UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

INTECEPTING CONTAMINATION

IMPROVING THE QUALITY OF THE VAAL RIVER NETWORK THROUGH SELF-REPLENISHING NATURAL SYSTEMS

JANI GRALA

Jani Grala [29168334]

Submitted in fulfilment of part of the requirements for the degree of Magister in Architecture (Professional)

Department of Architecture, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria

Course Coordinator
Dr. Arthur Barker

Study Leader
Derick de Bruyn

Pretoria, South Africa
November 2016

PROJECT INFORMATION

Research Field
Environmental Potential

Programme
Water Treatment and Research Facility with Community Interface

Site Description
North western quadrant of the intersection of the R42 and R57, on the peripheral edges of Bophelong Township and Vanderbijlpark

Site Location
Old Sewer Pump Station, 550-IQ Zuurfontein, Outspan Servitude A.24/62 and A.376, Vanderbijlpark

Coordinates
26 °42'30.51" S, 27°48'49.21" E, elevation 1478m

Client
Industrial Companies

ABSTRACT

This dissertation's urban vision looks at the environmental issues of land, water and the health of the people of Vanderbijlpark, all of which have been affected by heavy industry. The study sets out to address the deteriorating quality of the Vaal River's water and how this is affected by the tributaries feeding into it. This dissertation will focus on the remediation and monitoring of the contaminated water through an ecosystemic approach.

The programme involves the removal of heavy metals from the industrial effluent from the surrounding heavy industry that flows into the Rietspruit Canal. The potential of micro-organisms, plants and insects will be explored as elements of a natural treatment system of the contaminated water. The site identified for the remediation processes is an abandoned parcel of land - a remnant of the natural landscape after urban sprawl.

The algae and wetland treatment system will run through the facility, becoming the spine for the remediation process and movement through the facility. The production of silk, its uses and by-products will be integrated to support the overall system which treats the contaminated water. The facility aims to address the community's need to express their voice on environmental and health issues by integrating a community auditorium and exhibition space. The construction and materiality is grounded in the premise that the local companies will remain supportive and collaborative in the environmental intervention in the Rietspruit Canal system, into which they contribute considerable effluent. It will also be proposed that the local companies will fund and supply various steel products for the construction of the intervention. This will form part of the company's corporate social responsibility and a way of giving back to fringe communities affected by industry.

Keywords_ regenerative thinking, resilience, urban-rural land, remediation, contamination, phytoremediation, corporate responsibility, fenceline community

EKSERP

Die stedelike visie vir hierdie verhandeling fokus op die omgewingskwessies van grond, water en die gesondheid van die mense van Vanderbijlpark wie almal geraak word deur swaar nywerhede. Die studie spreek die verswakkende kwaliteit van die Vaalrivier se water aan en hoe dit geraak word deur sytakke wat daarin vloei. Die verhandeling sal fokus op wyses waarop besoedelde water deur middel van 'n ekosistemiese benadering herstel en gemonitor kan word.

Die program behels die verwydering van swaar metale uit die industriële uitvloeisel van die omliggende swaar nywerhede wat in die Rietspruit-kanaal vloei. Die potensiaal van mikro-organismes, plante en insekte as elemente van 'n natuurlike stelsel vir die behandeling van die besoedelde water, word ondersoek. Die terrein wat geidentifiseer is vir die herstelprosesse is 'n verlate stuk grond, 'n oorblyfsel van die natuurlike landskap na stadspreiding.

Die stelsel vir die behandeling van alge en vleilandhabitatte sal deur die fasiliteit loop en die ruggraat van die herstelproses vorm. Die produksie van sy en die gebruike en neweprodukte daarvan sal geintegreer word om die totale sisteem wat die besoedelde water behandel, te ondersteun. Die fasiliteit het ten doel om die behoefte van die gemeenskap om hul stemme oor omgewings- en gesondheidskwessies te verhef, aan te spreek deur die gemeenskapsamfiteater en uitstalruimte te integreer. Die konstruksie en materialiteit is gegrond op die veronderstelling dat die grootste staalnywerheid, ArcelorMittal, ondersteunend en samewerkend sal wees ten opsigte van die omgewingsingryping in die Rietspruit-kanaalsisteem, waartoe hul aansienlike uitvloeisel bydra. Daar sal ook voorgestel word dat die swaar nywerhede die befondsing asook verskeie staalprodukte vir die oprigting van die fasiliteit sal verskaf. Dit sal deel uitmaak van die maatskappy se korporatiewe sosiale verantwoordelikheid en is 'n manier om aan gemeenskappe wat deur die industrie geaffekteer word, terug te gee.

Trefwoorde_vernuwende denke, veerkragtigheid, stedelik-plattelandse grond, herstel, besoedeling, fitoherstel, korporatiewe verantwoordelikheid, grenslyngemeenskap

UMQUONDO WOMBHALO

Intloso yalombalo wukubuka izikhalo ezimayelana nomhlaba, amanzi nokuphila kwabantu ababuya endaweni yase Vanderbijlpark. Izimpila zalabahlali balendwawo nomhlaba wabo ucindezelekile kakhulu imboni yezintsimbi. Siyobesibuka ukuwohla komfula wase Vaal noku thinteka kwalowomfula ngenxa yemi mfundlane engenayo. Lombala uzogxila ekususeni kwesikhunta nokugada kwamanzi angcolile noku sebenzisa ihlelo lomphakathi wezilwane nendawo yazo zokuphila.

Loluhlelo luhilela ukususwa kokungcola, kwezintsimbi ezisindayo, okubuya ezimbonini eziseduze, okungena eRietspruit Canal. Kuzobe kuhlolwa amandla eszilwanyana esincane, izitshalo nezinambuzana, okususa ukunngcola emanzini. Indawo esikhonjelwe inqubo yokususwa kwaleso sikhunta, yindawo elahliwe – yindawo ebeseyisetshenziselwe ukuwandisa izindawo.

Uhlelo lokwelashwa lezilwelwe kanya noxhaphozi, luzoba wumgogodlo wenquba yokulungisa, kanya nekunyakaza ngokusebenzisa isikhungo. Ukhukhiqzwa kasilika, ukusetshenziswa kwayo futhi nemikhiqizo yawo izobe ihlanganiswe ukusekela uhlelo jikelele lapho aphatha ngayo amanzi anqcolile. Isikkhungo sihlose ukubekana nesidingo somphakathi ukuba baveze izwi labo ngezemvelo Kanye nempilo ngokuhlanganisa isiteji somdlalo somphakathi Kanye nesikhala sokubukisa. Ukwakhiwa Kanye nokubaluleka kuhlala phezu kwesisekelo sokuthi ukuvulwa kenkampani enkulu kunazozonke yezintsimbi, ArcelorMittal, izohlala isekela ekubambisaneni kokungenela kwezemvelo ohlelweni. Rietspruit Canal, lapho bathuthukisa ukungcola okuningi. Kuhlongozwe ukuthi isokhokhela, futhi inikeze imikhiqizo ehlukahlukene yezintsimbi zokwakha izindlela zokuyenza isimo sibengcono. Lokhu kuzoba yingxenye yenkampani yokuba ibenesibopho nomphakathi, Kanye iqhamuke nezindlela zokunikela emphakathini, upheto ohlaselwe umkhakha.

Amagama abalulekile – ukucabanga okuzivuselela, khono eliphawulekayo, umhlaba wase dolobeni nasemakhaya, ukususwa kwesikhunta, ukungcola, ukusebenzisa izitshalo ukususa ukungcola, umthwalo, wemfanelo wenhlangano, Umphakathi ohlukanisiwe.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

TABLE OF CONTENTS

A NOTE FROM THE AUTHOR

As a child I grew up on the farmlands just beyond the site selected for this dissertation. My grandmother, Irene Grala, who stayed on the farm with our family, would always tell me the water is dirty and that we should boil it before drinking it, yet I never understood why. This very same water will form the base of inspiration for my dissertation. I return home to explore the convoluted relationship of opportunity brought by industry and the effect that industry has on the environment and the immediate community.

Time spent in Vanderbijlpark left me wondering why a large majority of the community are so poor and sickly. Even though all the generations of men in my family had worked for ArcelorMittal at some point in their lives, I never understood the underlying history of the place or the complexity that the industry posed for the people. After completing my degree in Architecture, I left Gauteng to work for a small architectural practice in Kalk Bay,Western Cape. Stuart Thompson, one of the partners gave me a book to read called Toxic Futures which focuses on towns disadvantaged by mega industry. An entire chapter was dedicated to Vanderbijlpark and for the first time I understood how spatial planning and economic growth affected the area of my upbringing, Vanderbijlpark. There was no hesitation when the time came for me to choose a topic for my dissertation - I decided to go back to my hometown.

SPECIAL THANKS

In chronological order:

Jesus Christ [my Saviour and Helper]
Paul Plummer [all the love, wedding planning, calculations, editting & model building skills]
Ruth Grala [searching for a site & continuous prayers]
Dinah Louw [providing Emfuleni Municipality maps]
Ingrid Booysen [University of Pretoria GIS maps]
Morne Pienaar [understanding urban-rural land]
Derick de Bruyn [teaching me to listen]
Professor Piet Vosloo [technical understanding]
John Grala [calculations]
Peter Grala, Coert Welman & Nico Coetzee [system feasibility]
Lynn Grala [proofreading]
Thereza Norton [layout & presentation]

01

CHAPTER ONE

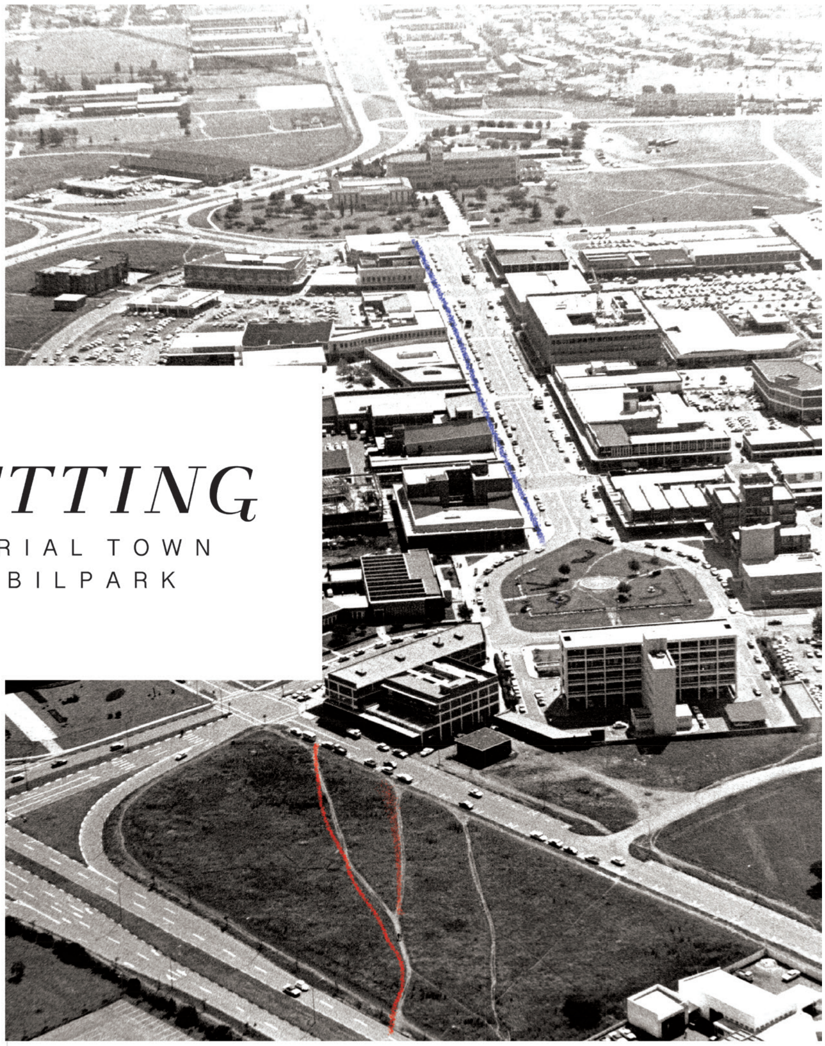
INTRODUCTION

1.1

THE STORY OF A PLACE [HISTORICAL BACKGROUND]

Vanderbijlpark is one of the earliest examples of an industry centric town developed in South Africa. A large part of South Africa's history is rooted in the discovery of minerals and the location of settlements and towns were a result of the migration of people to meet the large work force required by the developing mining industry. New towns were developed by companies serving the state, which meant that the new towns were also company towns. These new towns have been influenced by the International New Town Movement which had a distinct lay-out and social vision. (Brockett, 1996:161)

Chronologically, the Vaal Triangle's development began in Vereeniging directed by Sammy Marks who had the vision to establish the steel industry in South Africa. The Vaal Triangle includes the towns of Vanderbijlpark, Vereeniging and Sasolburg. The entire Vaal area has large amounts of coal deposited beneath its surface which made it the ideal location for the mining venture in 1897. The South African Iron and Steel Corporation (ISCOR), now ArcelorMittal, developed the new town of Vanderbijlpark near these coal deposits which were crucial for the production of steel. The industry was expected to deliver cheap inputs for a great profit – exploiting the cheap labour of the area. ISCOR was established in the 1920's in response to the large scale industries required for the growth of the engineering and automotive sector in South Africa crucial for World War 2. (Brockett, 1996:161)



THE SETTING

THE INDUSTRIAL TOWN OF VANDERBILPARK

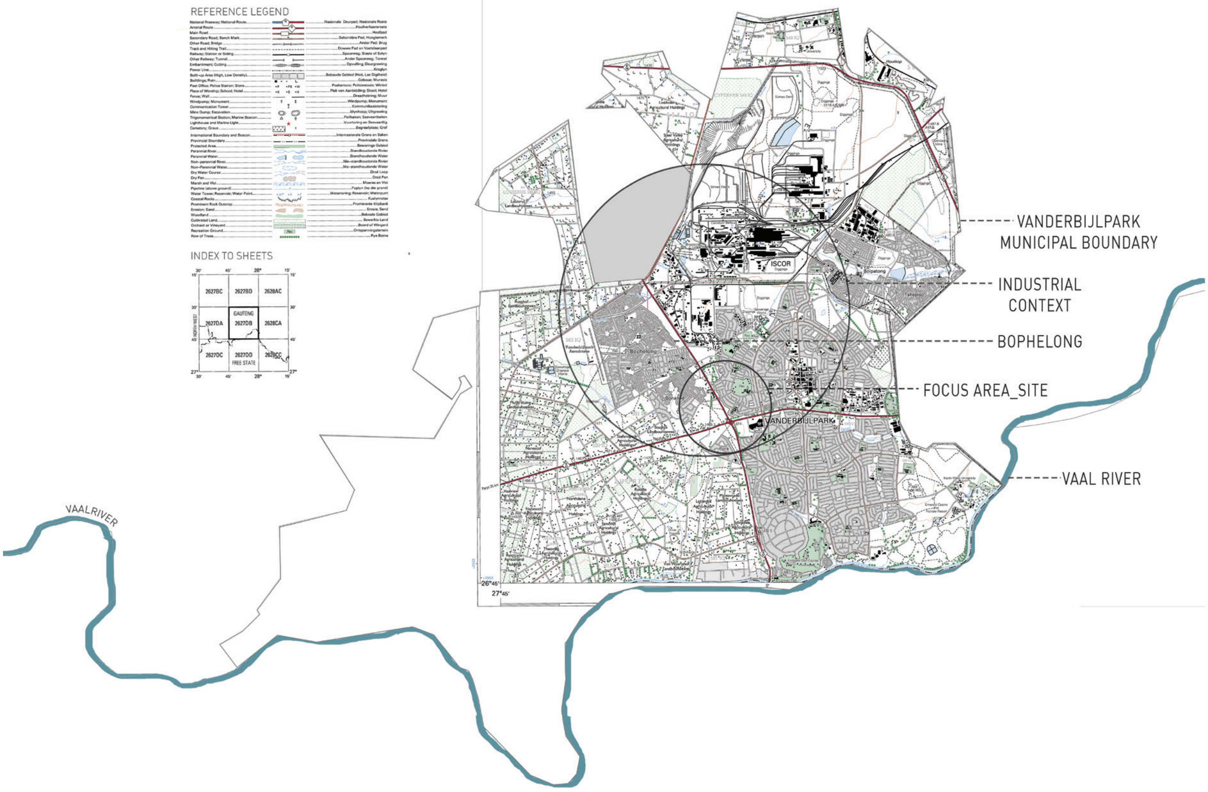
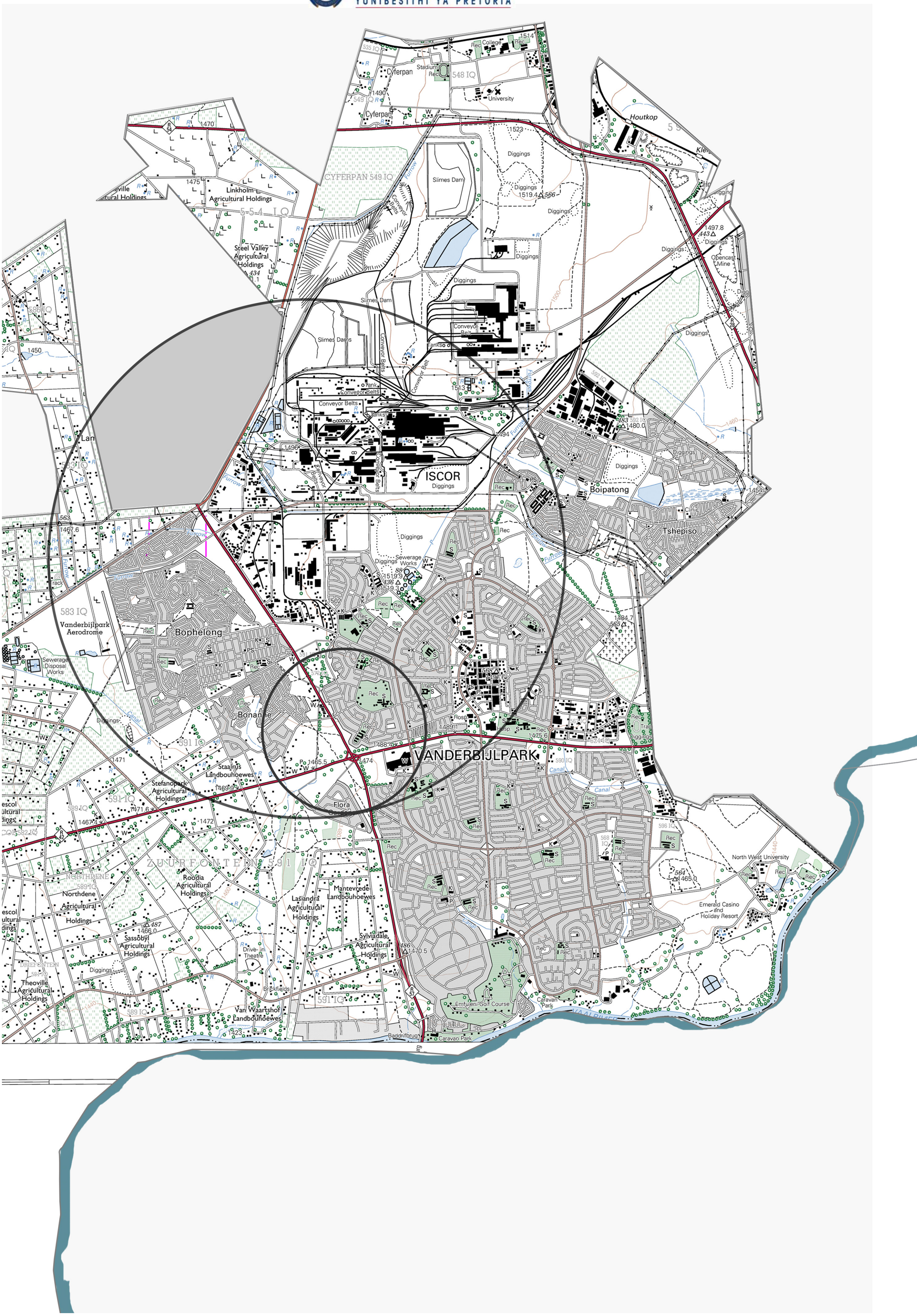


Figure 1.1: Vanderbijlpark Municipal and GIS overlay. (Author, 2016)

Developed in 1943 to house ISCOR workers, Vanderbijlpark is one of the earliest examples of the New Town Movement in South Africa. The New Town idea evolved from social principles of lifestyle and equality, but this was inappropriate due to South Africa's apartheid policy which was in full force. The black population were excluded from the town's vision of better living and working conditions. (Brockett, 1996:14) Vanderbijlpark's estimated population was 90,000 whites and 120,000 blacks who were housed in separate zones over an area of 10,900 acres. The majority of the black communities were and still are housed within 5km of ISCOR. Bophelong, established in 1955, was Vanderbijlpark's original township for the black Iscor workers. This segregation through racial zoning and class stratification made a mockery of the social principles of the New Town Movement.

Today South Africa is sub-Saharan Africa's primary steel making producer - 1 of 65 countries in the world which have primary steelmaking production. The Vaal Triangle is the heart of South Africa's mineral and energy complex and continues to play a role as one of Gauteng's top economic value contributors. In South Africa, the top five steel companies together contribute approximately R600 billion to the nation's Gross Domestic Product (GDP) (15% of the total GDP) and employ more than 8 million people. The mineral and energy workers of the Vaal Triangle industrial sector add value to South Africa's economy, yet these people are some of the poorest and most disadvantaged people of the entire country. In Vanderbijlpark, two thirds of the households are dependent on the steel industry for their livelihood. (O'Flaherty, 2015: online) The persistent state of poverty and daily environmental battle is an accepted norm in the lives of the industrial working class.



