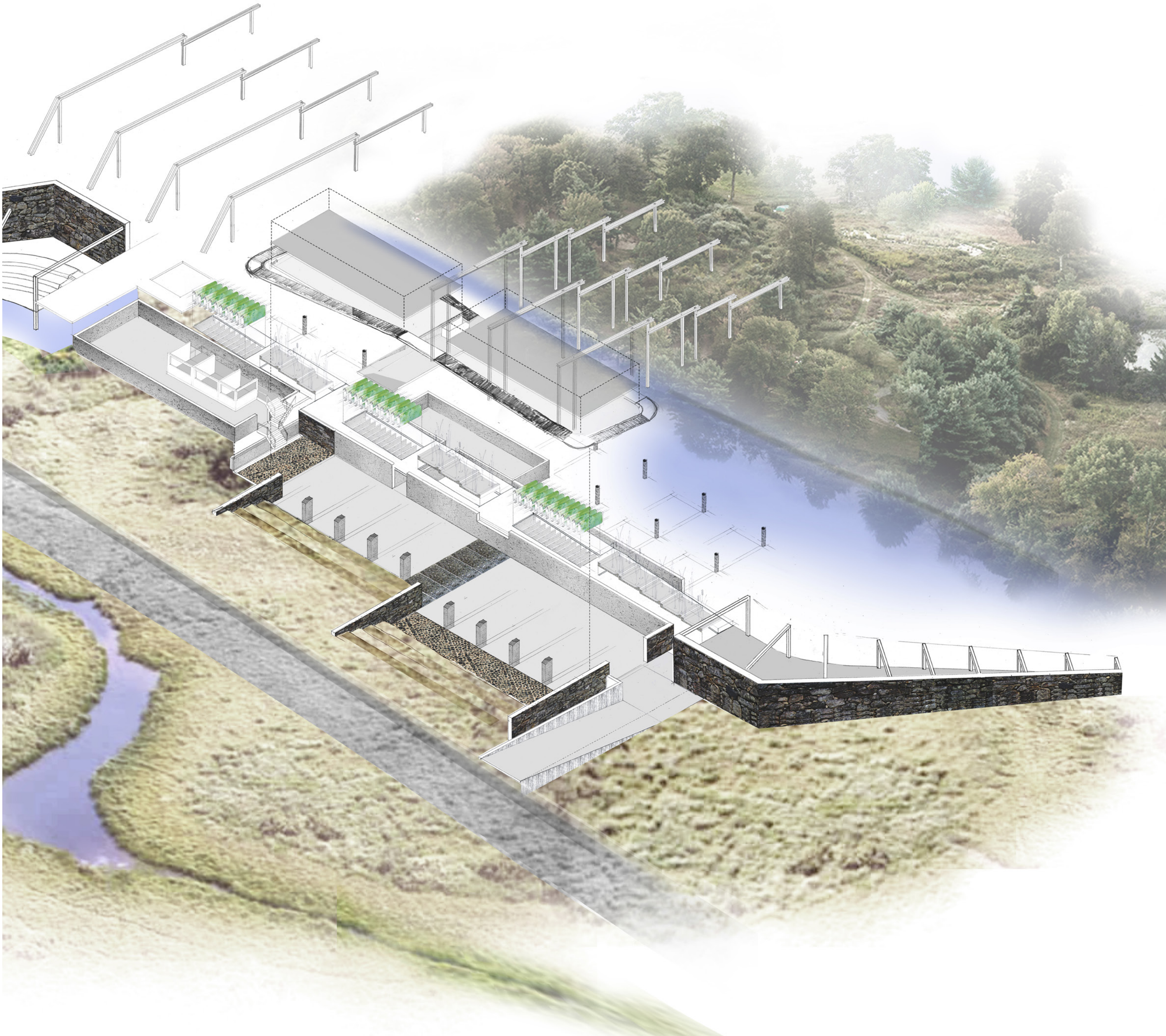


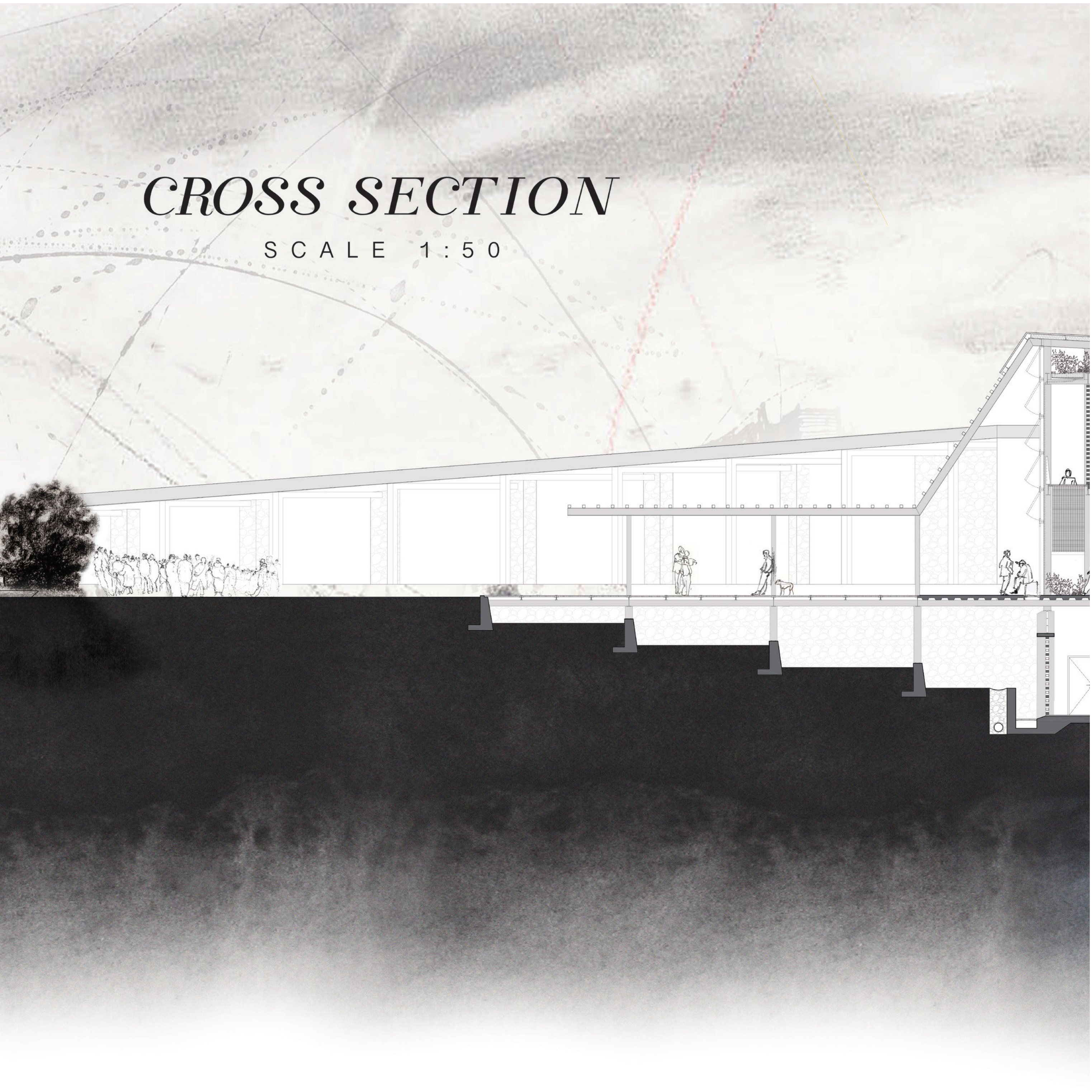
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

AN ALTERNATIVE APPROACH
WATER TREATMENT

A REGENERATIVE APPROACH TO INFRASTRUCTURE SUSTAINS HEALING A POLLUTED ENVIRONMENT






CROSS SECTION
SCALE 1:50


REARING HALL
REARING HALL
BASEMENT FOYER
ALGAE AND WETLAND SPINE
MEETING ROOM
WAITING AREA
GRAINAGE HALL
ALGAE CULTURIST LABORATORY