Cyferpan
University
Stadium
College
548 IQ
Houtkop
Slimes Dam
Diggings
CYFERPAN 549 IQ
Linkholm
Agricultural Holdings
Steel Valley
Agricultural
Holdings
Slimes Dams
Conveyor Belts
ISCOR
Boipatong
Tshepiso
Sewerage Works
583 IQ
Vanderbijlpark
Aerodrome
Bophelong
Bonanne
591 IQ
Staalrus
Landbouhoewes
Stefanopark
Agricultural
Holdings
VANDERBIJLPARK
Flora
ZUURFONTEIN 591 IQ
Northdene
Agricultural
Holdings
Roodia
Agricultural
Holdings
Lasiandra
Agricultural
Holdings
Mantevrede
Landbouhoewes
Sassoby
Agricultural
Holdings
Theoville
Agricultural
Holdings
Sylviadale
Agricultural
Holdings
Drive-in
Theatre
Van Waartshof
Landbouhoewes
Emfuleni Golf Course
Caravan Park
North West University
Emerald Casino
and
Holiday Resort

1.2

THE INDUSTRIAL LANDSCAPE'S GROWTH LIMIT

One thing is certain, as humans take more of the primary productivity of the earth for themselves and the life forms of their choice (such as corn and cows), they leave less for other life forms. The result is a loss of economic value: game, fish, chemicals, medicines, foods may be disappearing with species that no one has even identified. There is also a spiritual and aesthetic loss; a loss of colorful companions in creation. There may be, for all anyone knows, a loss of critical pieces that hold together ecosystems. There is certainly a loss of genetic information that has taken billions of years to evolve – and that humanity is just beginning to learn how to read and use. (Meadow et al. 1992:66)

Growth is seen as the answer to poverty and creates an illusion of a more prosperous future. It is measured and compared in financial terms of GDP rather than looking at characteristics such as health, education and the well-being of the communities which support the ability to produce the final goods or services which are eventually converted into monetary value. Growth is seen as economic development rather than its more important social-ecological value. (Meadows et al. 2004:19)

The current growth model, also visible in Vanderbijlpark, is rooted in separation. It is a story of self and a story of the natural world. This worldview has separated human and other living systems,and the natural world is shrinking as humans turn the natural into materials, energy, title deeds and money. Economists believe in endless growth, yet economic growth requires consumption of natural resources. (Meadows et al. 2004:19)

Natural resources can be renewable, like the soil and its ability to yield crops year after year by implementing crop rotation to avoid exhausting the soil. On the other hand, most of the materials and energy extracted from our environment are limited and non-renewable.

The earth provides a steady flow of resources into the economic system only to end up with waste sinks and brownfields. These waste sinks/ brownfield sites accumulate large quantities of hazardous substances and contaminants which are rarely treated. Although the earth's processes of regeneration attempts to protect the remaining natural world and the people, this regenerative ability is limited. Earth only has a limited capacity to deal with the pollutants generated by the materials and energy used for economic growth. When the growth exceeds the earth's ability to recover the world will reach a point of complete exploitation. Endless growth is impossible without a balance between nature and man. (Meadows et al. 2004:19)

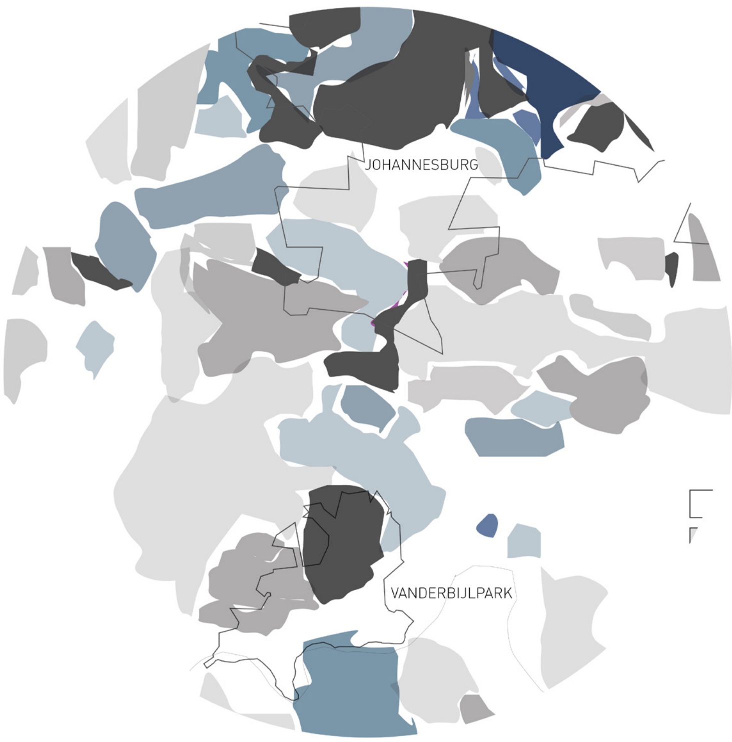


Figure 1.2: Author's Mapping of GDP. (South Africa Data Portal, 2016)

A CONTAMINATED LANDSCAPE

THE GENERAL ISSUE OF EXPLOITATION

The steel works in Vanderbijlpark is one of the largest in the world, yet the mega industry's success has had an adverse effect on the community and environment. The environmental concerns caused by the industry are deeper, more complex issues of groundwater, land contamination and pollution of the air quality.

Figure 1.3: Industrial landscape. (Author, 2016)

1.3

THE GENERAL ISSUE

Continual growth in pollution and consumption could severely damage the ecosystems and social systems that support life on earth. The drive for limitless economic growth could eventually disrupt many local, regional, and global ecosystems.

The steelworks in Vanderbijlpark is one of the largest inland steel works in the world, yet the mega industry's success has had an adverse effect on the community and environment. Issues of exploitation of resources and people, and flouting environmental laws are the top issues of injustice. The environmental concerns caused by the industry however, are even deeper, more complex issues of ground water, land contamination and pollution of the air quality.

The Vaal Environmental Justice Alliance (VEJA) is an active player which focuses on monitoring the main polluters in the Vaal Triangle. The Vaal Triangle is the first area in South Africa to be declared an Airshed Priority Area in terms of the National Environmental Management Act (39/2004). An Airshed Priority Area is regarded as a polluted area which is detrimental to human health and the environment.

Fenceline communities are the people directly affected by the operations of the industry. The Bophelong Township in Vanderbijlpark is classified as a fenceline community as it falls within a 5km radius of the high risk zone of the Airshed Priority Area. (Environmental Affairs and Tourism, 2007:27) A survey by The Benchmarks Foundation recorded that 49% of the Bophelong residents and workers suffer from respiratory problems, loss of eyesight and hearing. Other cases involve kidney failure, cancer, tuberculosis, manganese and cadmium poisoning and chronic bronchitis. (The Benchmarks Foundation, 2013: online)

The general issues of contaminated land, water and health are part of a complex problem not only limited to Vanderbijlpark, but a major concern globally. This dissertation will focus on one of the major, more visible issue of the quality of the water of the Vaal River. Mega industries have been identified as point sources as they contributed to the contamination of the water network.(Groenewald, 2000:122)

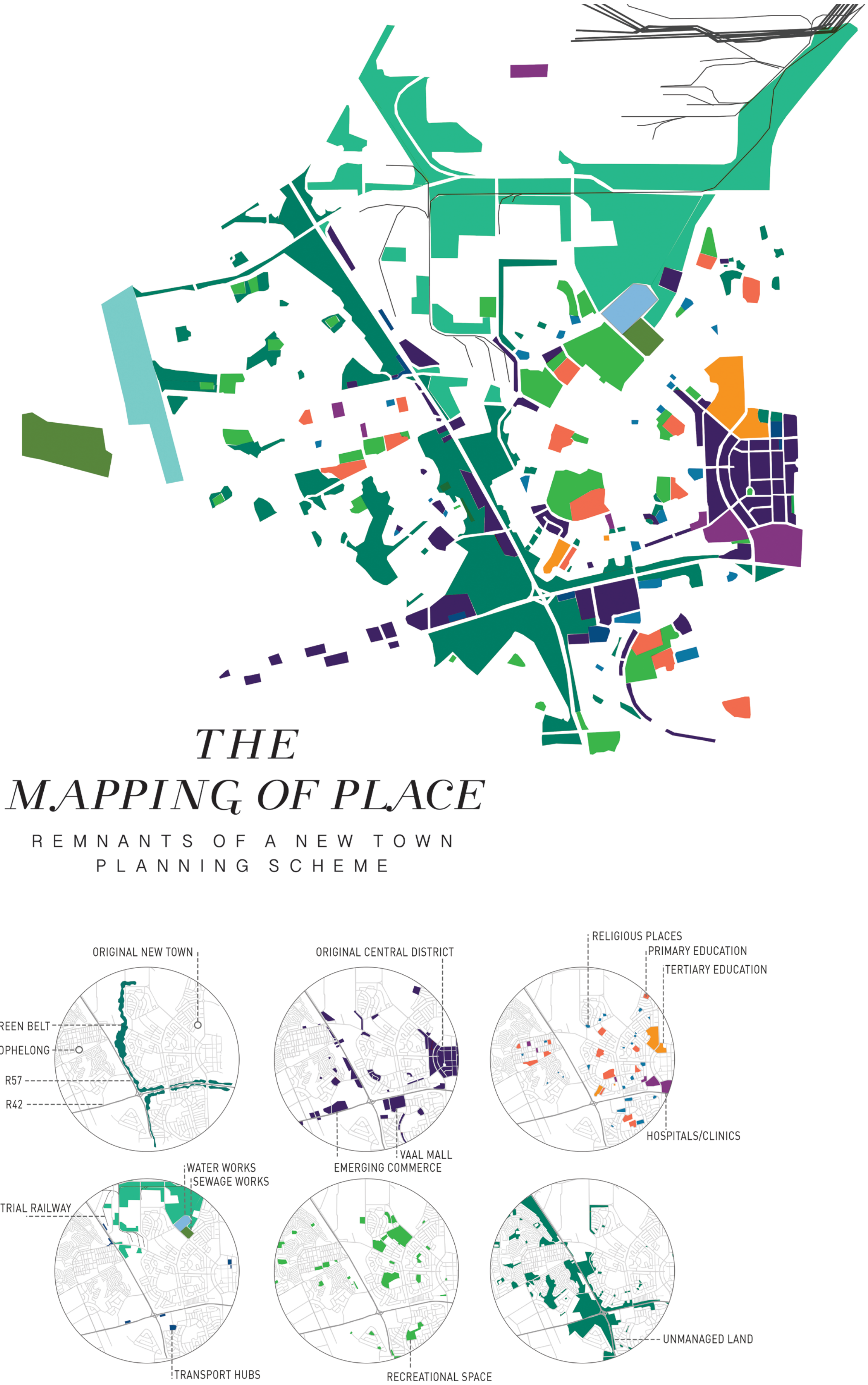


Figure 1.5: Context Mapping. (Author, 2016)

1.4

THE URBAN ISSUE

Cities and towns are dynamic human artifacts which will experience structural change, development and growth. This dynamic change will occur in the relationships of the urban with the surrounding territory. Change is most visible on the outskirts, the transitional zone between rural and urban areas. (Fazal, S.2012:1)

The town planning layout of Vanderbijlpark is one of the most deliberate examples of apartheid planning in South Africa. Bophelong is located on the outskirts of the town that has been segregated from the central district/heart of the town by the large regional road (R57) and industrial areas. This forced segregation has resulted in the fenceline township of Bophelong being located on the perimeter of the steelworks, resulting in the community being largely affected by the heavy industry. (Brockett, 1996:165)

ISCOR's intention for Vanderbijlpark was for it to be surrounded by a continuous greenbelt which would serve as a recreational space and buffer outward development. The greenbelt was a large part of the town's strategy, but ISCOR never managed to procure the surrounding land and hence was unable to control development. The greenbelt consequently failed to control expansion and limit urban sprawl. (Brockett, L. 1996:166) Figure 1.4 shows the demographic data of the dissertation's focus area at the intersection of the R42 and R57. The blue indicates white afrikaans speaking people and the the sesotho people.

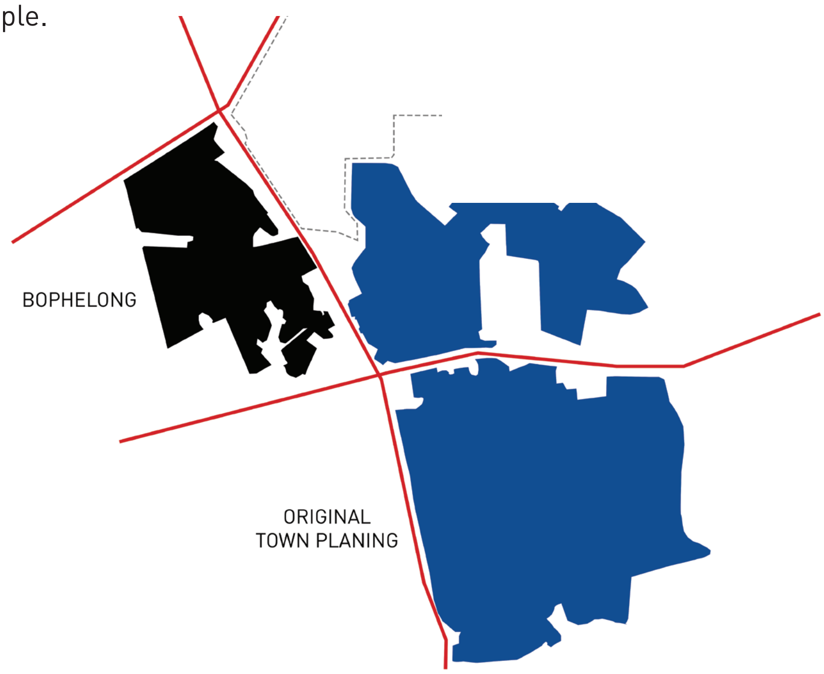


Figure 1.5: Dot mapping showing the focus area with bophelong and the original town. (DotMap, 2016)

FRAGMENTED TERRITORY

URBAN SPRAWL AND SHIFTING RURAL LAND

Figure 1.7 Urban development pushes back rural land (Author, 2016)

The development of 65,000sqm Vaal Mall in 2007 marks the moment of critical urban change. The Vaal Mall was a response to the demands of a growing town. The concentrated civic energy at the original Central District was dwindling and shifting to a new emerging district at the intersection of the R42 and R57 near the Vaal Mall development. The new emerging node has been declared an official node by the Emfuleni Municipality since 2014 (Emfuleni Local Municipality. 2014:34). The emerging node has had a positive impact on the urban issue of the apartheid planning in Vanderbijlpark. It acts as a mitigation device to lessen the severity of the deliberate segregation of the New Town planning.

The declared node is situated between urban and rural land, outside the perimeter of the original town and green belt buffer. When unplanned urbanization occurs the rural land often disappears piece by piece. In Vanderbijlpark, the expanding town is slowly pushing the rural area back as development progresses, leaving unresolved parcels of land which are neither rural nor urban in the battlefield of the environmental and socioeconomic change. Historically, rural and urban land has been viewed as two separate social and economic systems with few interactions. The term urban-rural has been used to define this open, and often neglected land, and attempts to recognize the link between urban and rural.

Urban-rural land parcels are seen as places with potential for dynamic landscape and social change. This land has the potential to provide for the people who have been pushed to the edge of town either due to their economic status, race or livelihood. The urban-rural fringe phenomenon can be identified in Vanderbijlpark and traced back to the ineffectiveness of the green belt concept of the New Town Movement and the segregation of communities under apartheid town planning.

1.5

THE ENVIRONMENTAL ISSUES OF THE STEEL INDUSTRY

The industrial activities of steelmaking disturb and destroy the natural ecosystems. The processes use large amounts of water during the processing and separating of the minerals from ore. The primary waste produced in metal processes includes untreated water, oil, grease and mill scale (microscopic steel shavings) which are deposited into tailing dams. The leakage of waste liquid from the tailing dams causes serious environmental damage and affects the health of those who live within close proximity (fenceline communities). Contaminated sediment and heavy metals are a major hazard when damaged dams/ deliberate actions release them to enter the downstream water course. These heavy metals are transported into the river network as surface run-off or directly enter the groundwater. Even the repairing of a tailing dam requires the dam to be emptied and toxic water is released as surface run-off.

The Rietspruit Canal in Vanderbijlpark is an example of a downstream water canal which transports surface run-off contaminated with heavy metals and chemicals into the Vaal River network. There is currently no infrastructure or water reclamation systems in place to deal with the daily industrial effluent flowing into the Vaal River network.

1.6

THE ARCHITECTURAL ISSUE

The industrial sector is a vital part of our economy, yet the industrial landscape is associated with exploitation of resources to construct the new development required. An alternative approach to infrastructure development will be proposed through this intervention. The approach aims for the reinterpretation of production and manufacturing by natural mechanisms which can regenerate and improve the environment instead of exploit and pollute it. The approach aims to reunite man and the natural environment. Infrastructure is traditionally perceived as a solitary object in the landscape; this intervention proposes an alternative, dynamic infrastructure that uses a construct of natural, regenerative systems. The intervention proposes intercepting the polluted condition of the site by implementing natural systems to form a restorative architecture which sustains a healthy thriving social-ecological system.

The insertion of an alternative infrastructure requires an approach which integrates complex systems and local people into a single balanced system.

1.7
MAIN OBSERVATION

The current state of the industrial landscape requires reworking of existing infrastructure as well as introducing new infrastructure which will protect the environment. In this instance the alternative infrastructure should intercept the contaminated water and improve the quality of the water before entering the Vaal River Network. The urban-rural site identified for the insertion of the new infrastructure can be used as a habitat for the processes and production methods needed to improve the quality of the water currently passing through. The processes and production methods require an understanding of the natural mechanisms as parts of the constructed, holistic treatment system.

1.8
PROBLEM STATEMENT

The theoretical point of departure of this dissertation argues that neglected parcels of land suspended between a rural and urban setting can assist the contaminated/disrupted industrial landscape by providing a balanced habitat in which natural healing mechanisms can thrive, eventually becoming an alternative regenerative, healing infrastructure.

1.9
RESEARCH QUESTION

How can architecture be constructed to intercept and create a condition which sustains the healing of a contaminated environment and its people?

1.10
DELIMITATIONS

The main environmental concerns caused by the industrial sector are deeper, more complex issues of polluted ground water, land contamination and unsuitable air quality. These more complex issues are not addressed in the chapters to follow, but primarily serve as an introduction/background to the severity of the industrial pollution in the Vaal Triangle and are included in the Urban Framework. Therefore, this dissertation does not attempt to solve the general problem of industrial pollution, but instead the project focuses on a facet of the greater water issue which is that of untreated industrial effluent. The industrial effluent referred to in this study is currently flowing via the open Rietspruit canal into the Vaal river network. The research will focus on the removal of heavy metals to ensure that they are permanently removed from the environment and not disposed of as hazardous waste.

1.11
INTENTION

The intention of this dissertation and the processes developed can be seen as a mechanism of systems which collectively create architecture to treat a contaminated condition. This will be referred to as the interception.

This dissertation's contextual and conceptual response is that of intercepting and treating the surface water travelling from the industrial area before it enters the Vaal River network. The understanding of the rural-urban condition has been introduced to set the scene to discuss importance and role of rural-urban sites. The potential of the site allows the interception to be submerged and processes flourish in the natural environment, close to the ground. The removal/treatment processes are supported by the natural environment of plants, insects and micro-organisms.

The intention is founded in understanding the requirements of a new self-replenishing infrastructure which relies on the natural potential of the site to facilitate healing/treatment of the contaminated water. Research of alternative removal/treatment processes will be interpreted to create a holistic system which will inform the design development and facilitate the treatment of the water.

The project sets out to include the fenceline communities by introducing a community development interface which will provide an integrated platform for meeting and sharing of information within the community or by VEJA, as well as a space where the client, ArcelorMittal can have face to face contact with the community and share an awareness of the continuum of mining activities and improvements can be displayed and discussed in the exhibition hall.

1.12
METHODOLOGY

"The dynamics of place begin to reveal themselves as tangible data that is used to generate information which informs the architecture." (Littman, 2009:10)

Experimental methodology applies a scientific approach to research which requires an understanding of data which can be recorded to evaluate the value of the exploration.(Lucas, 2016:45)

In this dissertation the identification of an appropriate site becomes critical for the foundation of the research. The informants influencing the design will include contextual data, technical calculations, water treatment methods and the functional requirements for each process. An understanding of the research and site will transform the proposal through a series of iterations.

1.13
STRUCTURE OF DISSERTATION

The dissertation's investigation will be divided into sections to understand the complexity of the processes and translation of the research into reality.

Chapter 3 – Client and Urban Considerations
Chapter 4 - Contextual Understanding
Chapter 5 – Regenerative Thinking and Replenishable Systems
Chapter 6 – Programme
Chapter 7 – Design Development
Chapter 8 – System Data & Technical Exploration

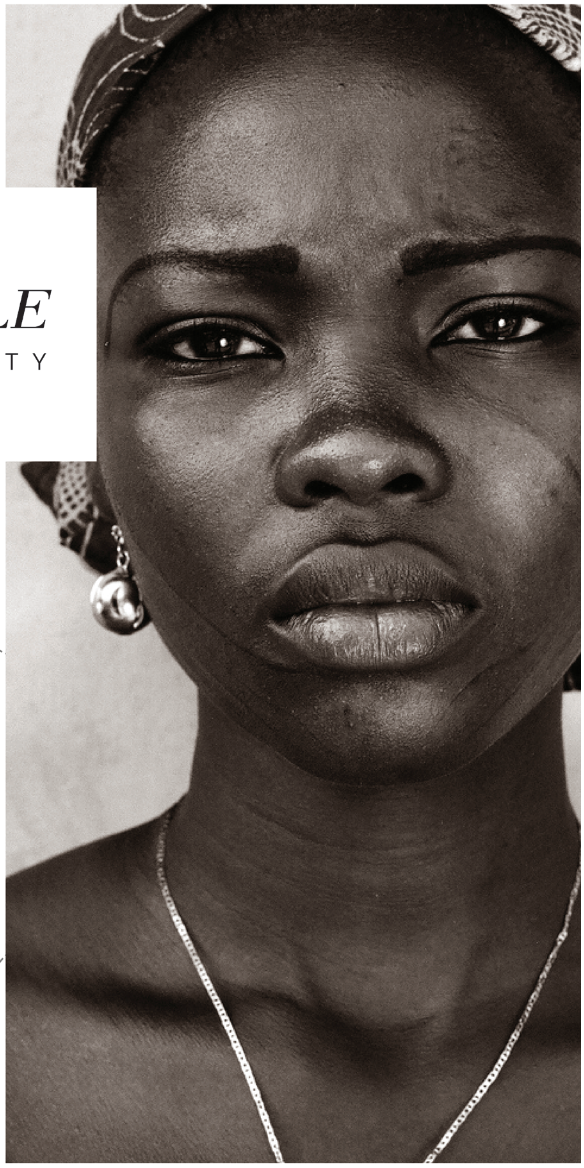
02

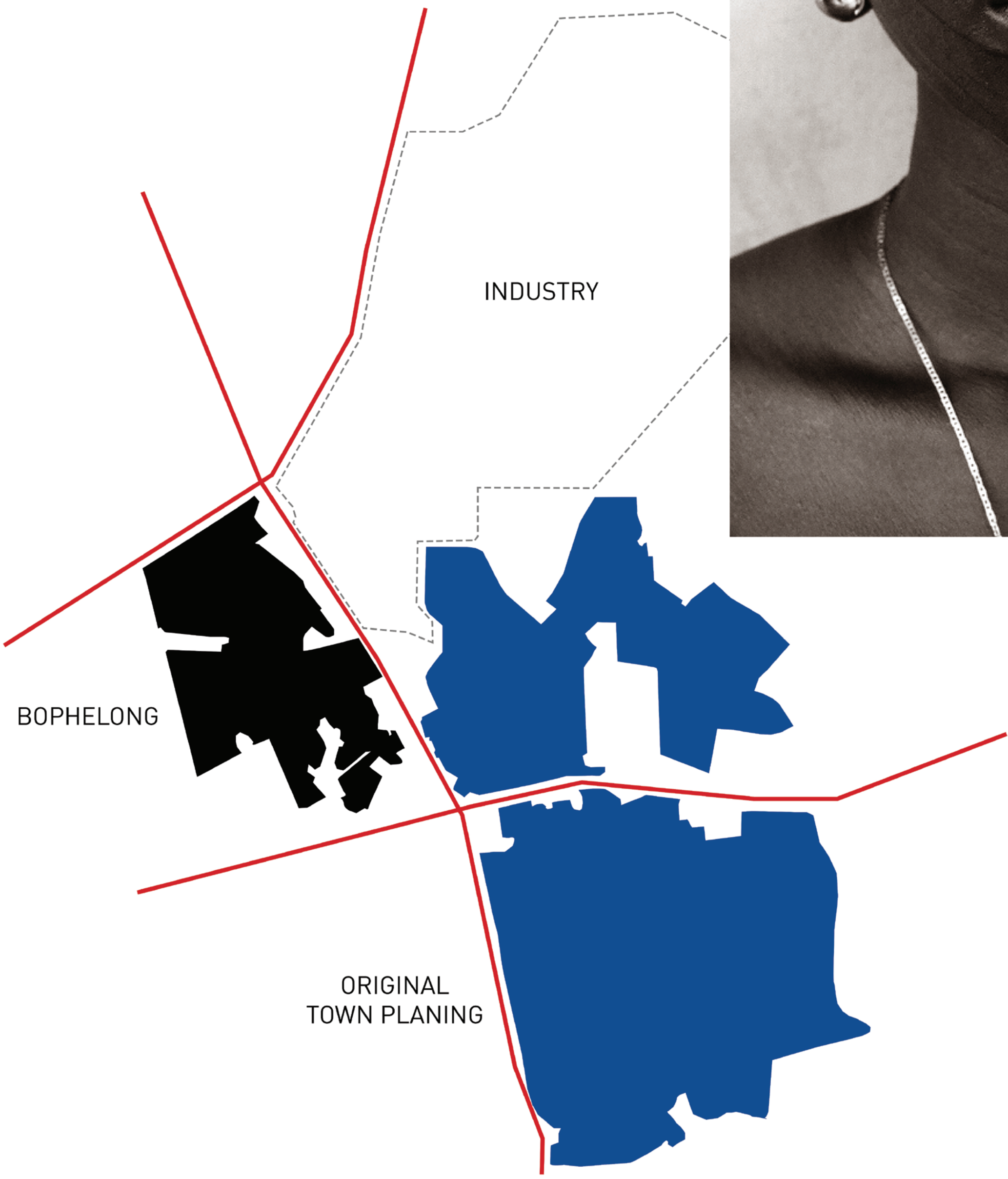
CHAPTER TWO

A VISION FOR THE PEOPLE

THE AFFECTED PEOPLE

THE FENCELINE COMMUNITY OF BOPHELONG





2.1
THE CLIENT

Many heavy industrial companies aspire to the highest standards of corporate social responsibility. Company visions include caring for the environment and the communities in which they operates, however contrary to corporate aspirations this is not always realised in practice. Steel production by nature is an industry which results in large amounts of pollution and requires strict management and oversight. In accordance with the various laws and environmental standards companies remain responsible for the environmental impact of their production processes. In instances where environmental damage occurs companies have both an ethical and legal responsibility to reduce the impact immediately and to restore the damaged ecosystem. Large companies tend to avoid addressing issues by paying government fees instead of introducing solutions which would improve the condition. (The Bench Marks Foundation, 2013)

2.2
THE URBAN FRAMEWORK

"Everyone has a right to an environment which is safe and not harmful to one's health..." Constitution of SA, 1996

The dissertation's urban framework aims to address the environmental issues associated with the industrial landscape. It is divided into three critical focus areas which need to be included in the development of the emerging node at the intersection of the R42 and R57.

- Community Health
- Agricultural Land
- Water Quality

2.2.1
COMMUNITY HEALTH

Steel production is a labour intensive industry and the majority of the communities' livelihoods depends on the income they receive from the company. The original township of Bophelong which provides the company with semi-skilled and unskilled labour was selected as the Bench Mark Foundation research area as it is closest to the heavy industry, making it the most vulnerable and affected fenceline community.

A community voice perspective on the impacts of steel works operations in Vanderbijlpark was released by the Bench Marks Foundation in 2013. The survey recorded that 49% of the Bophelong residents and workers suffer from respiratory problems, loss of eyesight and hearing. Other cases involve kidney failure, cancer, tuberculosis, manganese and cadmium poisoning and chronic bronchitis. The report's objective was to understand the community voices concerning environmental issues as well as the interventions/solutions proposed by the companies responsible. (The Bench Marks Foundation, 2013)

The Participatory Action Research Report in 2015 brought a different perspective. The report focuses on women affected by the impacts of the steel industry (Vaal Environmental Justice Alliance, 2015). The women's major concerns related to the toxic environmental conditions while working at, and living close to the steel works, was the loss of the men of the community due to sickness, disability or death.

Figure 2.1: Sebokeng Wellness Centre/Clinic. (news&media, 2013)

THE COMMUNITY'S VOICE

Selected stories from the Bench Marks Foundation and Participatory Action Report are included to frame the individuals of the immediate area and to provide context.

Bophelong Community Member
"There is contaminated water in the gardens. People are getting sick and children are dying because of water pollution"

Ex-worker of Arcelor Mittal
"I lost my eyesight and I don't have a job anymore. I can't provide for my family - I have no money for my children to go to school"

Wife of Deceased
"It was very difficult for the family when my husband died. The children had to leave school and there was no money for food"

The main issue voiced by the community was one of health. These community members are reminded on a daily basis of their powerful neighbour by a series of devastating changes that have affected their immediate environment including the air and water quality, affecting their land, livestock, crops and in turn their health. The prevalence of respiratory illnesses among workers, ex-workers and the community members, in particular children, is indicative of the extent of pollution in the area. The steelworks has an onsite clinic for employees, yet the environmental issues are the root causes for the fenceline communities failing health. It would seem logical for the community to focus on resolving the root cause of these issues, however due to the complex relationship of co-reliance the community and Companies conciously abdicate the need to address the toxicity of the situation. This state of unresolve has led to the constant decline and deterioration of the health of the community. The report explores the fear of the communities that are reliant on the industry as they note that as soon as their health fails they are retrenched or fired. Those who still have their health remain cautious to report any health issues in fear of losing their jobs.

Over the years 3 clinics have been established in Boipatong, a comparable township in the vicinity of Vanderbijlpark, however Bophelong remains with limited health facilities. On the 15th of June 2015 the Department of Health announced its intention to construct 5 new health facilities in the Vaal Triangle, Bophelong has been earmarked to house one of these health facilities. (Health Budget Speech, 2015: online) The urban framework for this dissertation includes the new Bophelong Clinic which will allow the people of the community to fearlessly address health issues.

2.2.2

CONTAMINATED AGRICULTURAL LAND

The economy of the Vaal Triangle has been dominated by two manufacturing sectors of metal and chemical production. The steel industry in Vanderbijlpark and the chemical industry in Sasolburg.

A major concern is the soil contamination caused by these sectors. A high concentration of these pollutants in the soil is harmful to humans and the environment. The steel and mining industry in Vanderbijlpark has affected the land directly leaving traces of heavy metals, along with other contaminants, in the soil. These heavy metals cannot be broken down and enter the food chain through plants, animals and agricultural produce. In 2011, the largest of the steelworks won the Environmental Excellence Award for the remediation of 80 hectares of land in Vanderbijlpark. The land had been contaminated for just over 40 years. The remediation method used was a mixture consisting of micro-organisms, nutrients and water that was sprayed onto the aerated soil. The before and after soil tests show that the process was successful in removing organic chemicals. On March 2015, the steelworks submitted a notification of contaminated land to the department of Environmental affairs in terms of Section 36(5) of the Environmental management Waste Act, 2008. The steelworks is required to submit a remediation plan.

The urban framework will include an agricultural soil remediation centre which will supply the micro-organisms and nutrients required to treat the soil condition.

2.2.3

WATER QUALITY

The urban framework also introduces the focus of this dissertation which is the water treatment infrastructure to protect the Vaal River from the impact of the steel industry thereby retain the ecological diversity of the site. The current polluted condition of the Vaal River has led to an understanding of the importance of protecting the existing wetlands and biodiversity.

2.2.4
A RECONCILING LANDSCAPE

The vision for the emerging node is an ecosystemic strategy which addresses the topics of health, water and land as a movement towards a new urban infrastructure. The site and majority of the surrounding area of the declared node has been identified by the author as uncultivated land which supports the environment by performing complex environmental tasks. The urban framework proposes infrastructure and interventions which will strengthen the site's ecological role of treating water prior to it joining the Vaal river system as well as improve the living conditions of the community.
The urban vision also addresses a much needed clinic for the adjacent township Bophelong, as well as an agricultural soil remediation Centre that will provide the Vaal Triangle industries with environmental remediation support.

Figure 2.1: Urban vision planning to address the issues of land, water and health (Author, 2016)

03

CHAPTER THREE

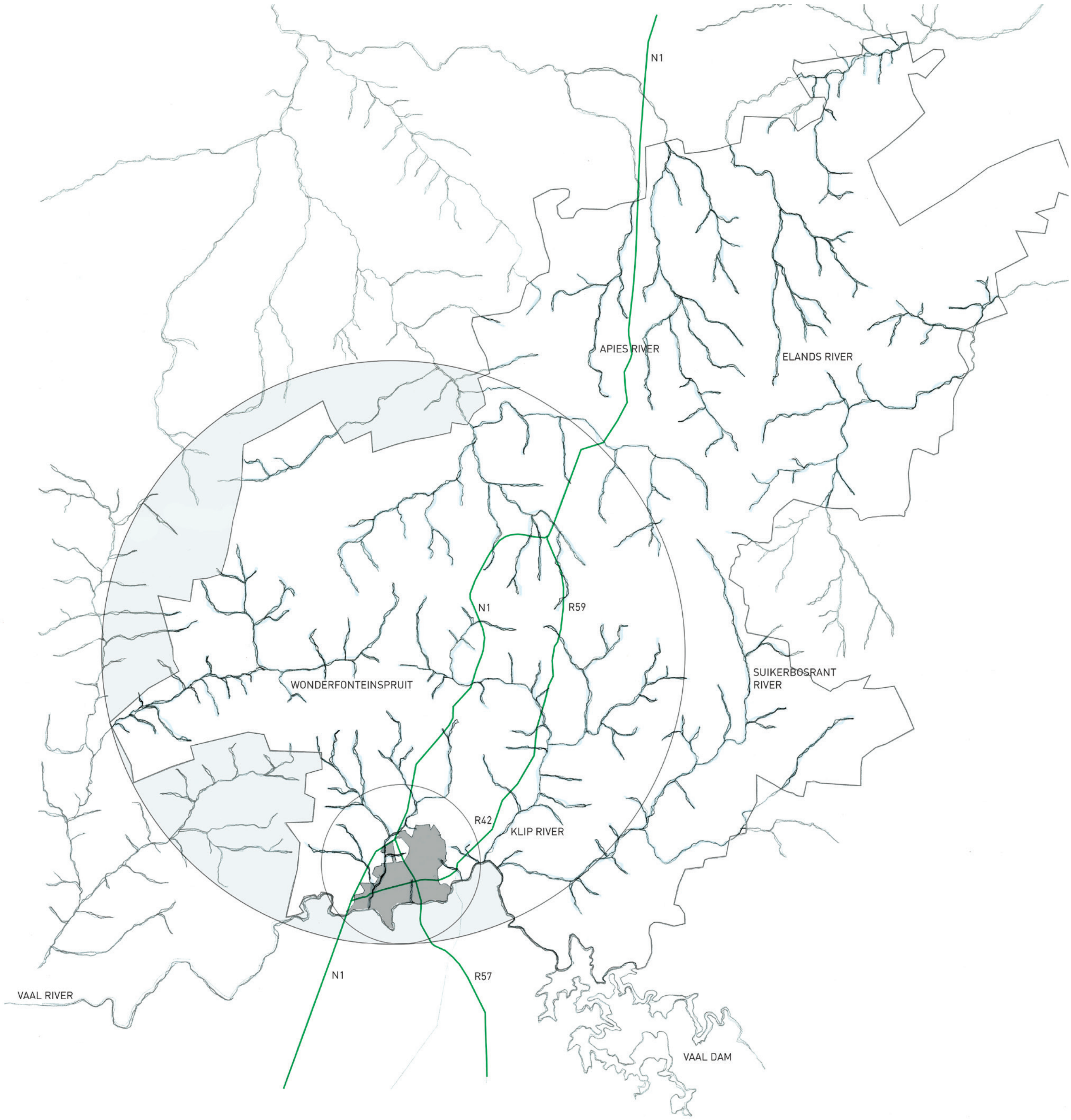
CONTEXTUAL UNDERSTANDING

3.1
THE VAAL RIVER

The Vaal River is the most important water supply in South Africa. It supplies water to large urban populations and economic sectors highlighting the importance of the quality of water flowing into the Vaal River system. This chapter reveals the importance of the river network and it's ability to enrich or destroy people's lives and biodiversity.

GAUTENGS RIVER NETWORK

STEWARDSHIP OF OUR MOST VALUABLE RESOURCE



GAUTENG'S RIVER NETWORK

Figure 3.1: Gauteng's River Network traced from Google Maps (Author, 2016)

29 Cu COPPER	24 Cr CHROMIUM	82 Pb LEAD

THE RIETKUILSPRUIT

A POLLUTED TRIBUTARY OF THE VAAL RIVER

In Groenewald's water sampling conducted on the tributaries of the Vaal River System, Rietkuilspruit and the site location was within the catchment area sampled. The Rietkuilspruit was detected as a point source between VR24 and V17. (Groenewald, 2000:122)

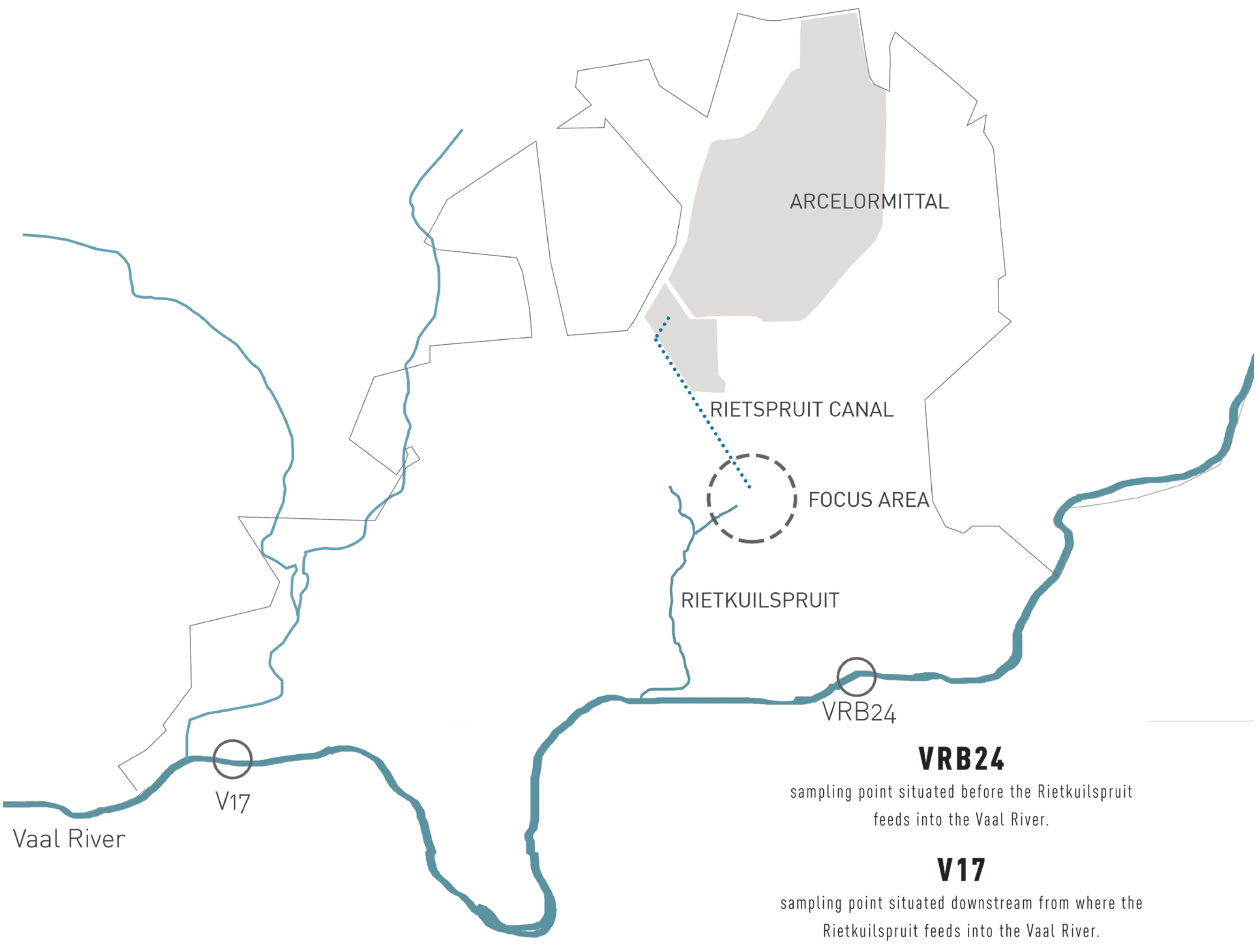


Figure 3.3: Rietkuilspruit tributary leading into Vaal River showing water sample points extracted from Groenewald's Magister Scientiae in Zoology (Author, 2016)

3.2

THE RIETKUILSPRUIT

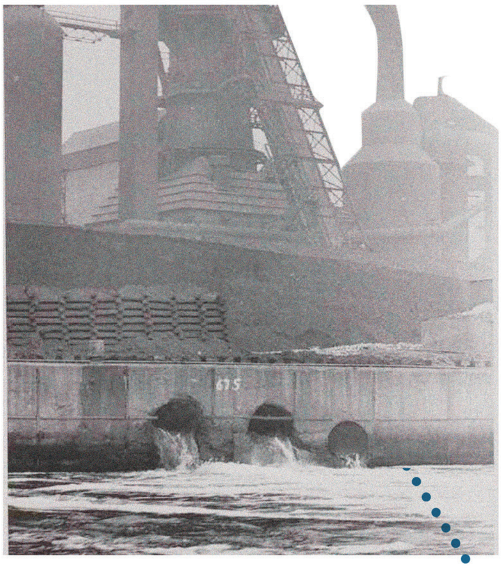
The deterioration in the water quality of the Vaal river system can be largely attributed to the quality of the water of the rivers and tributaries feeding into the Vaal River. Industrial and mining activities in the Vaal Triangle form part of the main contributors for the deterioration of the water quality.

In Groenewald's water sampling conducted on the tributaries of the Vaal River System, Rietkuilspruit and the site location was within the catchment area sampled. Groenewald's research explores the aquatic environment's adult fish communities which are bio-accumulators of heavy metals and are good biological indicator organisms for the assessment of chronic environmental stress. VRB24 is a sampling point situated before the Rietkuilspruit feeds into the Vaal River. V17 is a sampling point situated downstream from where the Rietkuilspruit feeds into the Vaal River.

The V17 catchment area was surveyed and identified as an area in the Vaal aquatic system where fish have high metal levels in their tissues and organs, which can be directly linked to the high levels of contaminants entering the system as part of the industrial run off. Metals which attatch to sediment particles are more persistent and pose a threat to the aquatic environment. These contaminants have affected the ecology of the area as the health of the fish is linked to human health risks. (Groenewald, 2000:122)

Sample point V17 also had the highest correlation of pollutants which pose the biggest threat to the health of the entire body of water, showing high levels of chromium, copper and lead. These levels did not comply with recommended safe water values. During periods of high rainfall, lower concentrations of pollutants were recorded highlighting a point source that is contaminating the water. Amongst the main point sources identified, Groenewald noted the effluent flowing from the immediate industrial area as a prominent contributor. (Groenewald, 2000:122)

This data links the Rietspruit canal which is polluted with heavy metals from the industrial area to the Rietkuilspruit that feeds into the Vaal River. The objectives of this dissertation will be to intercept and remediate the contaminated water prior to it entering the Vaal River system, preventing heavy metals from entering the water system.