BASEMENT PLAN

SCALE 1:200

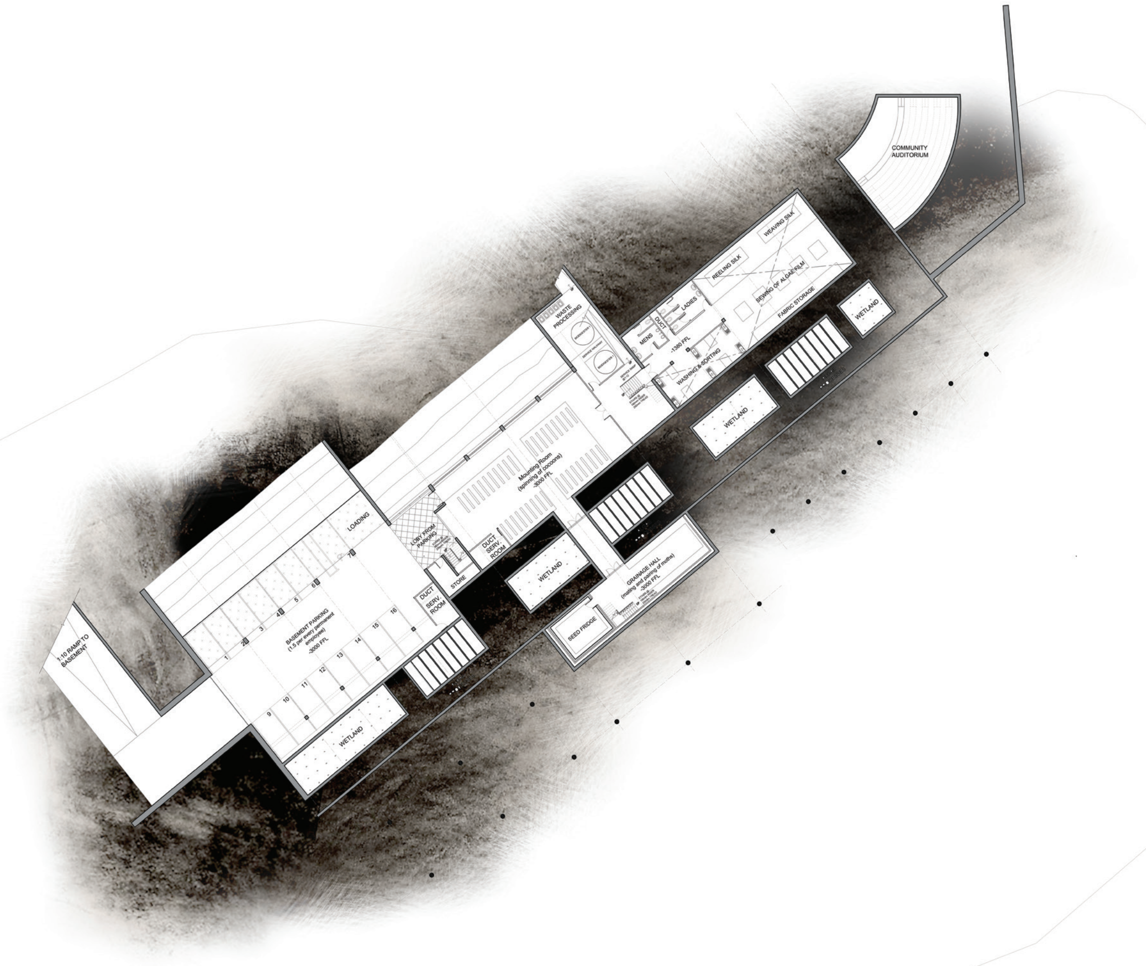