THE RIETSPRUIT CANAL

THE INTERSECTION
OF POLLUTED
AND CLEAN
WATER

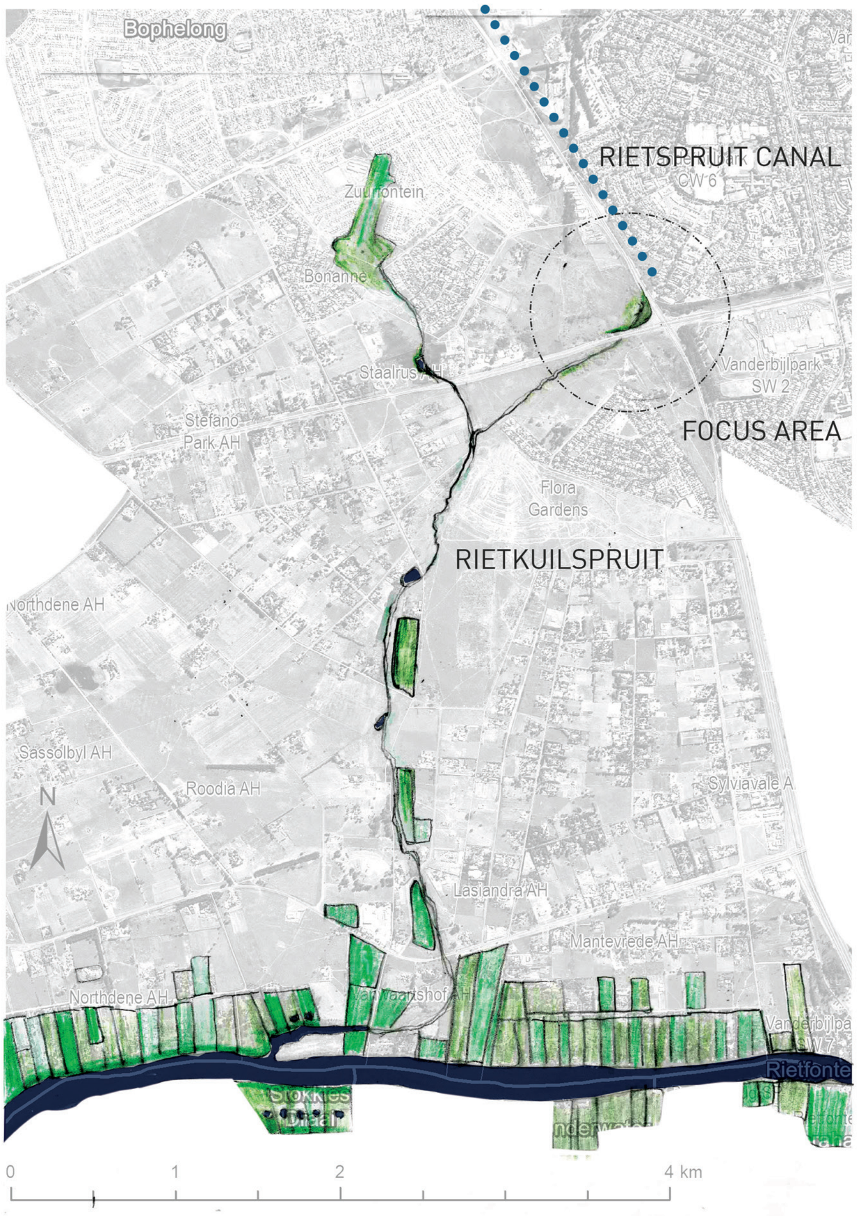


Figure 3.2: Water Network boundaries of the site traced from Google Maps. (Author, 2016)

3.3
THE RIETSPRUIT CANAL

The Rietspruit Canal forms part of the tributary network of the Rietkuilspruit which feeds into the Vaal River system. The Rietspruit Canal accumulates the run-off from industry with storm water networks precipitating a natural wetland at the intersection of the R42 and R57. The quality and impact of the industrial water of the Rietspruit Canal has been recorded as unacceptable by the Bophelong community speared headed by Vaal Environmental Justice Alliance (The Bench Marks Foundation, 2013).

Currently there are no interventions, water treatment works or filtration infrastructure to act as an ecological safe-guard prior to the water entering the Vaal River System. This established wetland serves as a potential restorative interception within the tributary network and has the potential to play a further critical role in treating the industrial effluent, yet a more intensive approach is needed to address the removal of heavy metals. This undeveloped site presents an opportunity to intercept the Rietspruit Canal's industrial effluent before it enters a more complex water network. .

Unknown
(unknown)
Plant Type: Shrub
Found on neglected sites

Goats Foot
(Ipomoea pes-caprae)
Plant Type: Shrub with long stems
Indigenous to South Africa

River Reeds
(unknown)
Plant Type: Reed
Unknown

Simon Poplar
(Populus)
Plant Type: Large tree

Honey Locust
(Gleditsia triacanthos)
Plant Type: Medium to large tree
Indigenous to South Africa

Mulbery Tree
(Morus nigra)
Plant Type: Medium to large tree
Tolerates wetland

Garden Privet
(Ligustrium Ovalifolium)
Plant Type: Medium Tree
Invasive

Tall Verbena
(Verbena bonariensis)
Plant Type: Shrub
Common weed

White Stinkwood
(Celtis africana)
Plant Type: Medium to large tree
Indigenous to South Africa

River Bush Willow
(Combretum erythrophyllum)
Plant Type: Medium to large tree
Indigenous to South Africa

POINT OF INTERCEPTION

STRENGTHENING AN EXISTING ESTABLISHED ECOLOGY

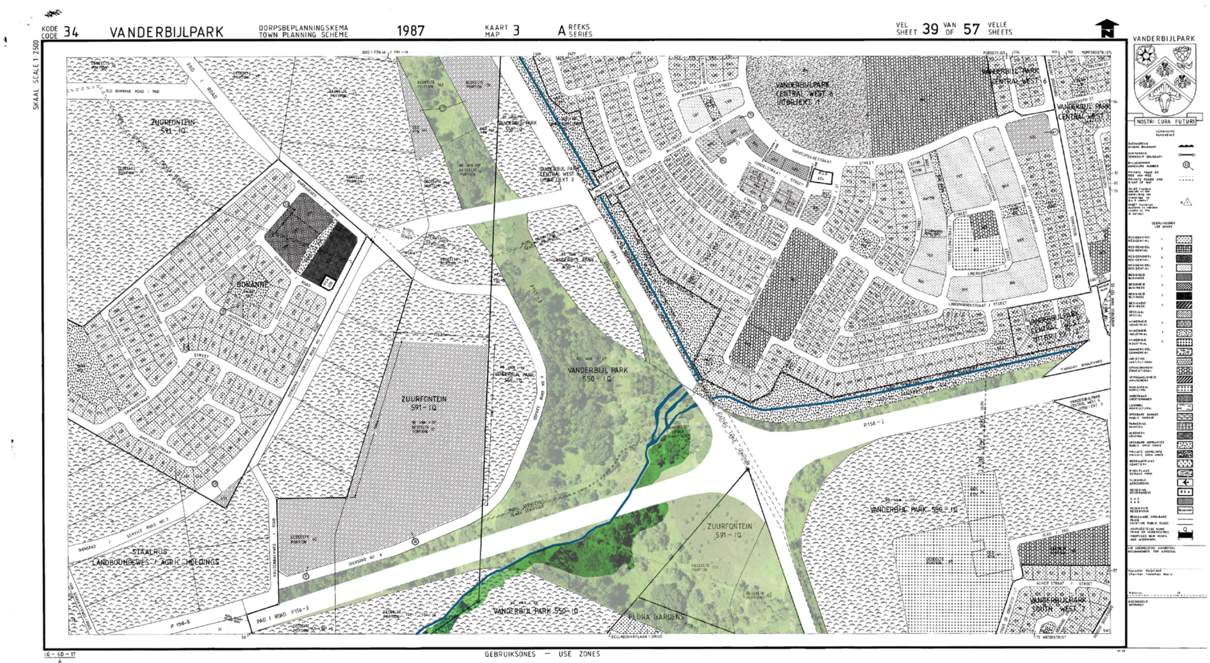


Figure 3.4: Site Mapping of rezoned road reserve with wetland and hydrology network. (Author,2016)

3.4

THE VALUE OF URBAN-RURAL LAND

"... Nature ... a certain appreciation for what it represents; that we come from nature and we have to understand what it is. There is an importance to have a certain reverence for what nature is, because we are connected to it and we are part of it. And if we destroy nature, we destroy ourselves. Maybe the new landscape of our time... is the landscape that we change. The one that we disrupt in pursuit of progress... look at the industrial landscape as a way of defining who we are and our relationship to the planet. It is this thing that is growing and part of our economy, it is part of our politics, and it is part of how we elect our governments, it is part of everything we do. It is this big machine that started rolling..." Burtynsky, E. 2006

Urban-Rural land refers to the parcels of land left behind, the spaces which have never been exploited, most commonly situated between the built environment and agricultural land. This fragmented territory of undecided, residual and suspended space is in most instances uncultivated, open land which highlights the flaws of urban planning logic and the effects of urban sprawl. Urban-rural land is with and not against nature, observing, complying and intervening as little as possible. The value that can be ascribed to these natural parcels of land lies in their unadulterated attestation to the indigenous environment's ability to restoratively adapt to the external pollutants posed by the encroaching urban and industrial sprawl. The resident ecology including plants, algae, micro-organisms, etc within the developed wetland showcases nature's ability to adapt to external stresses in an attempt to address the pollutants. The natural wetland and the associated fauna and flora act as a restorative urban rural interception of the water network in this context. It exists with the intention to correct the damage done by the industrial landscape. (Quodlibet, 2005)

The author is looking to explore the lessons observed in these urban-rural parcels, taking key notes from the adaptation of the natural environment to address the external factors. The intention is to leverage off these lessons, replicating these restorative interventions by proposing dynamic infrastructure as part of the development.

FRAGMENTS OF PLACE

THE VALUE OF URBAN-RURAL LAND IN A CONTAMINATED WATER NETWORK

Figure 3.5: Site mapping of urban land use outlining rezoned road reserve. (Author, 2016)

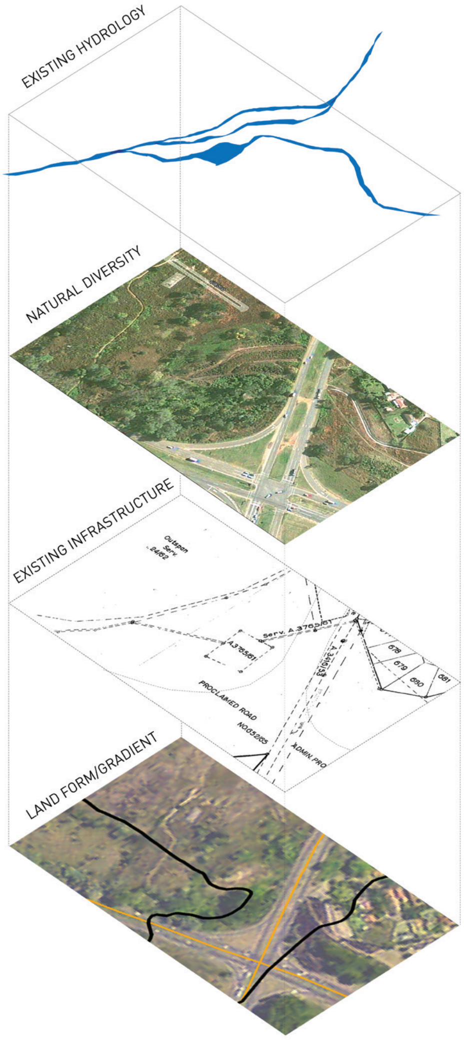
3.5
IDENTIFYING A SITE

In Vanderbijlpark an urban-rural site has been selected which is an example of the urban-rural. The main reasons that this specific site has been selected is due to its geographic position within the water network, the potential area available for development of the intervention, the revised intention of the town planners for the site and the proximity of the site to the affected community.

One of the most important characteristics of the site is that it is currently a place of ecological diversity, performing complex environmental tasks of attempting to improve the quality of the water entering the Vaal River network. This is currently performed by the extensive wetland. The site's diversity has been established over many years of the parcels of land being neglected. The site is an example of an urban-rural land which over the decades of neglect has become an archive of untouched diversity of tomorrow's genetic heritage. (Quodlibet, 2005)

In an undisturbed ecosystem (pre-industrial and natural landscapes) everything is in balance. Since the industrial revolution, pollution and exploitation of resources have affected the ecosystems, creating disturbances which result in an imbalanced system. Human are now part of the ecosystem. The role of humans in their environment is to understand how it works to ensure it continues working. Humans need to understand how to tap into the environment without destroying the diversity or mechanisms. (Quodlibet, 2005)

As an urban-rural landscape the site's value lies in its deliberate intention to correct the damage done by the industrial activities. It currently plays an important role in the ecosystem by performing complex environmental through an extensive naturalized wetland.



THE SITES POTENTIAL

THE GREATEST POTENTIAL
LIES IN THE SITES
EXISTING QUALITIES

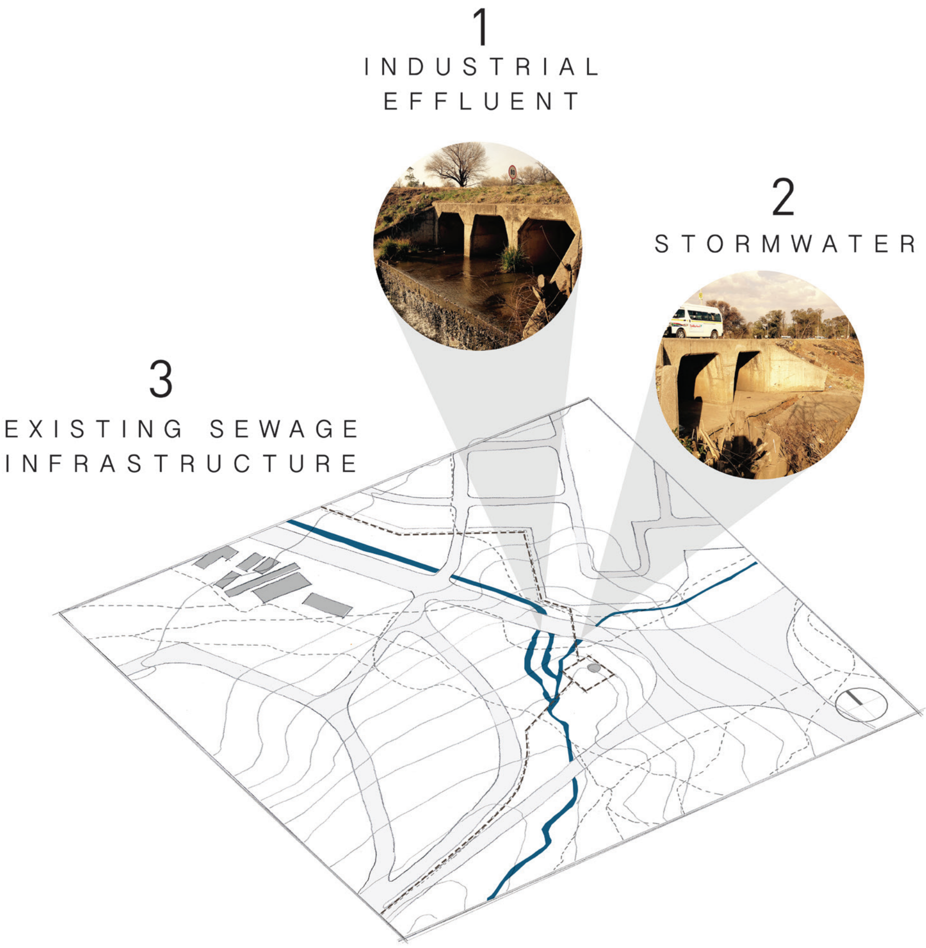
The greatest potential for the water treatment facility lies in the site's existing hydrology, natural diversity, existing infrastructure and land form. The project intends to protect the existing wetland as well as the established natural diversity by strengthening and activating the environmental potential of the neglected parcel of land.

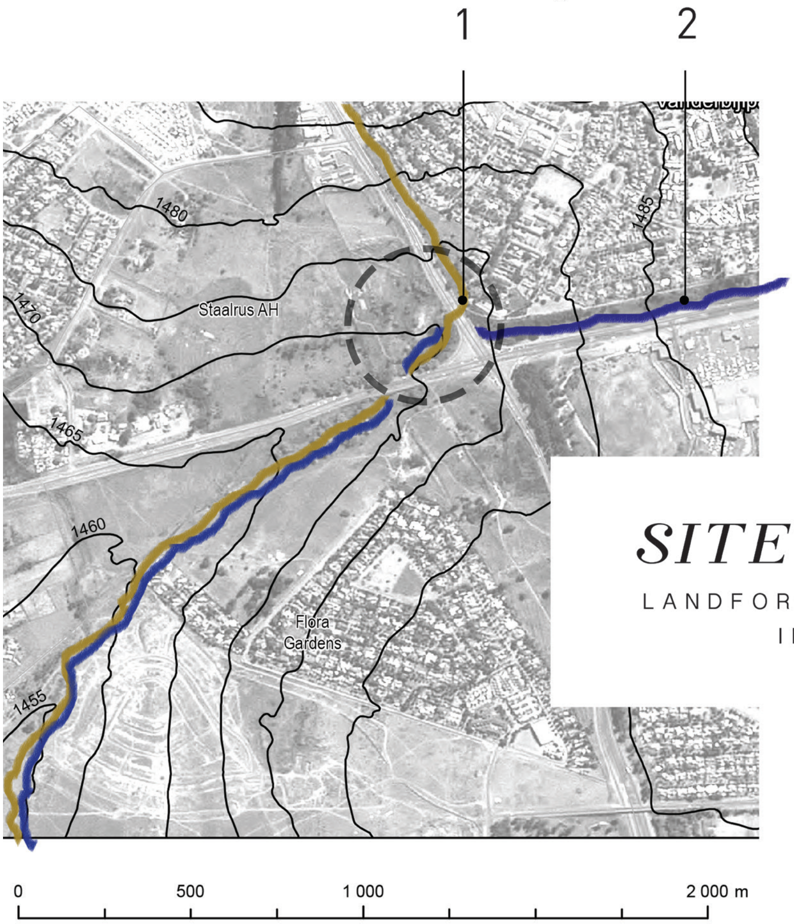
Figure 3.6: The layers of the site's potential (Author, 2016)

3.6
THE SITE'S POTENTIAL

The potential of the site is currently overlooked and the town planners developing the emerging node at the R24 and R57 intersection run the risk of disregarding the site's natural wetland filtration role in the greater Vaal River system. The greatest potential for the water treatment facility lies in the site's existing hydrology, natural diversity, existing infrastructure and land form. The project intends to protect the existing wetland as well as the established natural diversity by strengthening and activating the environmental potential of the neglected parcel of land. The urban-rural nature of the site has the potential for the client to engage with the community of Bophelong by integrating a community development interface for job creation and stewardship which will nurture a sense of well-being for the people.

Figure 3.8: Established natural wetland. (Author, 2016)





SITE HYDROLOGY

LANDFORM, HYDROLOGY, EXISTING INFRASTRUCTURE

Figure 3.9: Sites hydrology showing natural movement of water through the site. (Author, 2016)

3.61

EXISTING HYDROLOGY NETWORK

The wetland accumulates water from the Rietspruit Canal and transfers it into Rietkuilspruit which feeds into the Vaal River System. The site's wetland is currently performing environmental tasks of water filtration and purification, yet these are not at a stage where all the contamination is removed as heavy metals remain untreated and are potentially entering the Vaal River network.

Water flow observations and documentation from the Rietspruit Canal were performed by the author in the year of the study, 2016. A steady flow of industrial effluent was noted by the author in August when the rainfall is the lowest in the Vanderbijlpark area. The rainfall is highest in the summer months posing a challenge of capacity of treatment for the volumes of water. The site's North to South gradient allows the water to flow through the wetland and into the Rietkuilspruit.

The site's existing hydrology can be analyzed and separated into three types of water which enter the site through 3 separate systems

1. Existing Sewage Infrastructure
2. Urban Storm Water
3. Industrial Effluent

EXISTING SEWAGE INFRASTRUCTURE

The R42/R57 intersection is the lowest point of the adjacent residential area and industrial area which houses a subsurface sewage lift station. The sewage is lifted and moved to the nearby sewage facility. The station is fully operational and fully contained resulting in no effluent/run off occurring from this facility into the wetland and or Rietkuilspruit system. The sub-station will however be taken into account in the design, layout and orientation of the intervention as it represents existing infrastructure that will remain.

URBAN STORMWATER

The storm water which flows from the residential area has a separate canal to the industrial effluent canal. Storm water contains floating debris, contaminants lighter than water (oil/grease), contaminants heavier than water (sediment) and dissolved minerals which can be treated by implementing a storm water wetland. (Vosloo, 2016) Constructed wetlands are designed to remove pollutants from storm water using several mechanism (microbial breakdown of pollutants, biological uptake by plants, retention, settling and absorption).

The intention is that the storm water will enter the site and flow directly into a constructed storage wetland which overflows directly into the Rietkuilspruit. This will allow the sediment to settle and grease to be removed.

INDUSTRIAL EFFLUENT

The water entering the site from the industrial area contains sediment contaminated with heavy metals, primarily chromium, copper and lead. The intervention's intention is to keep the industrial effluent separate from the storm water which will be treated separately. The position of the site for the intervention to treat the water quality is crucial. This point will become an ecological safeguard ultimately protecting the Vaal River System.

The site is considered an uncultivated parcel of land. The site was previously proclaimed as a reserved space for the expansion of the road infrastructure, however, the intervention proposes the rezoning the status of servitude for urban infrastructure. The site currently fulfills a hybrid role despite the current zoning classification. The site currently houses the local sewage lift pump which will remain where it is currently situated.

3.62

SERVITUDE WITH EXISTING INFRASTRUCTURE

The site is considered an uncultivated parcel of land. The site was previously proclaimed as a reserved space for the expansion of the road infrastructure, however, the intervention proposes the rezoning the status of servitude for urban infrastructure. The site currently fulfills a hybrid role despite the current zoning classification. The site currently houses the local sewage lift pump which will remain where it is currently situated.

3.63

LANDSCAPE FORM

The natural contours have a north to south gradient, sloping down toward the Vaal River. The site has a low lying basin which has created a natural wetland. This makes it ideal for the proposed intervention as the contours facilitate a natural run off required for the treatment facility with minimal civil works, landscape disturbance or construction.

3.64

NATURAL BIOME & DIVERSITY

The site falls into the Grassland Biome of the Soweto Highveld Grassland and is the host to a variety of plant species making it rich in diversity. The various plant species collected by the author on site depicts the natural diversity.

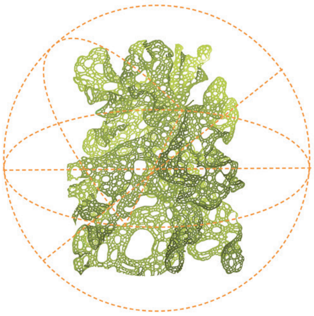
04

CHAPTER FOUR

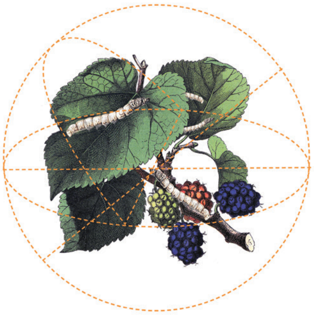
REGENERATIVE THINKING

SELF-REPLENISHING
REGENERATIVE APPROACH

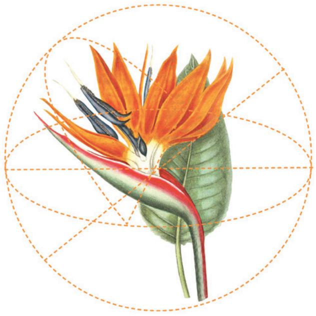
AN ARCHITECTURAL INTENTION TOWARDS
A CONDITION WHICH SUSTAINS HEALING
OF CONTAMINATED ENVIRONMENT



MICRO-ORGANISMS



INSECTS



PLANTS

REGENERATIVE ARCHITECTURE FOCUSES ON THE NATURAL WORLD AS THE BUILDING BLOCKS AND GENERATOR OF THE ARCHITECTURE. THE THEORY OF REGENERATIVE DESIGN IS BASED ON THE BELIEF THAT EVERYTHING CONSTRUCTED/BUILT HAS POTENTIAL TO BE INTEGRATED INTO AN EXISTING NATURAL NETWORK. THE NATURAL WORLD IS CONSIDERED A SHARE HOLDER AND COPARTNER TOTHE BUILT ENVIRONMENT.