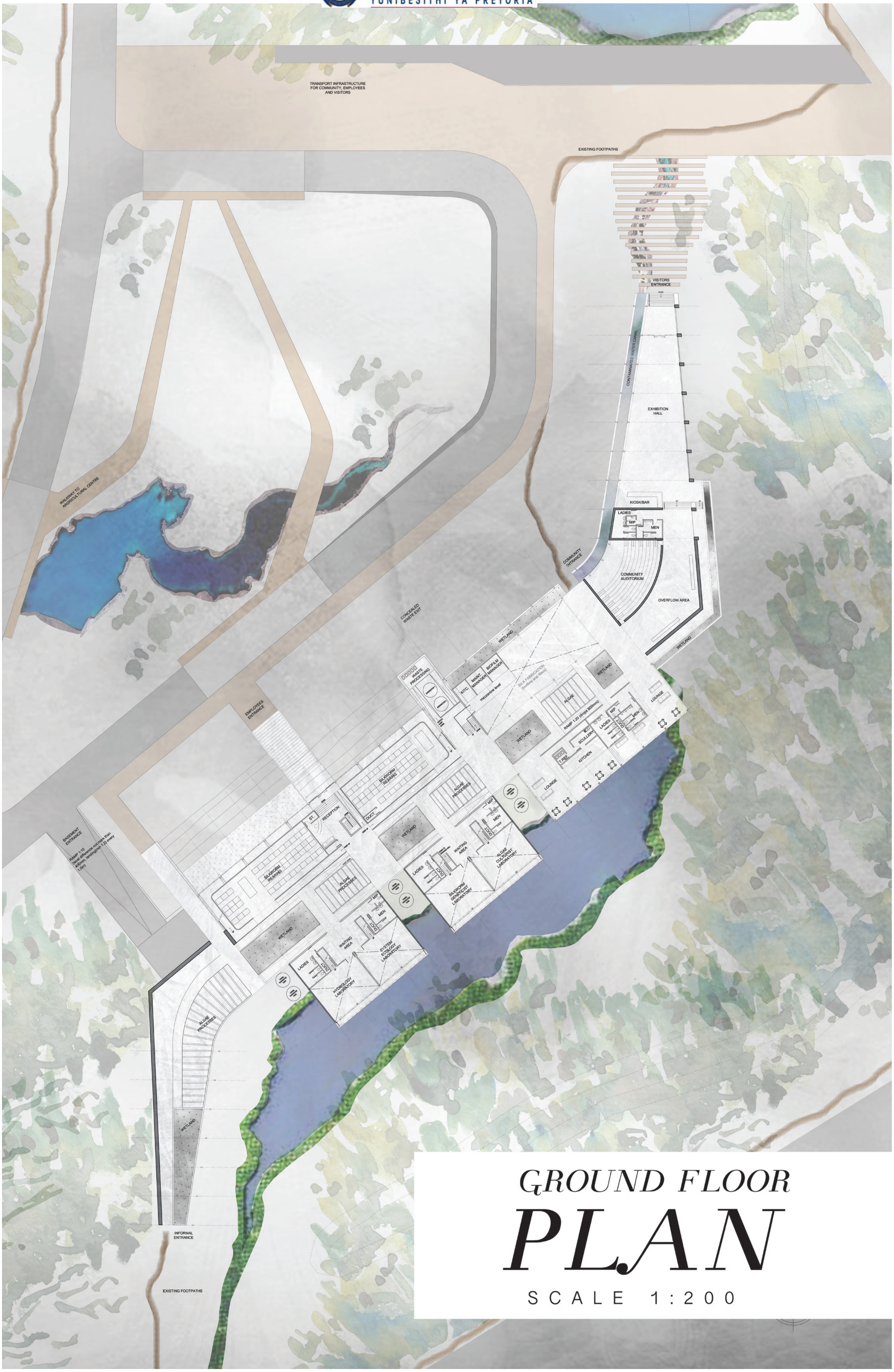


Figure 7.18: Basement plan of water treatment facility. (Author,2016)

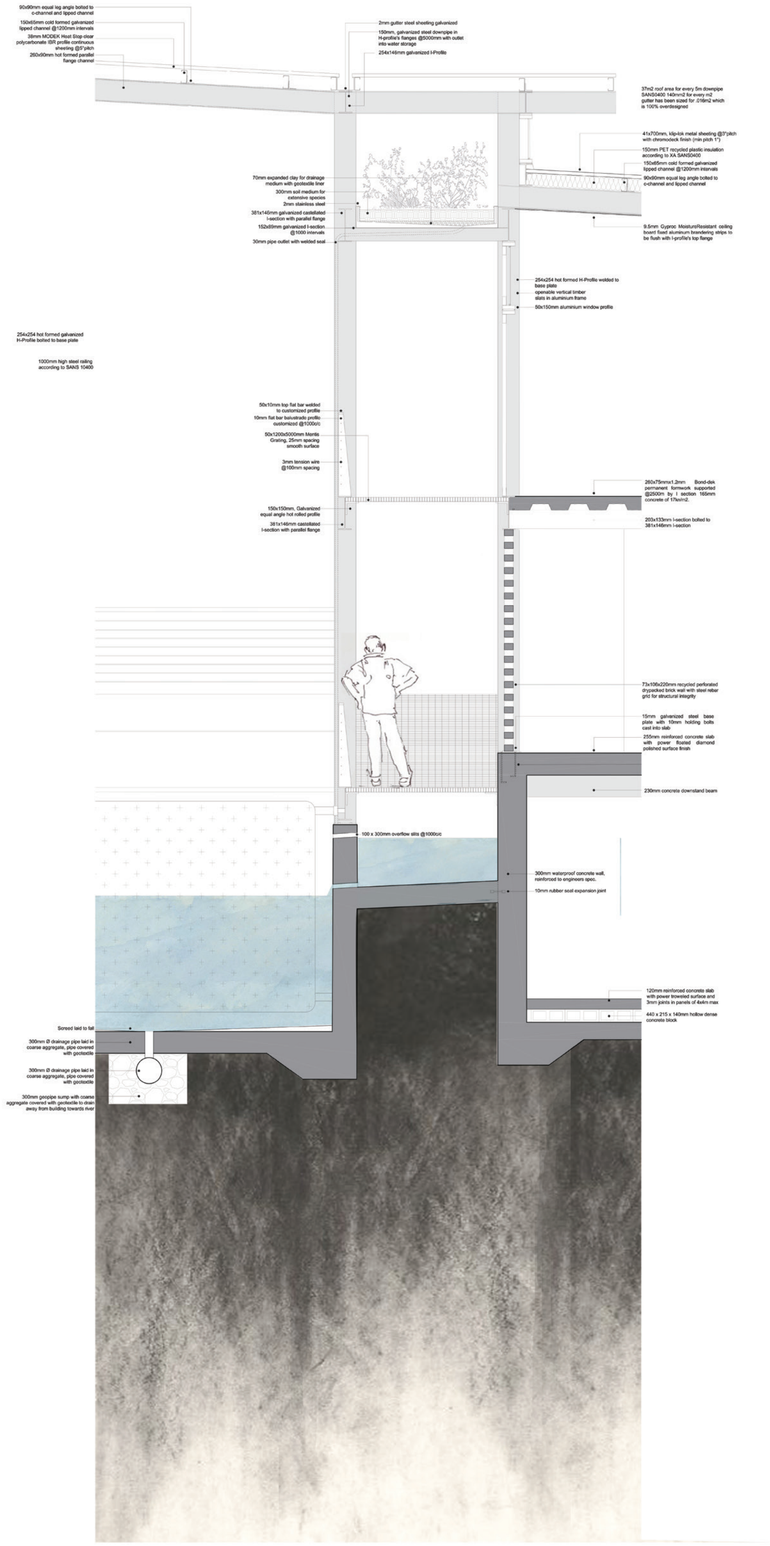


GROUND FLOOR PLAN