4.1
REGNERATIVE THINKING

The potential of the site is currently overlooked and the town planners developing the emerging node at the R24 and R57 intersection run the risk of disregarding the site's natural wetland filtration role in the greater Vaal River system. The greatest potential for the water treatment facility lies in the site's existing hydrology, natural diversity, existing infrastructure and land form. The project intends to protect the existing wetland as well as the established natural diversity by strengthening and activating the environmental potential of the neglected parcel of land. The urban-rural nature of the site has the potential for the client to engage with the community of Bophelong by integrating a community development interface for job creation and stewardship which will nurture a sense of well-being for the people.

4.2
A SELF-REPLENSHING SYSTEM

Architecture as a disconnected object requires a constant input of resources and energy which disadvantages the environment. Sustainable approaches use technology to reduce these inputs, yet the architecture remains separate from nature. In nature everything self-replenishes itself, naturally recycled and regenerated - there is no waste created or non-renewable resources that are used. The potential of regenerative approach is realized when the production output from the collaborative system is greater than the resources introduced into the system. Regenerative thinking brings an understanding that it is possible for architecture to co-exist with nature, together producing more than what is consumed, thus leaving the environment in a healthier state. (Littman, 2009:20)

4.3
NATURE VS MAN

"Humans need to understand how to tap into the environment without destroying the diversity or existing natural mechanisms. When ecosystems suffer so does the everyday quality of life of the people in that environment" (Quodlibet, 2005:online)

Recently an understanding of this relationship between man and nature and the effect we have on the environment has stirred up a movement in the built environment, which has led to the development of sustainability assessment tools. Sustainable development is defined as development which has minimum adverse impact on the built and natural environment according to the rating received. (Littman, 2009:1) Although the ethos of the standards aspire to effectively address sustainability, the current standards and accepted norms are generally very low, resulting instances where the exercise results in superfluous tick lists. The awareness and strong movement towards biodegradable, renewable, sustainable and carbon-neutral solutions are admirable, yet with the movement it is also important to develop an understanding of the object in its ecosystem and the natural systems which can be enhanced or tapped into. (John, et al, 2004:319)

A paradigm shift is occurring from sustainability to a position of natural resilience. This movement of resilient thinking has recently brought about an ethos and understanding that the built environment is a vital part of the natural world and natural systems. Through this perspective of living systems working with, and integrated into the built environment it is possible to have an urban system that is not only sustainable, but rather capable of renewal and regeneration. This gives it the resilience and ability to adapt to urban pressures and disturbances to avoid environmental collapse. (Peres, 2015:40)

The focus of this intervention is to understand the production routes/ infrastructure that will support an ecosystemic approach to challenge conventional methods of heavy metal removal from contaminated water. The intervention's alternative infrastructure focuses on creating a treatment system using self-replenishing mechanisms/elements which fulfill the same role as conventional treatment processes. Decontamination processes are costly and time consuming, yet natural systems are inexpensive and readily available. The proposed alternative infrastructure for water treatment explores biological remediation methods for each process involved with heavy metal removal.

4.4
SYSTEM METHODOLOGY

A system is an interconnected set of elements organized in a coherent way to achieve a purpose. A system must consist of elements, interconnections and a function. The systems behaviour is determined by its purpose. (Meadows, 2009:28)

The system is be divided into the following categories:
1. The Purpose/function
2. The Interconnection
3. The elements

THE FUNCTION OF THE SYSTEM

Why is the system needed? In this intervention the water entering the river network is contaminated with heavy metals. The function of the system determines which elements are required to remove the heavy metals. If the function had to change then so would the elements. The function of the system involves the restoration of water, including removal of heavy metals in industrial effluent, treatment of grey water and removal of pollutants in storm water.

THE INTERCONNECTION

The interconnection is the relationship which holds the elements together. In the proposed system the contaminated water flowing through the system connects all the elements.

THE ELEMENTS

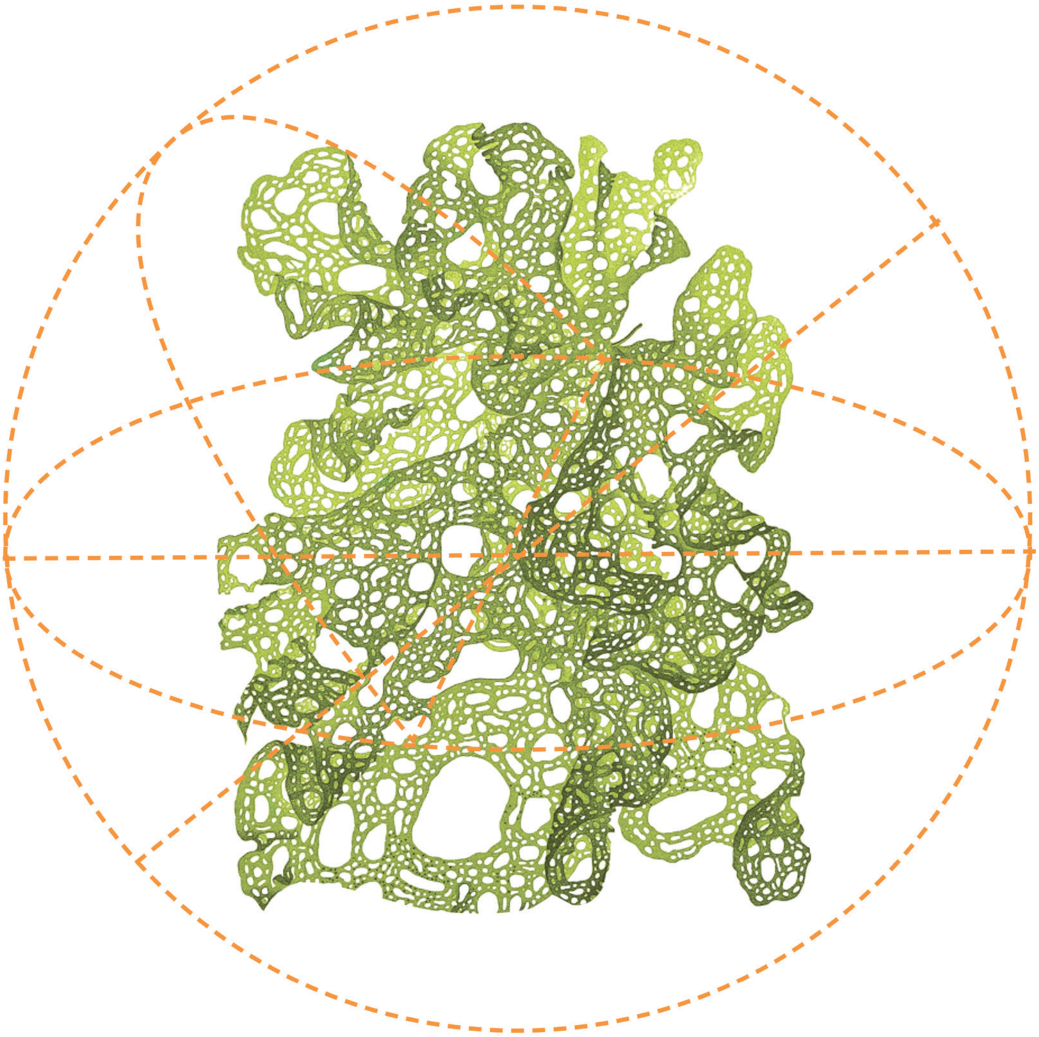
The elements are the visible, tangible parts, most likely seen by the observer. The system would not function properly if all the elements weren't present.

In this intervention the elements of the system are:

1. Algae which removes the heavy metals
2. Biodegradable silk biofilms on which the algae grows
3. Constructed wetland for the treatment of the building's grey water and removal of pollutants in effluent and storm water
4. Anaerobic digester for solid waste and saturated biofilms

INDIGENOUS ALGAE

MINING ALGAL-MICROBIAL
ULOTHRIX SP.



Algae biofilms are created through a process of free-floating organism that attach themselves to a fabric medium to create a slime layer. Once the biofilm has been saturated, it is removed and placed into a shredder which feeds into an anaerobic digester. A revolving algae silk biofilm challenges the conventional idea of large scale wastewater facilities that require a large area of land for cultivation of the organisms for the treatment of water.

Figure 4.1: Algae used for the removal of heavy metals from contaminated water. (ResearchGate,2016)

4.4.1
ELEMENT_ ALGAE

Biotechnology is the use of living organisms to perform specific industrial or manufacturing processes, specifically in this instance, to improve the water in the environment.

Micro-organisms have evolved to respond to heavy metal environmental stress with proven capability to take up heavy metals and transport them across the cell's membrane through reduction reactions. These processes are irreversible and ensure less risk of metal releasing back into the environment. (Malik, 2004)

The algal strain: Ulothrix sp. an indigenous mining algal-microbial has been tested to remove the heavy metals including copper, lead and chromium (Orandi, 2012). These are the same metals identified at sample point V7. (Groenewald, 2000:124) Growing metal resistant algal-microbial such as Ulothrix sp. poses a cost effective method for metal remediation due to the proven effectiveness of removing heavy metals and the cells ability to self-replenish. (Malik, 2004)

A revolving algae silk biofilm challenges the conventional idea of large-scale wastewater facilities that require a large area of land for cultivation of the organisms for the treatment of water. This alternative method has a smaller footprint due to the rotating belt that is submerged in the trough of contaminated water. (Bergstedt, 2013).

Algae biofilms are created through a process of free-floating organism that attatch themselves to a fabric medium to create a slime layer. Once the biofilm has been saturated, it is removed and placed into a shredder which feeds into an anaerobic digester.

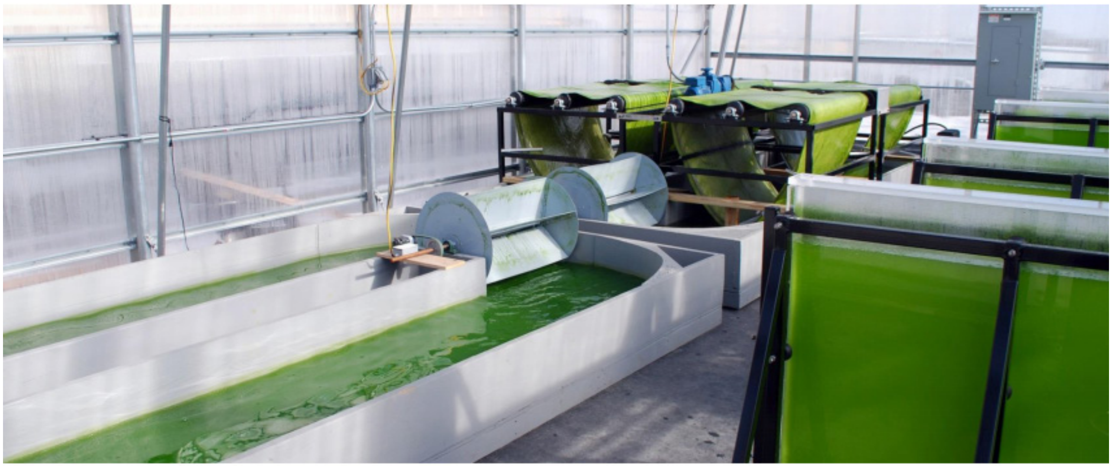
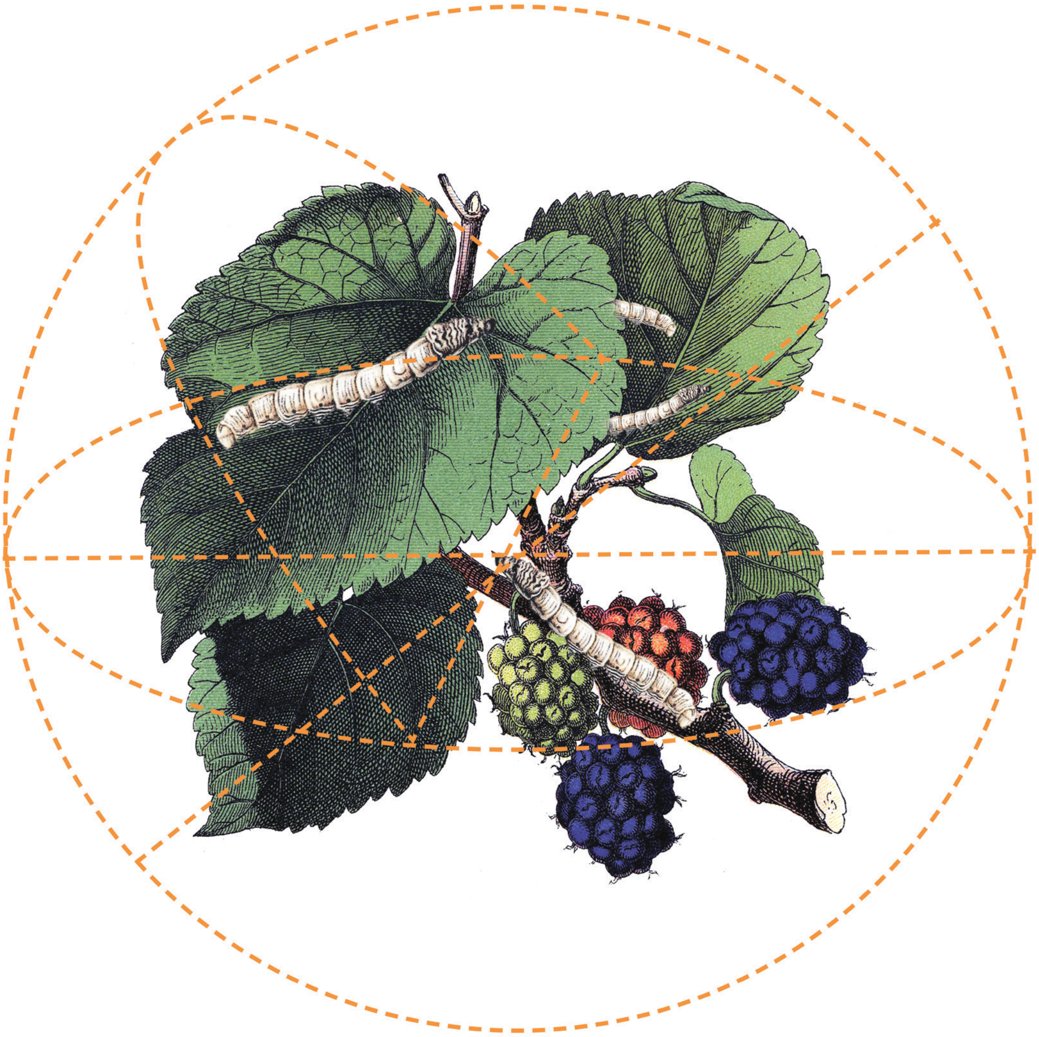


Figure 4.2: Revolving algal biofilm (ChEnected, 2016)

SILK BIOFILM MEDIUM

THE REARING OF SILKWORMS FOR THE PRODUCTION OF SILK



Natural silk fibers which are made of pure protein are known for their lightness, strength and durability.The good tensile properties of silk make it particularly suitable for the fabric medium onwhich the algae grows to create the biofilm.

4.4.2
ELEMENT_ BIOFILM

New sustainable production methods for the components needed for water treatment facilities have been developed. One of these methods includes the use of silk as the foundation for biofilm. The good tensile properties of silk make it particularly suitable for the fabric medium on which the algae grows to create the biofilm. Silk's natural properties enhance industrial ecology, produce less environmental stress and allow for ease in the process, as it can be shredded into the bio digester along with the algae - both being biodegradable.

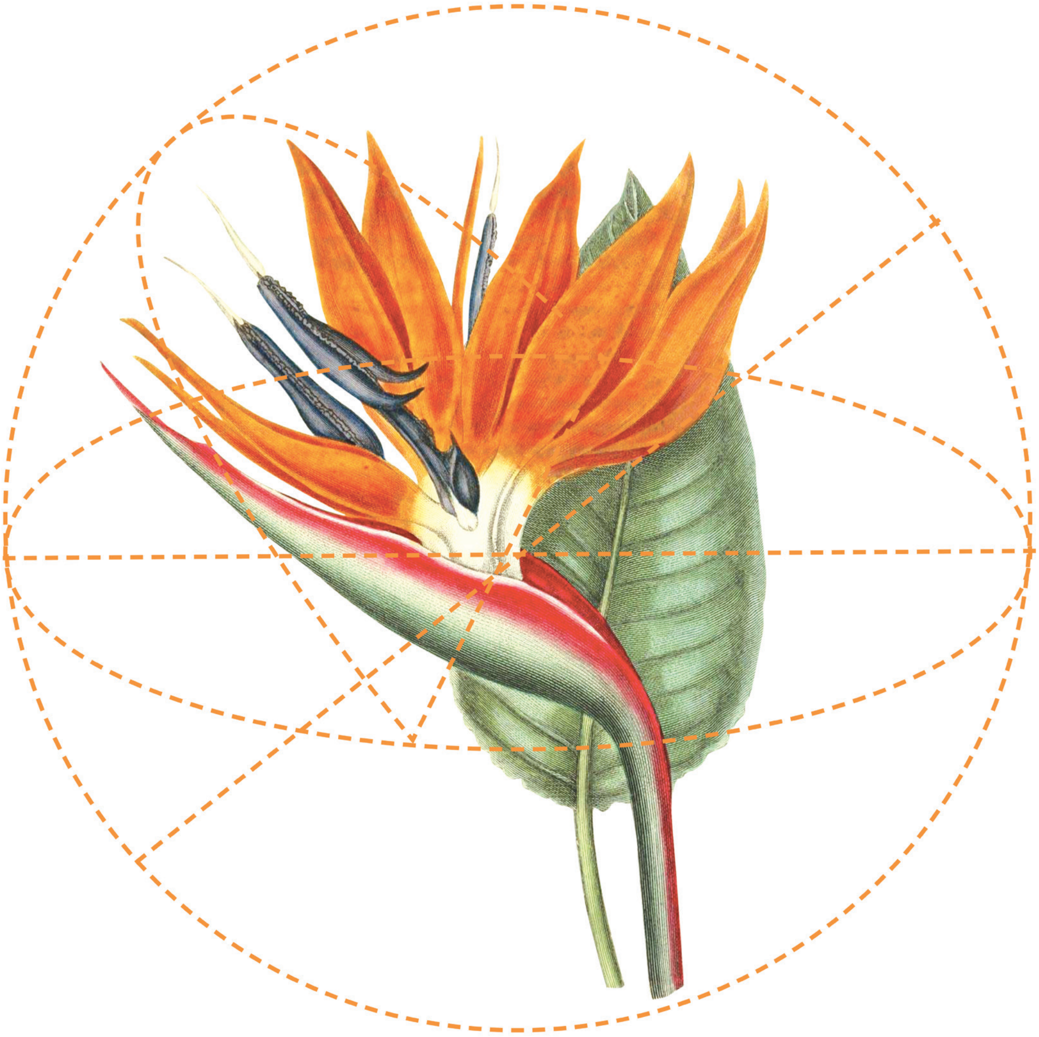
The common silkworm Bombyx Mori's silk membranes have remarkable performance which is on par with synthetic technologies. Natural silk fibers which are made of pure protein are known for their lightness, strength and durability.

The production of the silk biofilms forms part of the community development interface of the water treatment facility. The rearing of silkworms and fabrication of the biofilm forms a critical part of the community development interface with the intention to create job opportunities for the women of the township of Bophelong.

Figure 4.3: Replenishable Biofilm Fabrication. (Women in Sericulture,2016)

PHYTOREMEDIATION

HYPER-ACCUMULATING PLANTS
FOR THE REMOVAL OF
HEAVY METALS



Micro-organisms have evolved to respond to heavy metal environmental stress with proven capability to take up heavy metals and transport them across the cell's membrane through reduction reactions. These processes are irreversible and ensure less risk of metal releasing back into the environment.The algal strain: Ulothrix sp. an indigenous mining algal-microbial has been tested to remove the heavy metals including copper, lead and chromium.

Figure 4.4: Phytoremediation water treatment infrastructure. (Saier, 2010)

4.4.3
ELEMENT_ PLANTS

Phytoremediation is a process which uses plants to remove contaminants from the soil, sludge, sediment, ground water, surface water as well as waste water. The process utilises the plant's biological processes and physical characteristics of the plant. Plants use a variety of mechanisms to cope with heavy metals. There are two types of heavy metal accumulation by plants in constructed wetlands: phytoextraction and rhizofiltration.

Phytoextraction involves hyper-accumulating plants which take up the metals and concentrate them into the roots and stem (biomass) of the plant so they can be harvested and disposed. This is achieved by safely incinerating the biomass.

Rhizofiltration is the process by which plants absorb, precipitate and concentrate heavy metals in their roots. This can be achieved by filtering water through a mass of roots. The pollutants remain absorbed in or to the root system of the plants. The main advantage of phytoremediation is that it is a cost effective and efficient method once established.

Phytoremediation has however proved to be a challenge to implement previously as the effectivity is directly proportional to the time the plants are allowed to grow, requiring commitment to a long-term remediation process. A further challenge is that the method requires that the contaminated wetland plants are harvested and disposed of.

In this intervention phytoremediation will be used as the secondary treatment mechanism as part of te long term vision for the water treatment facility. The following plant species will be planted and left to establish an alternative long term solution to address the heavy metals found in the V17 water samples.