SCALE 1:200

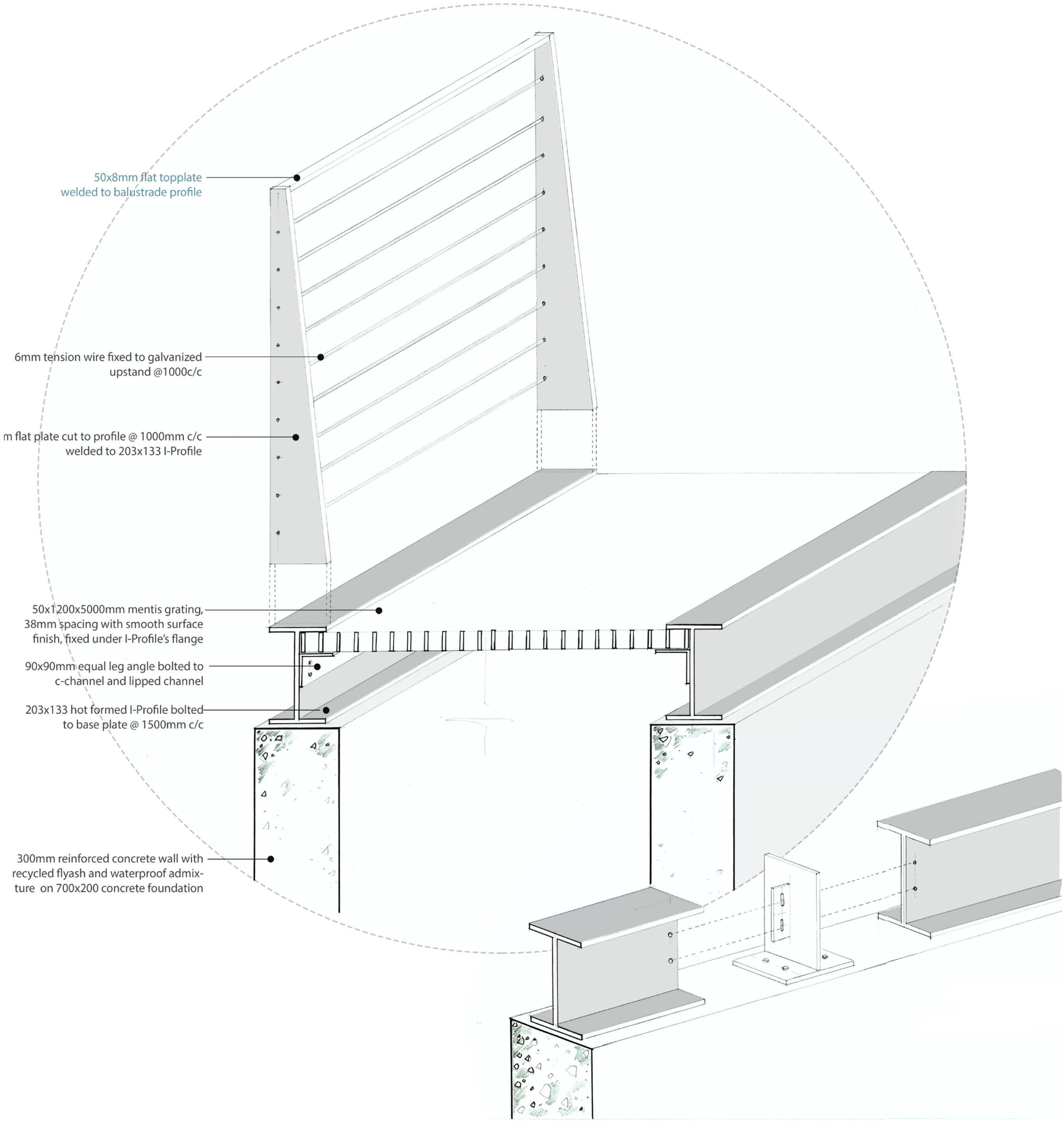
TECHNICAL SECTION

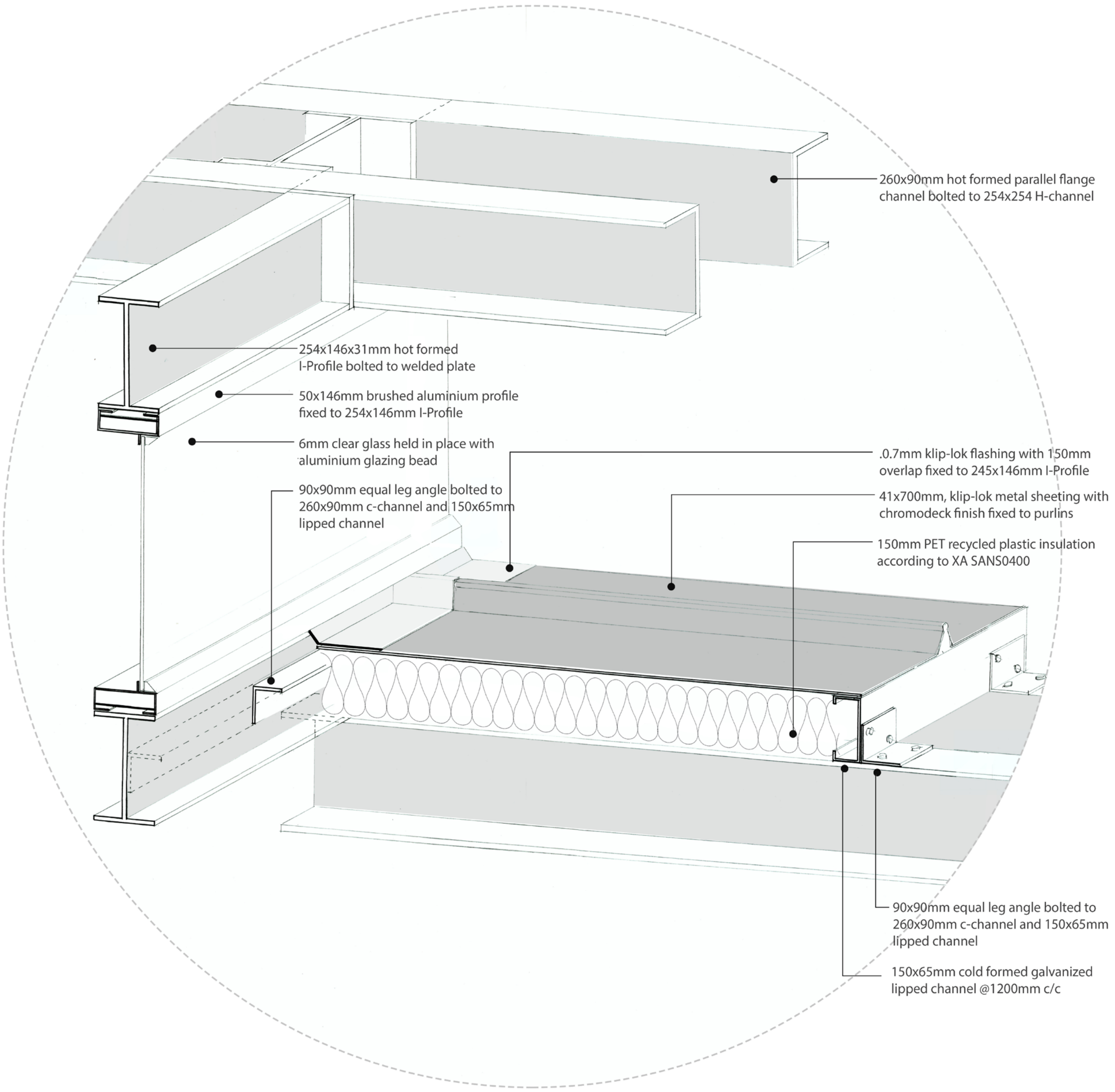
SCALE 1:20



WALKWAY DETAIL

SCALE 1:5

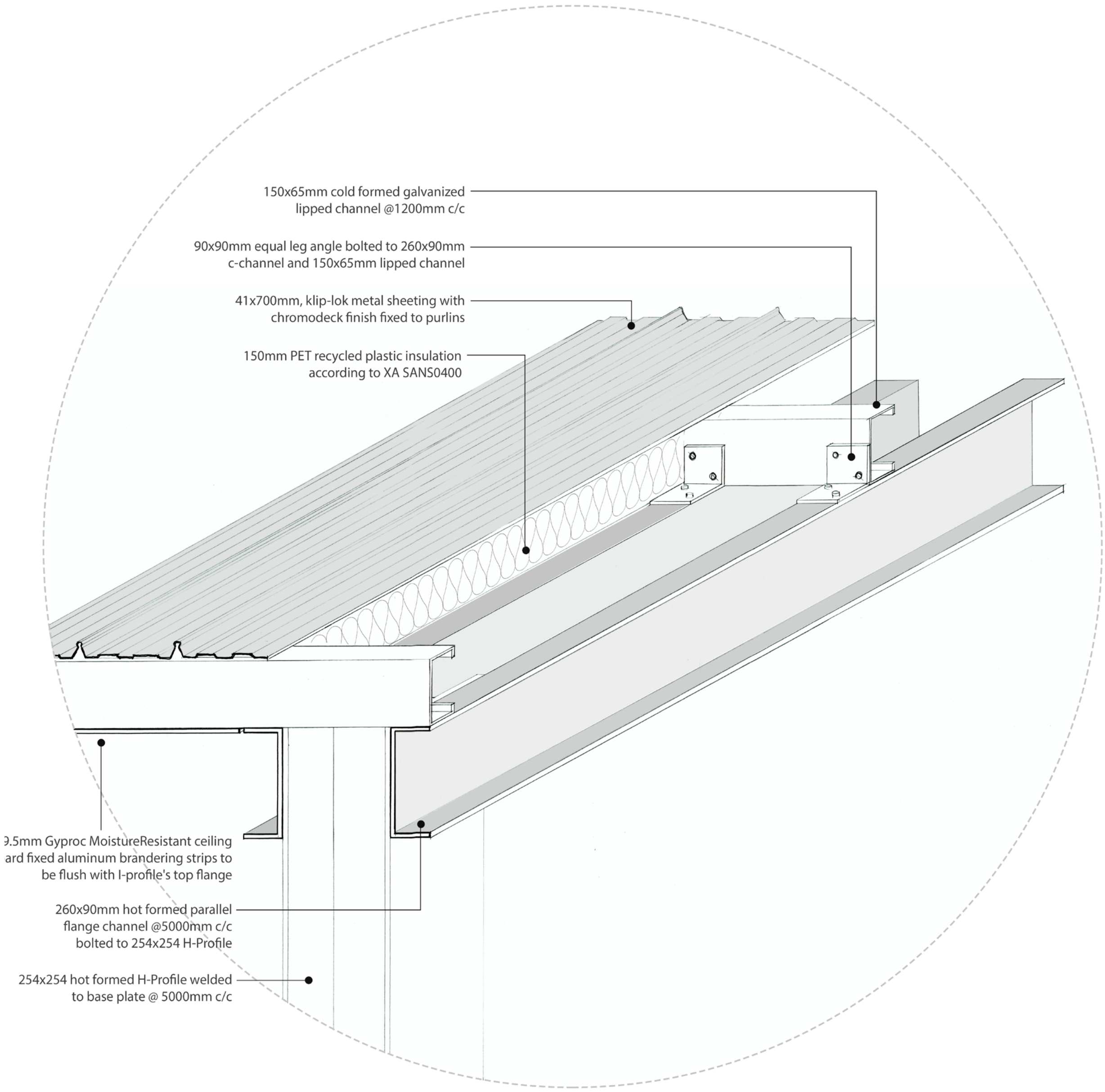




FLASHING DETAIL

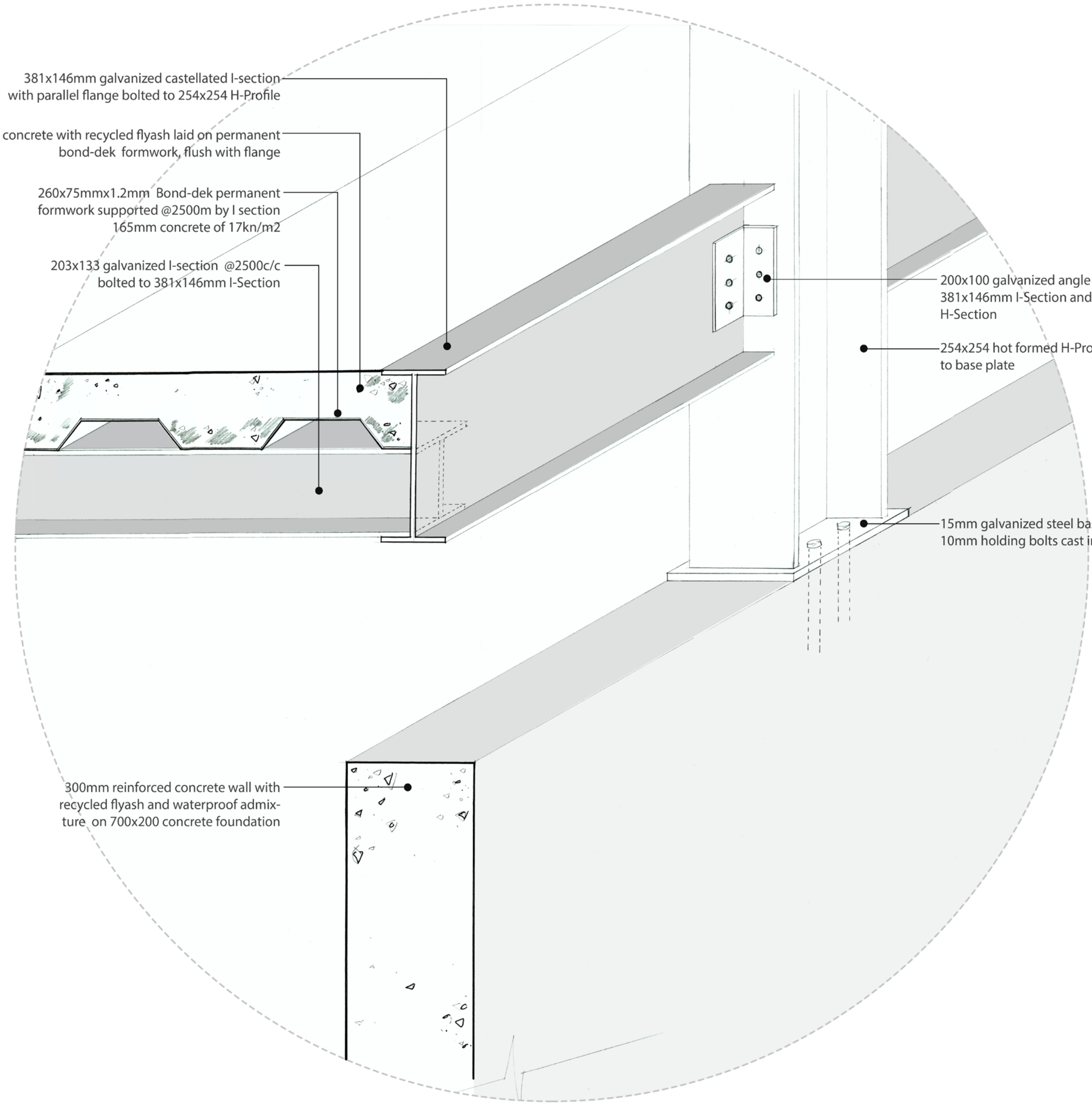
SCALE 1:5

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



SHEETING DETAIL

SCALE 1:5



SLAB EDGE DETAIL

SCALE 1:5


ALTERNATIVE APPROACH
SITE PLAN
PLAN