Chromium (Cr)
Azolla (duck weed), Bacopa Monnieri (water hyssop), Vallisneria americana (tape grass), Eichhornia Crassipes (water hyacinth), Hydrilla (water weed), Pistia (water lettuce), Salvinia Molesta (kariba weed), Spirodela polyrhiza (giant duckweed)

Copper (Cu)
Aeolanthus Biformifolius, Azolla filiculoides (Water fern), Bacopa Monnieri (water hyssop), Vallisneria americana (tape grass), Eichhornia Crassipes (water hyacinth), Lemna minor (common duckweed), Pistia (water lettuce)

Lead (Pb)
Azolla Filiculoides (water fern), Bacopa Monnieri (water hyssop), Vallisneria americana (tape grass), Eichhornia Crassipes (water hyacinth), Hydrilla (water weed), Lemna minor (common duckweed), Salvinia Molesta (kariba weed), Spirodela polyrhiza (giant duckweed), strelitzia reginae (bird of paradise)

4.4.4
ANAEROBIC DIGESTER

Anaerobic digestion is used as a waste management method for the disposal of the algae biofilms which contain heavy metals. Anaerobic digestion is a process by which micro-organisms breakdown biodegradable material in the absence of oxygen. The process produces biogas, a renewable source of energy, which can be used directly or converted to electricity by using a gas motor and generator conversion method. (Engineering News, 2016: online)

05

CHAPTER THREE

PROGRAMME

5.1
A RESILIENT APPROACH

The programme has been developed from an understanding of the dynamic relationship between man and the natural landscape. A Regenerative approach is adopted for this intervention; the idea of using natural systems becomes the dynamic alternative infrastructure for the treatment of the contaminated water. The success of a natural system as permanent infrastructure requires an understanding that the system needs to have the ability to cope with pressures or environmental stress the system might encounter, referred to as the resilience of the system. The adaptive capacity of a system to perform its function (in this case a natural heavy metal removal system) is determined by its ability to regenerate and flourish, or spiral into collapse. Diversity, Redundancy and Modularity are resilient concepts which improve the adaptive capacity of a system. These concepts can be applied on an urban scale to the tiniest microorganisms of a system. (Peres, 2016:160)

5.1.1
DIVERSITY

The more diverse a system, the better its chances for survival. Diversity has a variety of supportive elements which makes the system more flexible. Flexibility strengthens and stabilizes the system, ensuring it will still function even if the system experiences a shock. A level high diversity however doesn't necessarily mean a healthy system. An appropriate diversity needs to be developed that considers the required resources for the specific environmental intervention in within the complementary systems, bringing the correct level of diversity required for resilience. (Peres, 2016:162)

The function of this intervention is the removal of heavy metals via several systems. The diversity is attained through the use of settling detention dams, the algae biofilm system, as well as phytoremediation in the wetland. Diversity must also be applied and exist within the respective systems. This means that the resilience of the algae/ phytoremediation system is dependent of the level of diversity maintained within it. Practically this implies that ideally several complementary strains of algae and species of plants should form part of the ultimate intervention. Instead of depending on a single species, multi-species are proven to have a higher uptake than a single species. (Malik, 2004)

5.1.2
REDUNDANCY

Diversity and redundancy are interlinked, redundancy increases diversity (it's important to note though that diversity does not necessarily increase redundancy). Redundancy is considered a backup which replaces an element of the system,but without a backup a system becomes vulnerable and cannot fulfill its function. Profit-driven systems that run at a most efficient state will exclude redundancy as it is seen as a waste of resources. With natural, regenerative systems it makes sense to incorporate redundancy. It secures the system's reliability and functionality, thus providing a long tern solution. (Peres, 2016:173)

The algae and phytoremediation processes provide diversity and effectively redundancy in the system as there is a backup system in place. The wetland will serve its traditional role of removing organic pollutants, but if the need arises, it can replace and/or complement the algae system and perform the same function of heavy metal removal through the plants ability of phytoremediation. The detention dam and reservoir also at times operate as redundant systems.

5.1.3
MODULARITY

Modularity in simple terms prevents a failure in one part of the system from affecting the entire system's performance. It also allows the system to be adapted to increase or decrease capacity as required. By breaking the system up into smaller parts, it is possible to shut down or localize a crisis. Referring to the systems methodology, the elements of a system can be divided into sub-groups which perform exactly the same role as the whole, but have the ability to be removed if the need arises. In essence sub-groups are strongly linked internally, but loosely linked to the rest of the system, although they are performing the same function. (Peres, 2016:178)

In this intervention modularity can be seen in the sub-group systems of algae and the phytoremediation wetland combination. The whole system as infrastructure has been broken up into 5 smaller, identical sub-systems. The interconnection is the contaminated water which links all 5 systems, capable of flowing where it is directed.

INTERPRETATION

AN UNDERSTANDING OF THE SPATIAL REQUIREMENTS

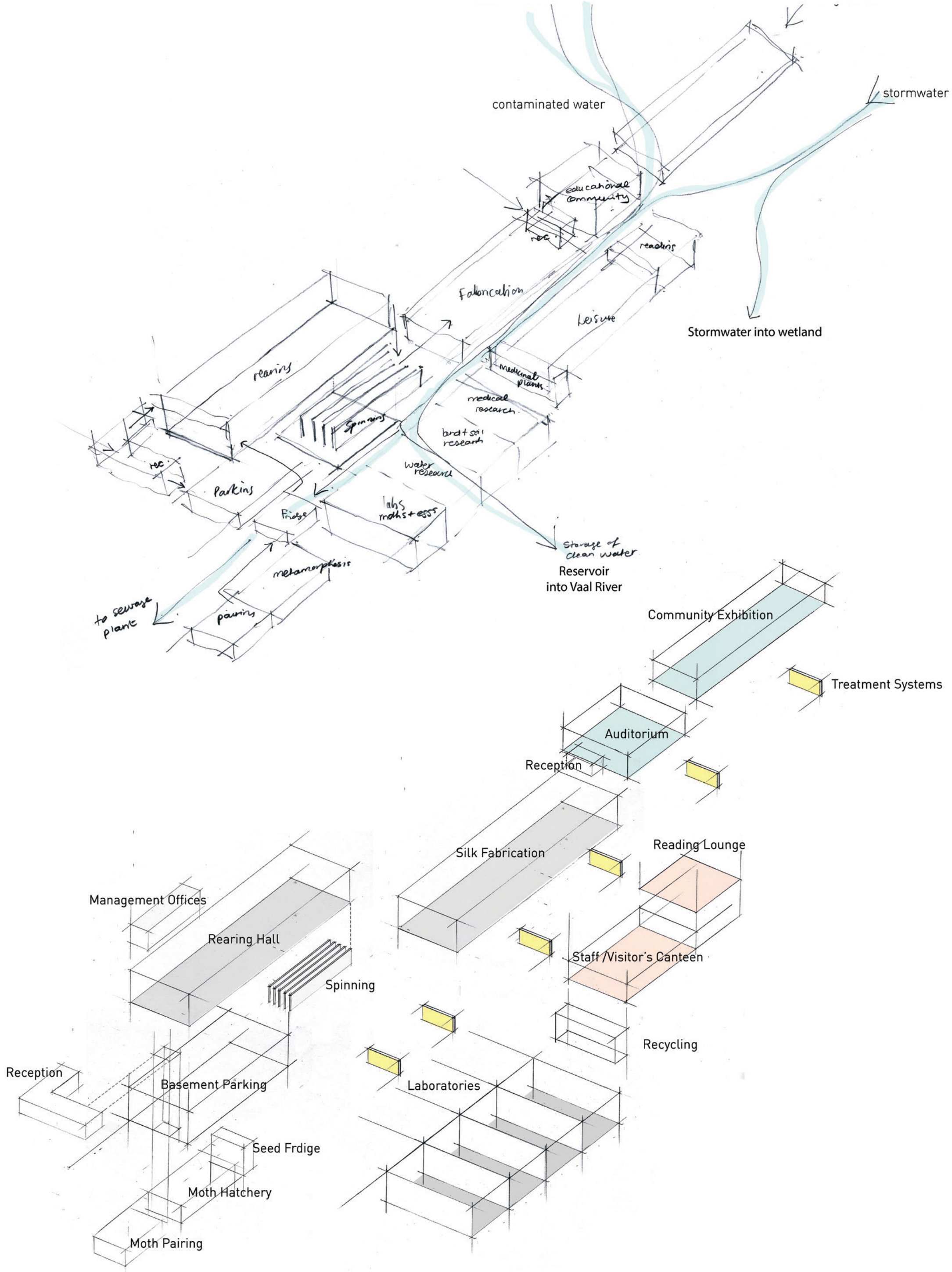


Figure 5.1: Programme and spatial planning. (Auathor,2016)

5.2
HEAVY METAL REMOVAL PROCESS

The industrial effluent and storm water will be stored in a detention dam which will regulate the water entering the revolving algal biofilm. The contaminated water remains in the troughs with the revolving algal biofilm for a complete cycle which will remove the heavy metals from the contaminated water. The metal free water will then enter a constructed wetland – this wetland also deals with the buildings grey water. The treated water will then flow directly into the river.

The plants selected for the constructed wetland system in the facility will be a secondary, redundant treatment method for the removal of heavy metals using the process of phytoremediation.

The intention is for the phytoremediation plants to become an established, dense network, which can replace the algae treatment method if a crisis arises or maintenance needs to be done on the algae system. The phytoremediation plants will be used as an experimental ground for research and community educational platform.

5.3
SYSTEMS LABORATORIES

Four different Laboratories are required:

1. Algae Culturist Laboratory
The growing of algae takes place in the laboratory. Testing and samples of metal resistant strains ensure the optimal performance of the system.

2. Silkworm Geneticist Laboratory
The moths required for mating and laying eggs are tested for diseases. The eggs laid by the selected moths are also tested to ensure the batch will produce good quality silk.

3. System Ecologist Laboratory
The plants, insects and micro-organisms are all monitored and tested to ensure a holistic system is working efficiently.

4. Hydrologist Laboratory
The quality of the water is tested and monitored to ensure the metal removal processes are working effectively.

5.4
BIOFILM FABRICATION

The programme for silk production includes:

1. Rearing Hall
The growth of the silkworms from 1st to 5th phase begins when the eggs enter the rearing hall. The hatching of the eggs takes place in complete darkness and then the eggs are exposed to moderate light. The silkworms are placed on trays, monitored and fed as they grow through phases 1-5. Each successive phase requires more tray space as the silkworms grow, from 18 to 360 trays - practically increasing the space requirement and employees needed for the management of the silkworms life cycle. The trays are 1.2x0.9m, the size allows the rearers to clean and move the worms easily.

2. Spinning
At the end of phase 5 the silkworms are placed on screens to spin cocoons which are harvested. The 1.8x1.2m screens have small compartments for each worm and are hung from the ceiling structure.

3. Grainage Hall
Cocoons enter the grainage hall for reproduction, the moths mate and lay eggs for the next cycle of silk production.

4. Reeling and Weaving Room
This is where the cocoons are processed for the weaving of the cocoons into fabric and the fabrication of the biofilms.

Figure 5.3: Spinning of coccoons. (Women in Sericulture,2016)

Figure 5.4: Soaking of coccoons. (Women in Sericulture,2016)

Figure 5.5: Reeling of coccoons. (Women in Sericulture,2016)

The spaces required involve specific considerations:

1. Rearing Hall
The silkworms are reared in a rearing hall, special care is taken to ensure the environmental conditions of temperature and humidity are kept within the recommended values. The process is relatively sensitive as both temperature and humidity affects the quality of the cocoon. The silkworms release CO_2, requiring proper ventilation to keep these toxic gases at a low level and to ensure that the silkworms do not experience any growth retardation or abnormalities. Silkworms are photosensitive to light, it is imperative that the hall caters for indirect, moderate lighting to encourage optimal growth cycles.

2. Spinning
When worms enter into their 5th phase, close to the time of spinning, they become more sensitive to the elements; temperature, humidity, light. The spinning phase requires that respective conditions should be optimal and moderate. The halls would need close monitoring of the elements, as these effect the worm's growth, spinning rate and strength of the silk filament.

3. Reeling and Weaving Room
Requires a large open area for the machinery used for soaking and processing of the cocoons. An automated reeling machine is used to convert the coccoons threads onto reels which is used to make the fabric. The making of the biofilm's custom sized film from the silk fabric produced will require a workbench and sewing machines.

4. Grainage Hall
A grainage hall is necessary for the pairing and laying of eggs. The grainage hall's location within the facility should be accessible from the geneticist laboratory as well as spinning room. The moths selected for the next cycle are tested in the labs for diseases which would affect the eggs/seeds. Unsuitable moths and eggs are incinerated to stop the spread of the disease. The moths prefer dim light for mating. After the eggs/seeds are laid, they too are tested for diseases before they are frozen. The grainage hall should have a large fridge for the storage of the eggs. (Rahmathulla, 2012: online)

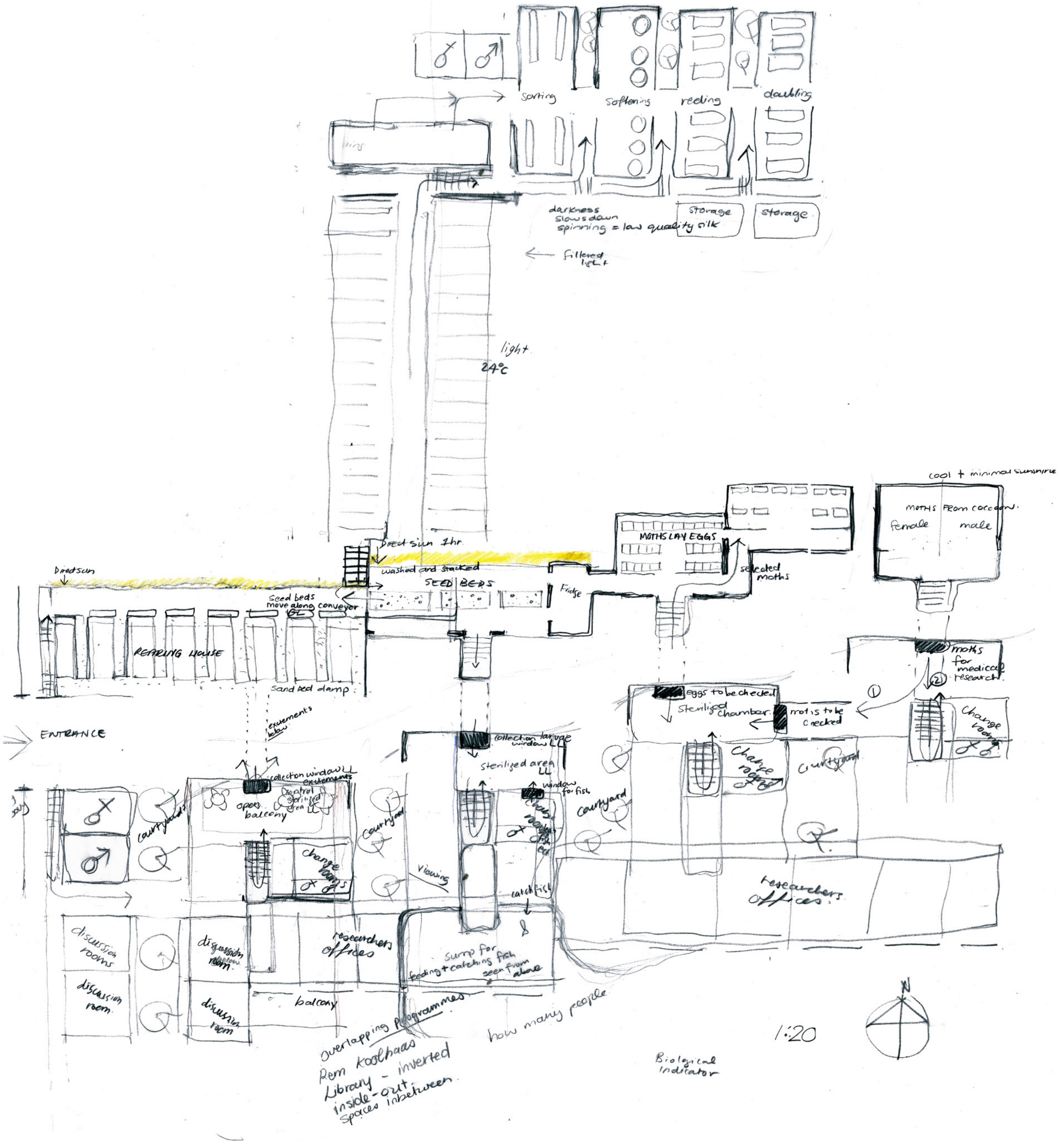


Figure 5.2: Diagram of spaces needed for silk production. (Author, 2015)

5.5
COMMUNITY DEVELOPMENT

The women from Bophelong will be responsible for the rearing of the silkworms and the fabrication of silk for the biofilm. The community auditorium is accessible to the public, and the exhibition hall also functions as the overflow area which is available for community talks, exhibitions and community events.

5.6
CANTEEN & LEISURE

The visitors and employees have access to a large canteen and lounge area for lunch and tea during their visit or daily routine.

5.7
SCHEDULE OF OCCUPANCY

Silkworm Rearers -60 workers
Biofilm Fabrication -10 workers, 1 manager
Algae and Wetland System – 7 workers, 1 manager
Researcher Department -4 scientist, 1 receptionist
Canteen/Leisure – 7 workers, 1 receptionist
Permanent Employees = 92 people
Learners and Visitors – 50 guests

*Refer to Annexure A for a breakdown of the detailed occupancy schedule.

5.8
TRANSPORT

Of the 92 permanent employers, 80-90% are expected to use the existing pedestrian footpaths and public transport as they will be employed from the adjacent community of Bophelong which is within a 3km radius. The facility will make provision for transport infrastructure on site for visitors, employees and local community to easily access the public facilities. Basement parking will be provided for 10-15% using vehicles and additional visitor parking will be provided on ground level within walking distance from the facility.

5.9
ABLUTIONS & SERVICES

The occupancy classification according to SANS 10400 is as follows:

A2- Canteen, Community auditorium and exhibition hall
D1 - Offices
F2- Silk fabrication, rearing hall and laboratories

TABLE 6

1	2	3	4	5	6
For a population of up to —	Number of sanitary fixtures to be installed relative to the population given in Column 1				
	Males			Females	
	WC pans	Urinals	Washbasins	WC pans	Washbasins
15	1	1	1	2	1
30	1	2	2	3	2
60	2	3	3	5	3
90	3	5	4	7	4
120	3	6	5	9	5
	For a population in excess of 120 add 1 WC pan, 1 urinal and 1 washbasin for every 100 persons			For a population in excess of 120 add 1 WC pan for every 50 persons	For a population in excess of 120 add a washbasin for every 100 persons

Figure 5.6: Table 6 - Ablution requirements. (SANS 10400,2011)

06

CHAPTER SIX

DESIGN DEVELOPMENT

6.1
INTRODUCTION

The design development is a response to the theory of regenerative thinking which attempts to integrate the understanding of the site as well as the programmatic requirements and the natural systems explored.

6.2
CONTEXTUAL INFORMANTS

The main design informants are the flow of the contaminated water through the site and the existing wetland. Figure 6.1 illustrates a model constructed during one of the first workshops expressing an intuitive design response to the site's natural landform and architectural concept of intercepting the landscape to heal the polluted condition. The first response was to have the contaminated water flow under the building, but as the research developed into processes and spatial requirements this concept evolved into the contaminated water running through the length of the building, becoming the spine. The three primary conceptual intentions developed as follows:

1. The landscaped dam as an urban filter
2. The phytoremediation wetland spine
3. A resilient algae and wetland spine

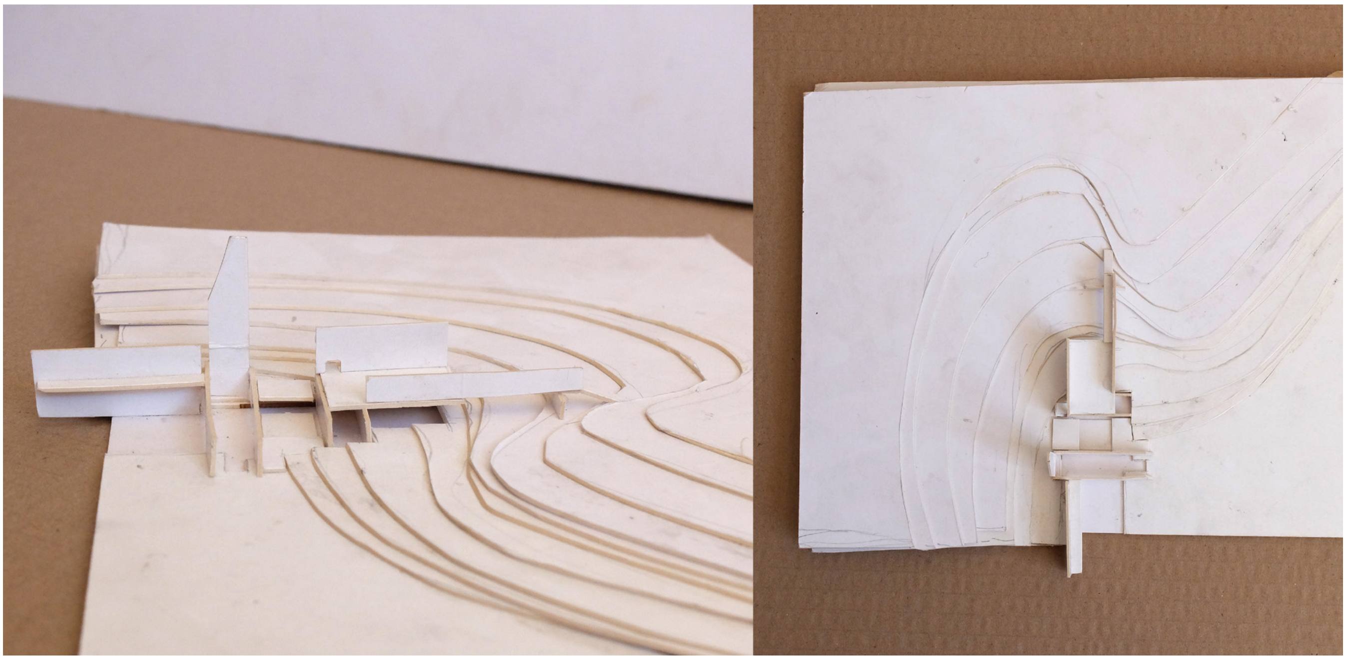


Figure 6.1: Model constructed during February workshop. (Author, 2016)

6.3
DESIGN PRECEDENT
SOCIETY & INFRASTRUCTURE

The Living Dam proposal is a response to the United Kingdom's water crisis where the government proposes a series of reservoirs that will maintain hydrological self-sufficiency. The Living Dam is a new typology constructing a dam, moving away from the image of hydrological infrastructure as a solitary object. It becomes a model which is integrated with society assisting to alter the public's perception of dams and dam management. The dam's hydrological network becomes a vital system that supports social and ecological aspects of the design. The dam is integrated into its environment to accommodate people, plants and the opportunity for new ecosystems to emerge.

THE LIVING DAM
The Bartlett School Of Architecture,UK
By Louis Sullivan 2014

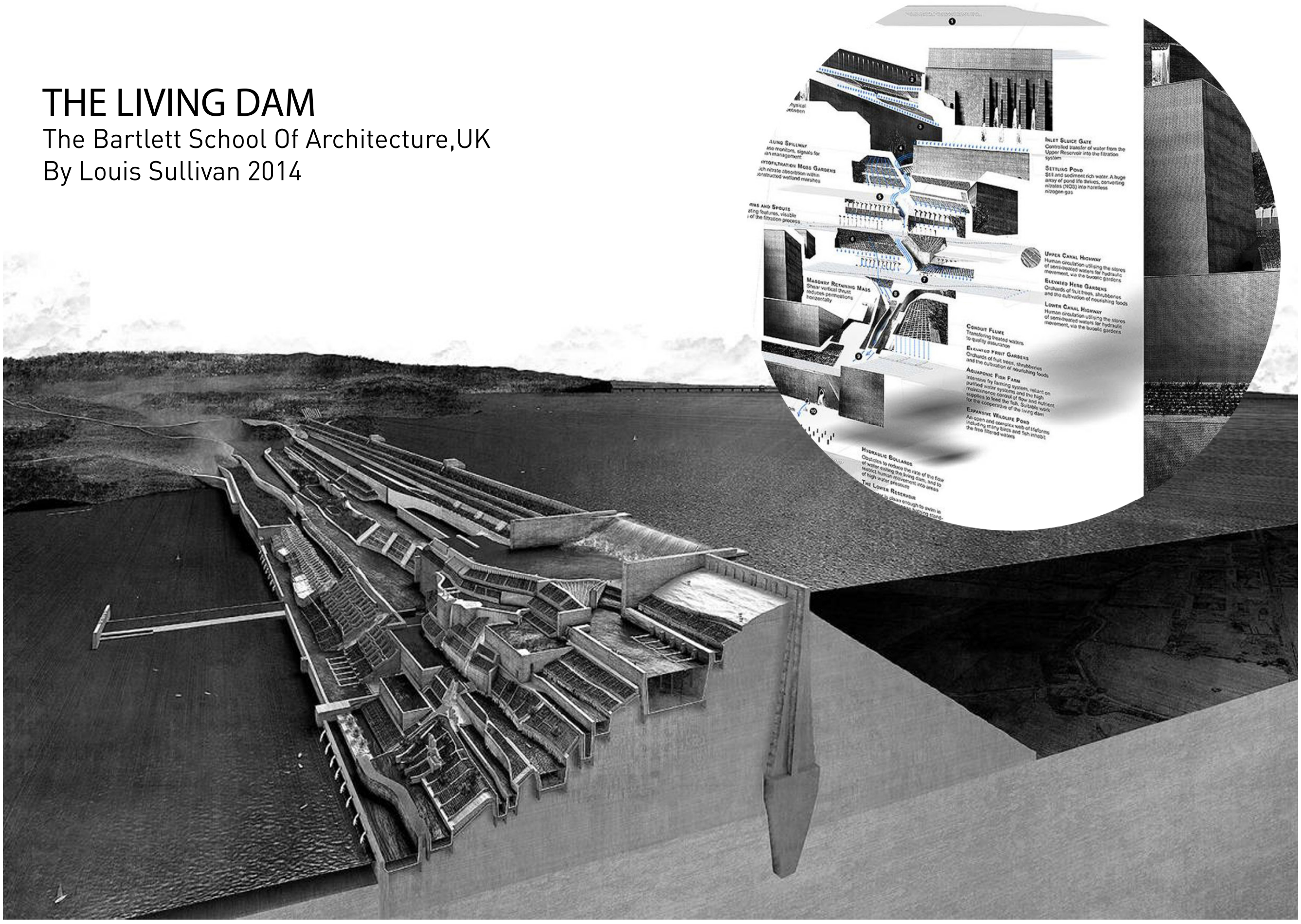


Figure 6.2: The Living Dam (The RIBA President's Medals Student Awards, 2014)

1 DESIGN ITERATION

THE LANDSCAPED DAM AS AN URBAN FILTER

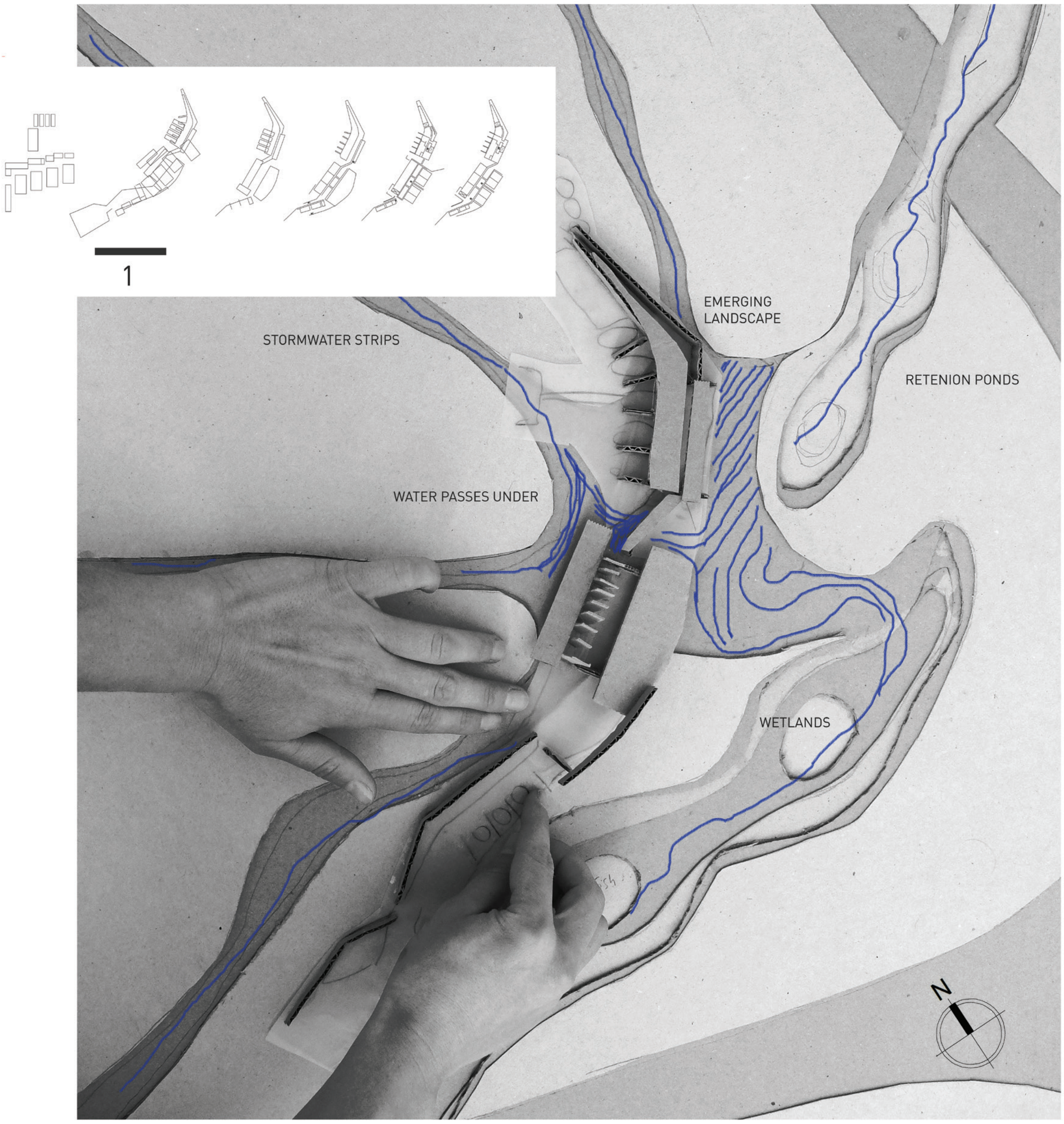


Figure 6.4: Model constructed for iteration 1. (Author, 2016)

6.3
ITERATION 1
THE URBAN FILTER

The design's intention is for the new infrastructure to be integrated into the landscape as a dam collecting the industrial effluent. A conventional planted wetland catchment is proposed to accumulate, purify and direct the water under the facility through an urban filter. The author researched the properties of silk as a removable, biodegradable filter for the removal of heavy metals from the water. The contaminated water passes through the wetland and silk filter under the building with the supportive functions of the facility above the contaminated water.

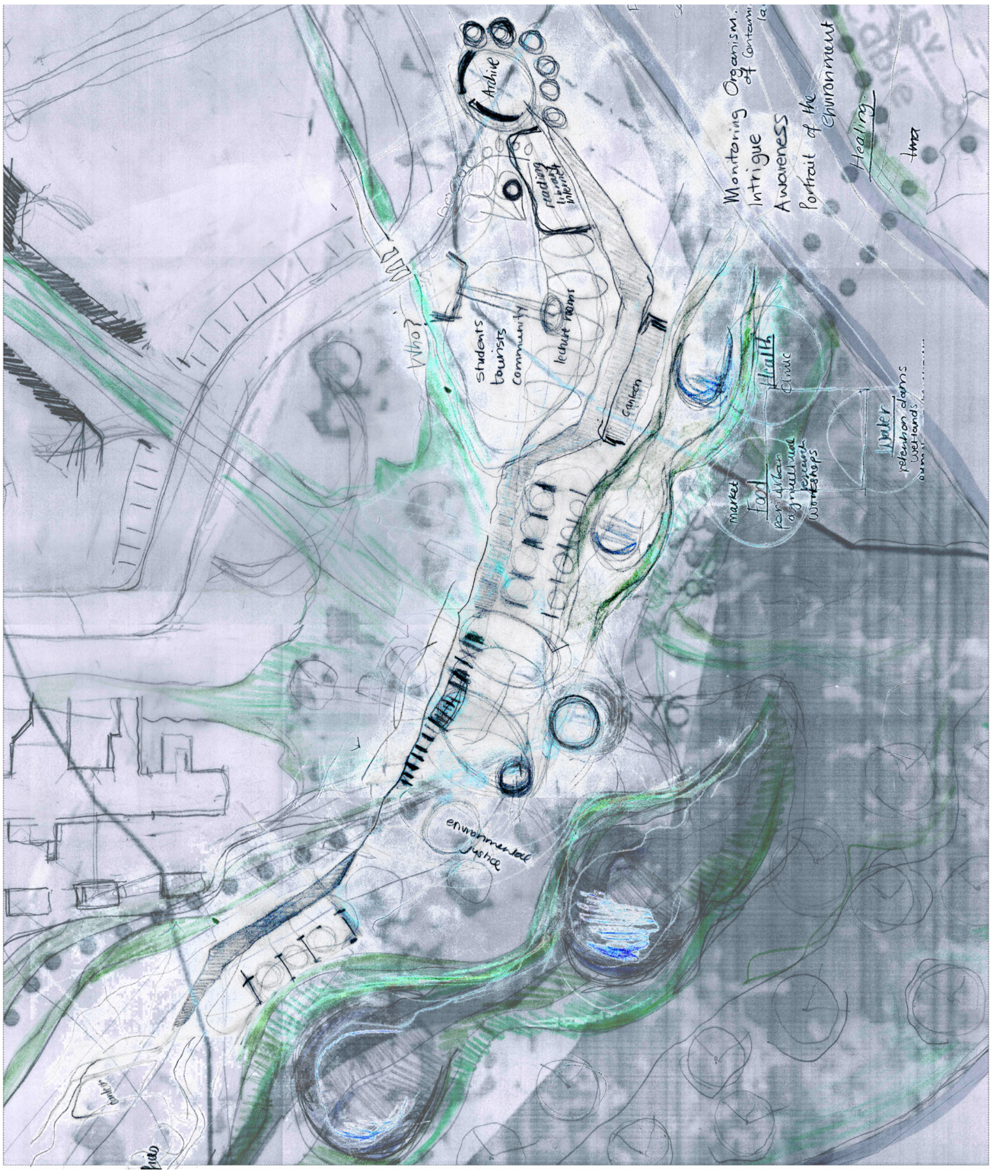


Figure 6.3: Site plan sketch responding to existing wetland. (Author, 2016)

Understanding that led to the next iteration:

Iteration 1 requires an understanding of the community's involvement. The precedent set by The Living Dam integrates infrastructure and social activities as a holistic system.

The process of heavy metal removal requires more than a planted wetland catchment and silk filter. At this point the author researched the bioremediation process called phytoremediation to understand how heavy metals can be mechanically removed from contaminated water.

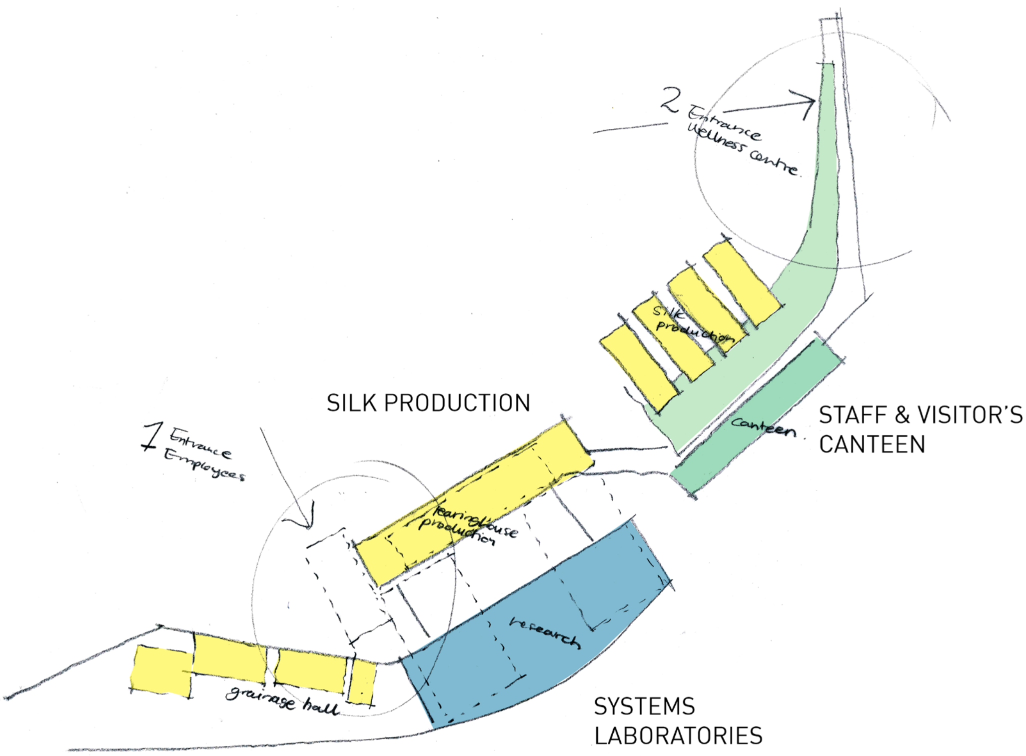


Figure 6.7: Iteration 1 area zoning of the water treatment facility - water flowing under the building. (Author, 2016)

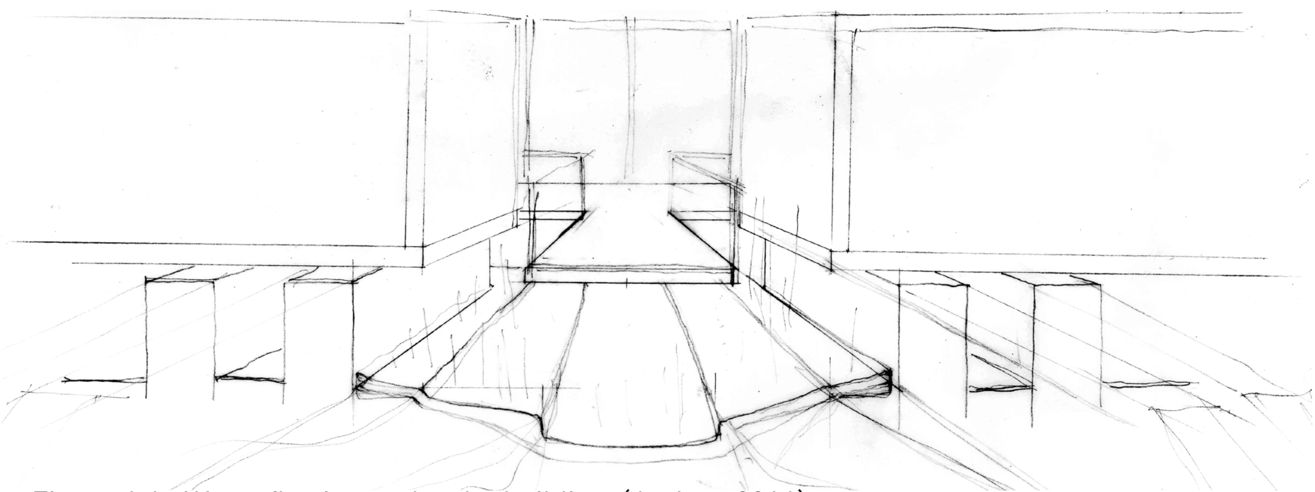


Figure 6.6: Water flowing under the building. (Author, 2016)

6.4
DESIGN PRECEDENT
A HABITAT INFRASTRUCTURE

The Institute for Forestry and Nature research merges nature and man in a new constructed habitat. A design strategy was developed which used the few remaining ecological qualities of the landscape to create a diverse new habitat which could accommodate both insect and animal species as well as the organizations staff. The building was designed to embrace its rural setting by including trees, alleys, hedges, berms, ponds, swamps and water channels to create intricate microclimates which support the ecosystem. Indoor water gardens provide a tranquil setting for meeting areas and serve as the lungs of the building, improving the performance of the external envelope. The designers chose to use standard mass produced roofs traditionally used for horticultural greenhouses, that costs 75% less than custom-made roofs. The building is highly flexible - capable of adapting to the changing requirements of the Institute.

INSTITUTE FOR FORESTRY & NATURE RESEARCH
NETHERLANDS
By BEHNISCH ARCHITEKTEN, 1998

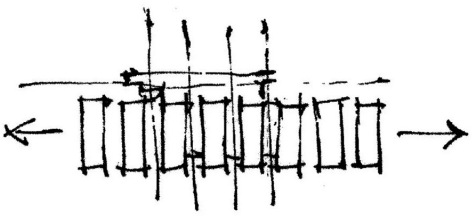
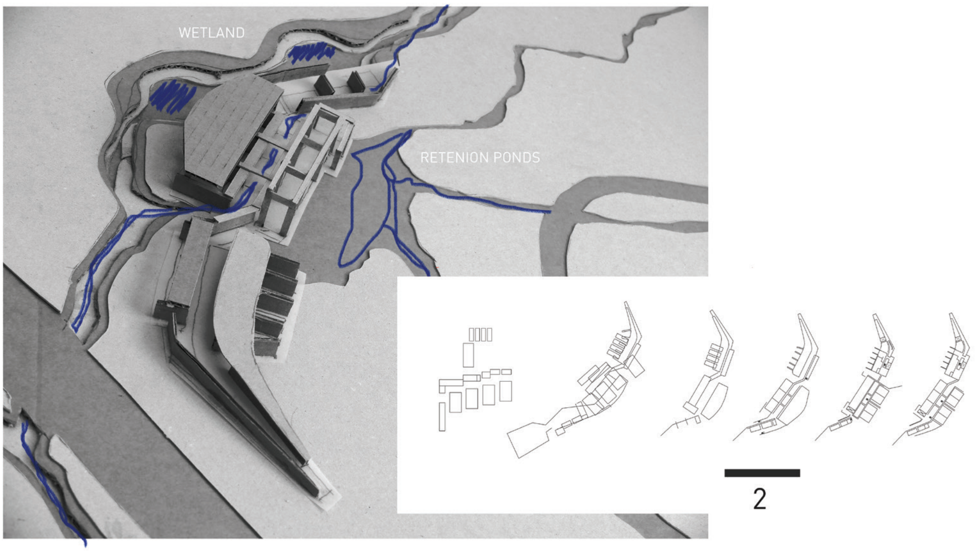


Figure 6.7: Institute for Forestry and Nature Research (Divisare, 2016)

2 DESIGN ITERATION

THE PHYTOREMEDIATION WETLAND SPINE



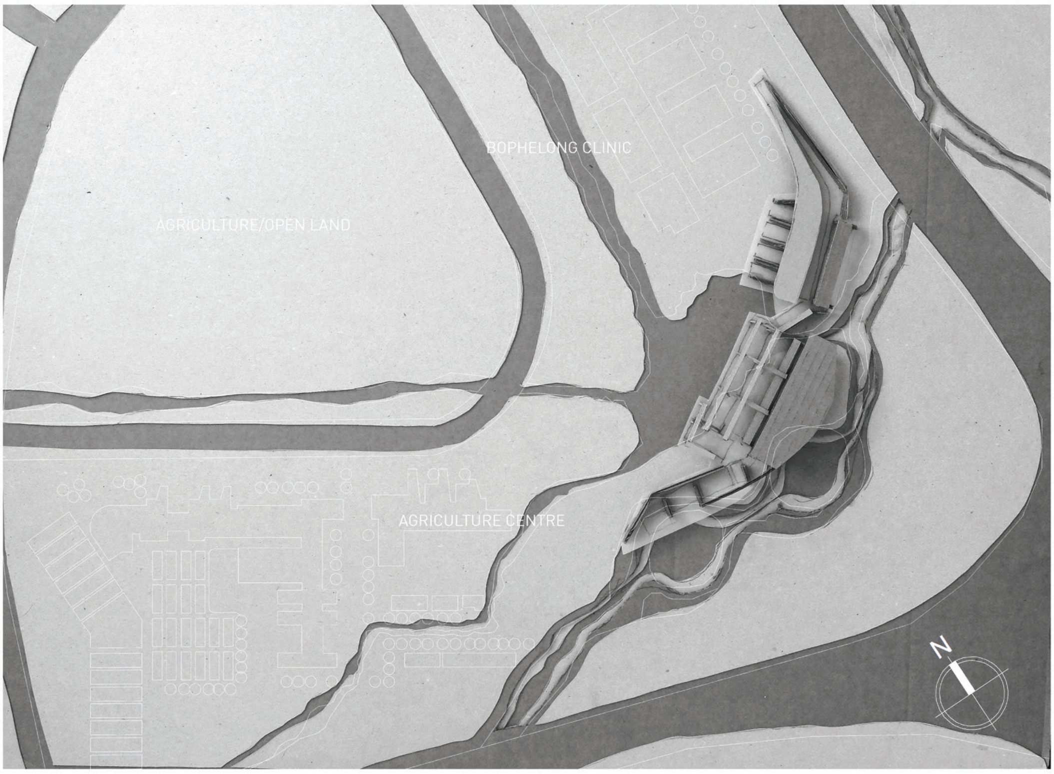
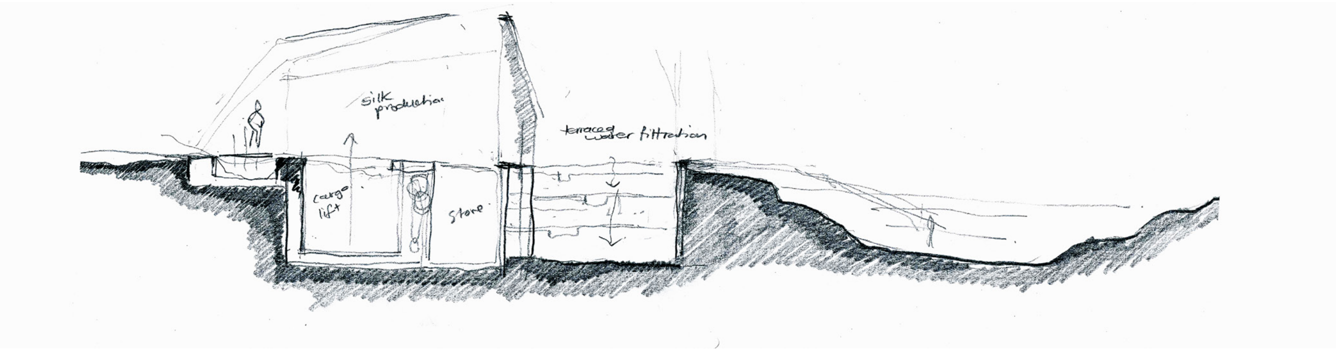


Figure 6.10: Model constructed for iteration 2. (Author, 2016)

6.5
ITERATION 2
PHYTOREMEDIATION WETLAND SPINE

The design development evolves with the knowledge of the potential of plants to remove the heavy metals, as well as the precedent study on The Institute for Forestry and Nature Research which integrates a constructed wetland within the envelope of the research facility. Iteration 2 focuses on revealing the treatment of the water, making it visible to the users of the facility. The spine of the facility is developed into a series of wetlands hosting phytoremediation plants that serve the purpose of accumulating heavy metals from the water. The community members have access to the facility and can move freely along the walkways connecting the supportive programmes of the facility.



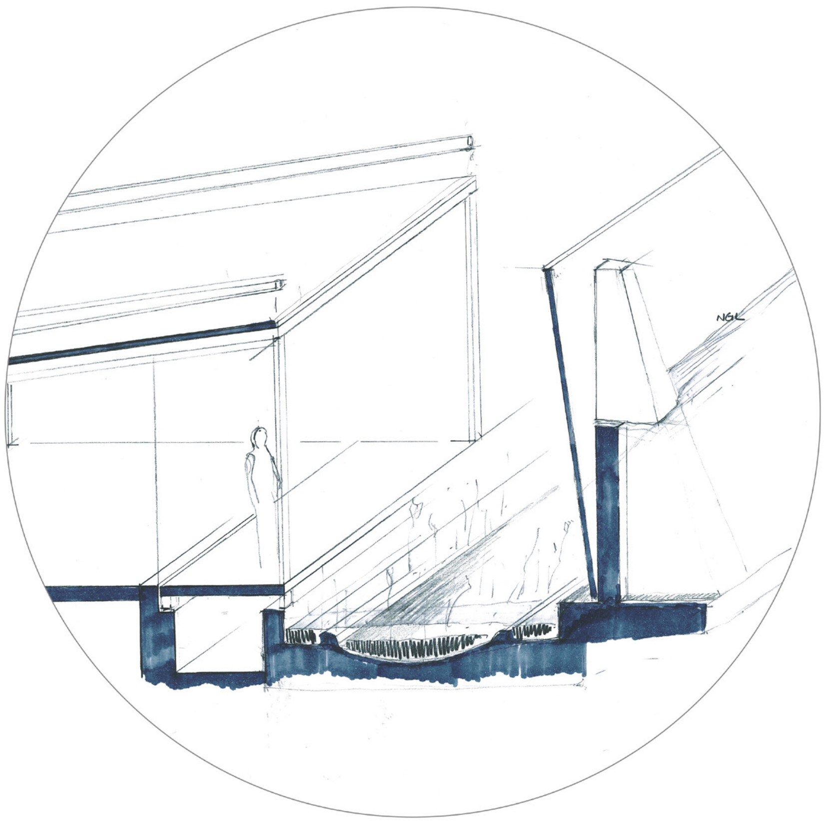


Figure 6.8: Integrated water treatment wetland. (Author, 2016)

Understanding that led to the next iteration:

Large quantities of water from the summer high rainfall period will flow too fast for the plants to perform their function. The facility will need an integrated detention dam that will regulate the water's speed, slowing it down for the removal of heavy metals by the plants.

The process of phytoremediation as an alternative infrastructure results in the accumulation of heavy metals on the plants roots which requires the entire plant to be harvested to ensure the contaminants don't enter the river network. High volumes of water will undermine the process of heavy metal removal as the contaminants would become dislodged from the phytoremediation plant's root structures. A natural treatment method that immobilizes and contains the heavy metals is required.

Figure 6.9: Ground floor planning for Iteration 2. (Author, 2016)

3 DESIGN ITERATION

A SELF-REPLENISHING ALGAE AND WETLAND SYSTEM

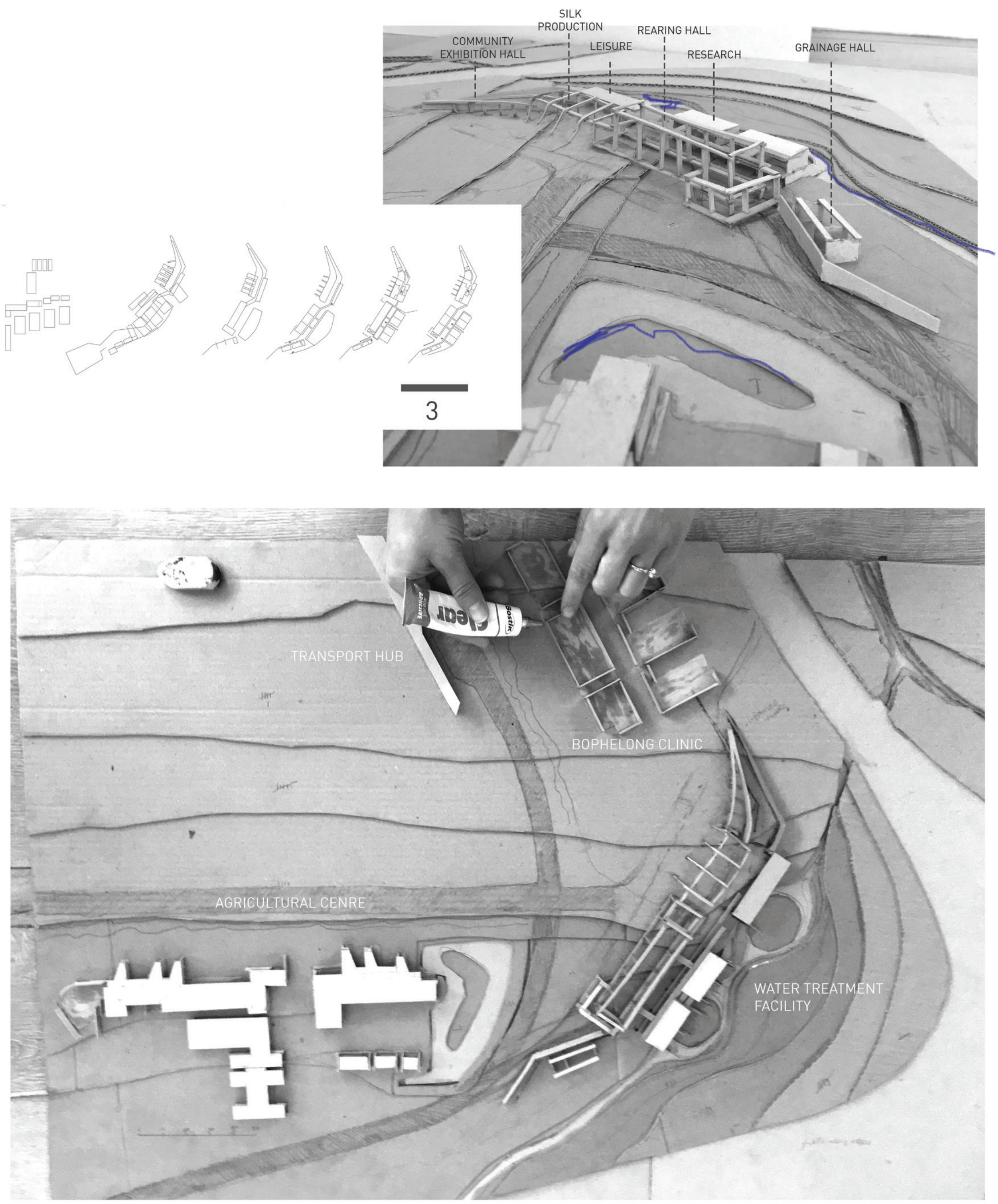


Figure 6.13: Model constructed for iteration 3. (Author,2016)

6.6
ITERATION 3
A RESILIENT SYSTEM

An understanding of the challenges linked to phytoremediation led to a more efficient method of heavy metal removal. A metal resistant algae water treatment method replaces phytoremediation as the primary method to remove heavy metals. Phytoremediation plants are incorporated into the wetland design s a supportive, backup heavy metal removal method.

The infrastructure is expressed as a constructed landscape form with the water treatment occurring in sub-system throughout the facility. The detention dam and network of water regulation direct the flow of water into the algae treatment troughs which flow into wetlands and into the river. All the supporting functions required for the new infrastructure, sit on either side of the spine and create rhythm throughout the building. The design evolves to accommodate the gradient of the site, and the landscape terraces down to create concealed basement parking.

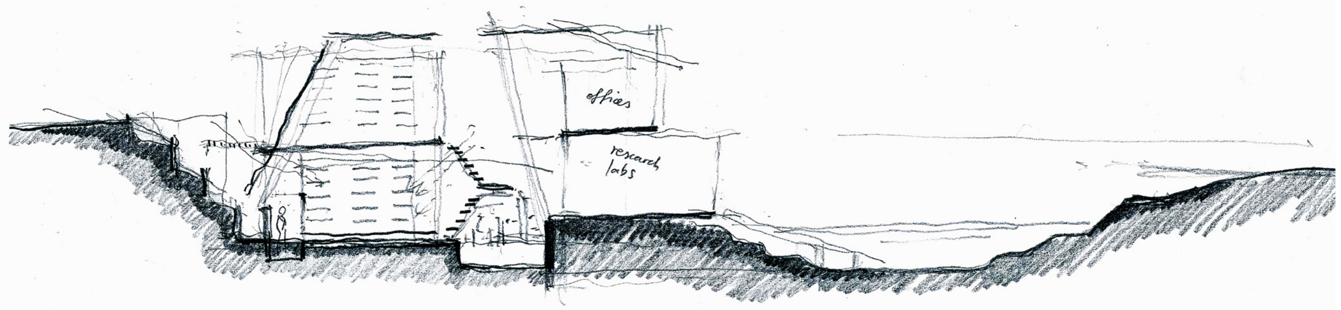


Figure 6.11: Sketch showing terraced landscape. (Author, 2016)

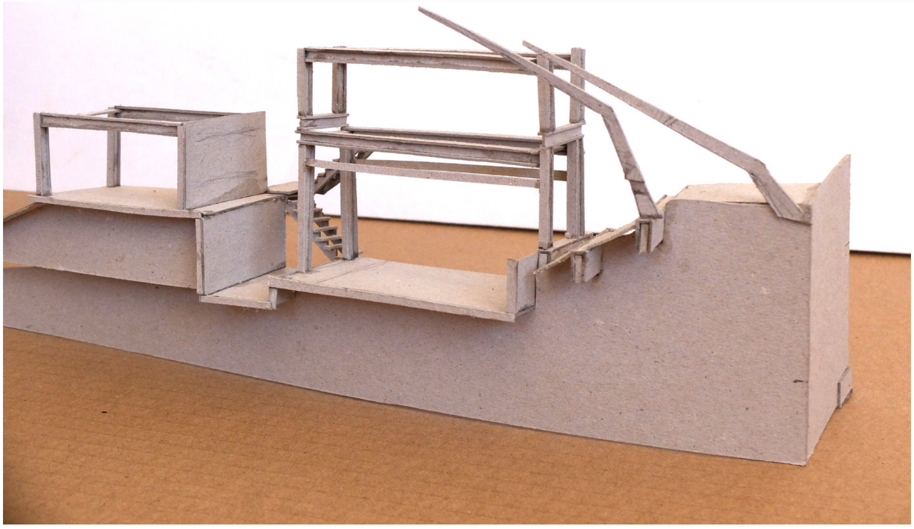
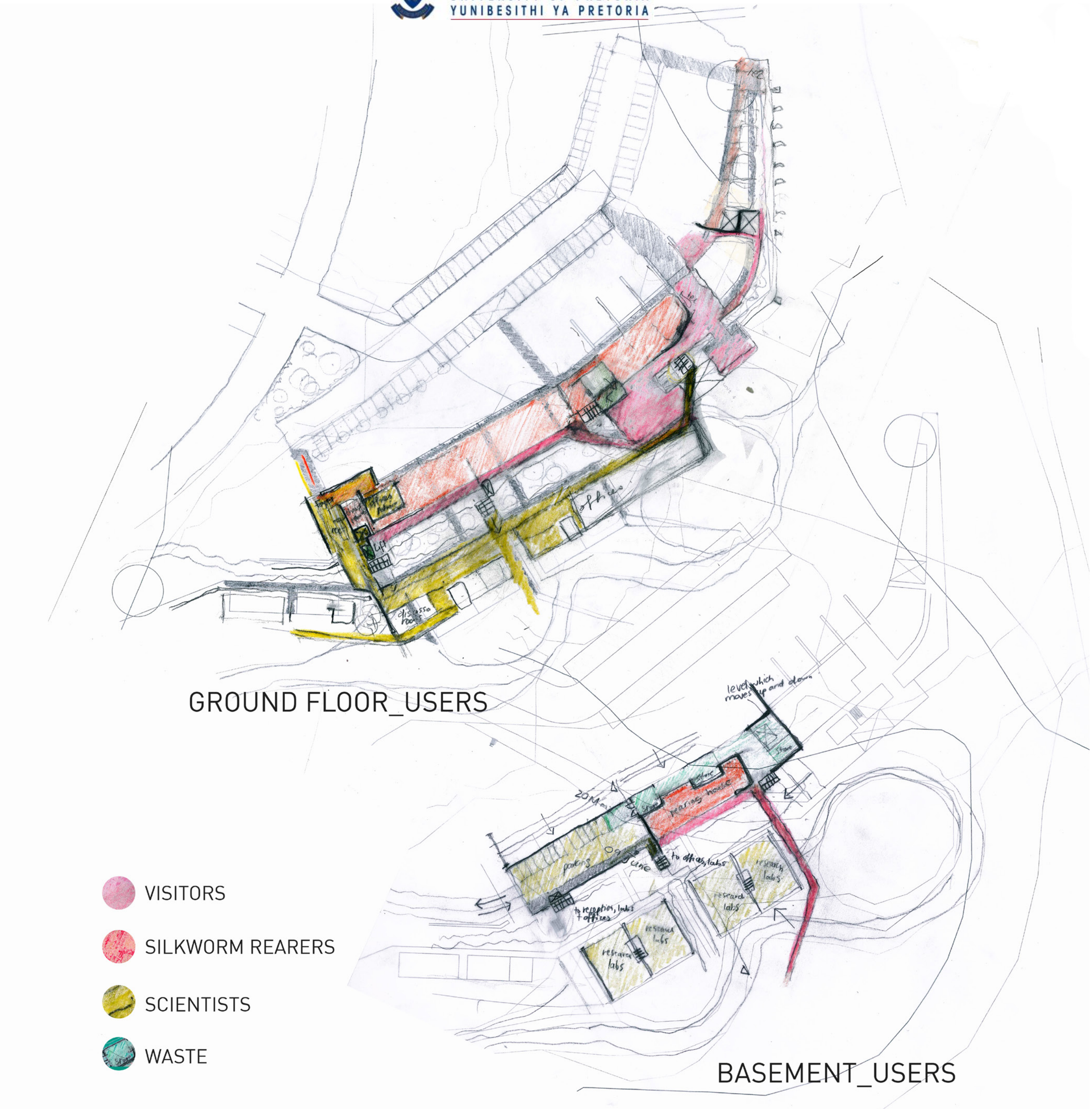


Figure 6.12: Model constructed for iteration 3. (Author,2016)



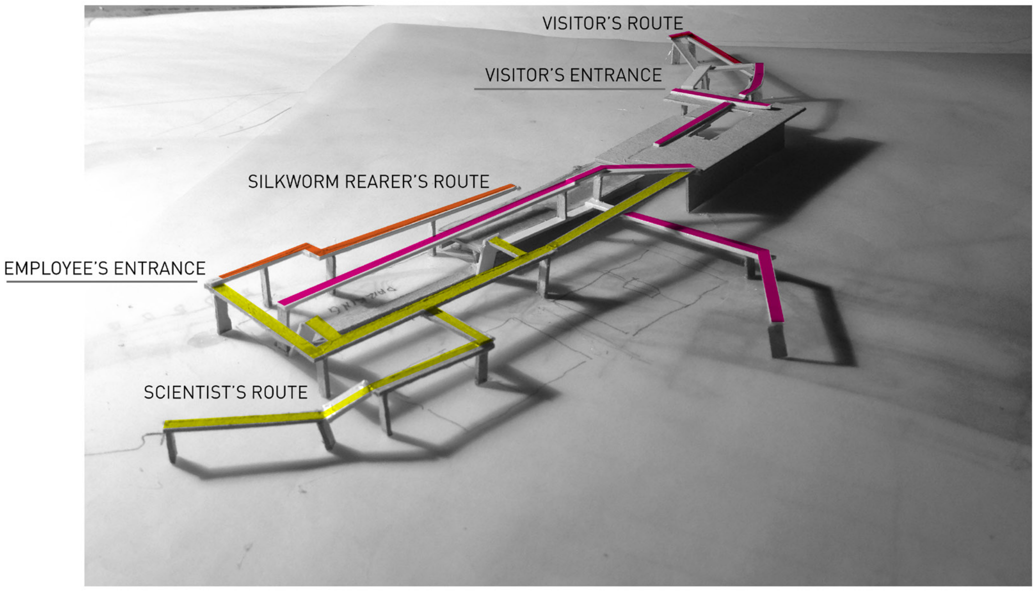


Figure: 6.19: User's movement diagrams. (Author, 2016)

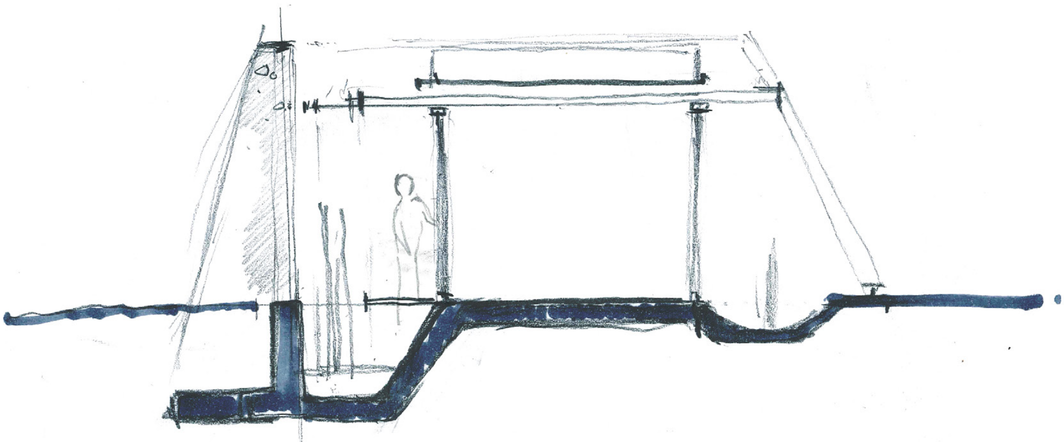


Figure 6.14: Section exploration of exhibition hall. (Author,2016)

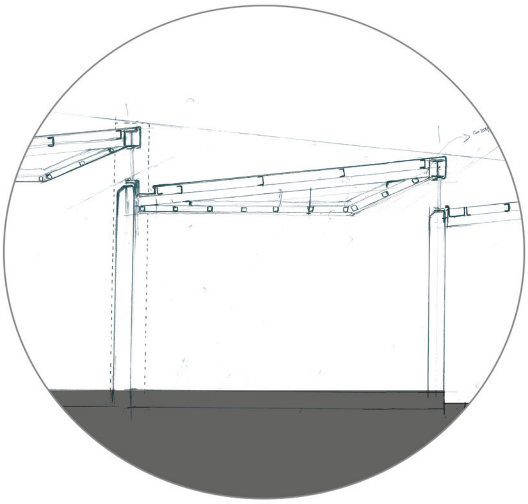


Figure 6.14: Section exploration of exhibition hall roof. (Author,2016)

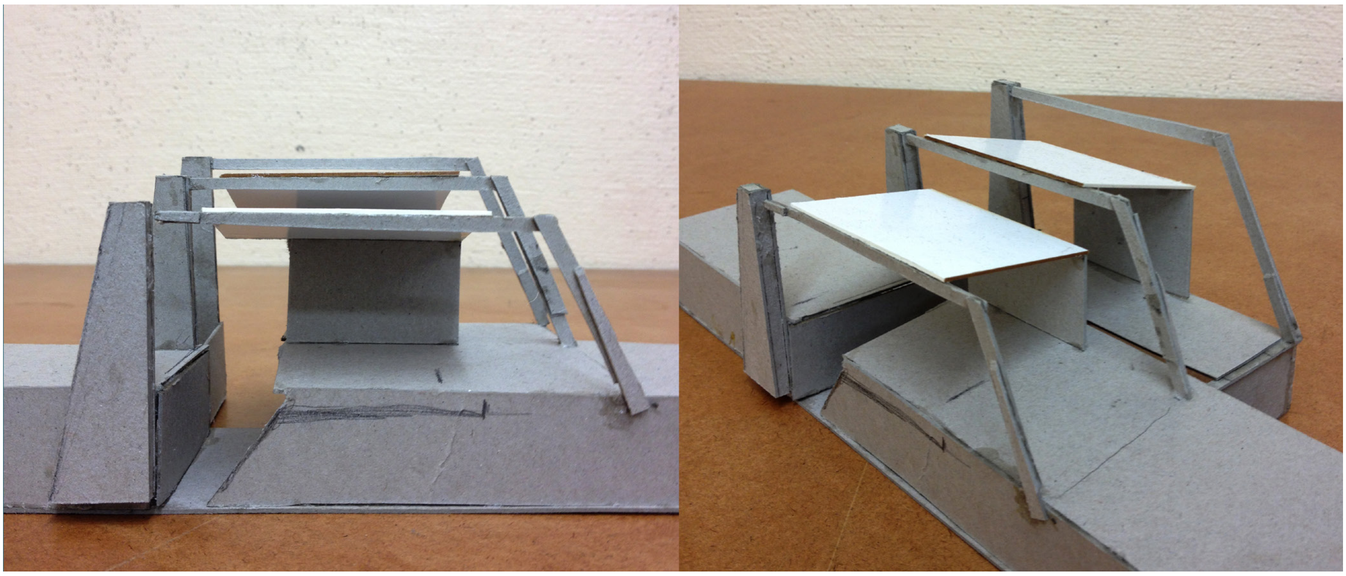


Figure 6.15: Model roof exploration for exhibition hall. (Author,2016)

4 DESIGN INTENTION

A HOLISTIC SOCIAL-ECOLOGICAL RESILIENT APPROACH

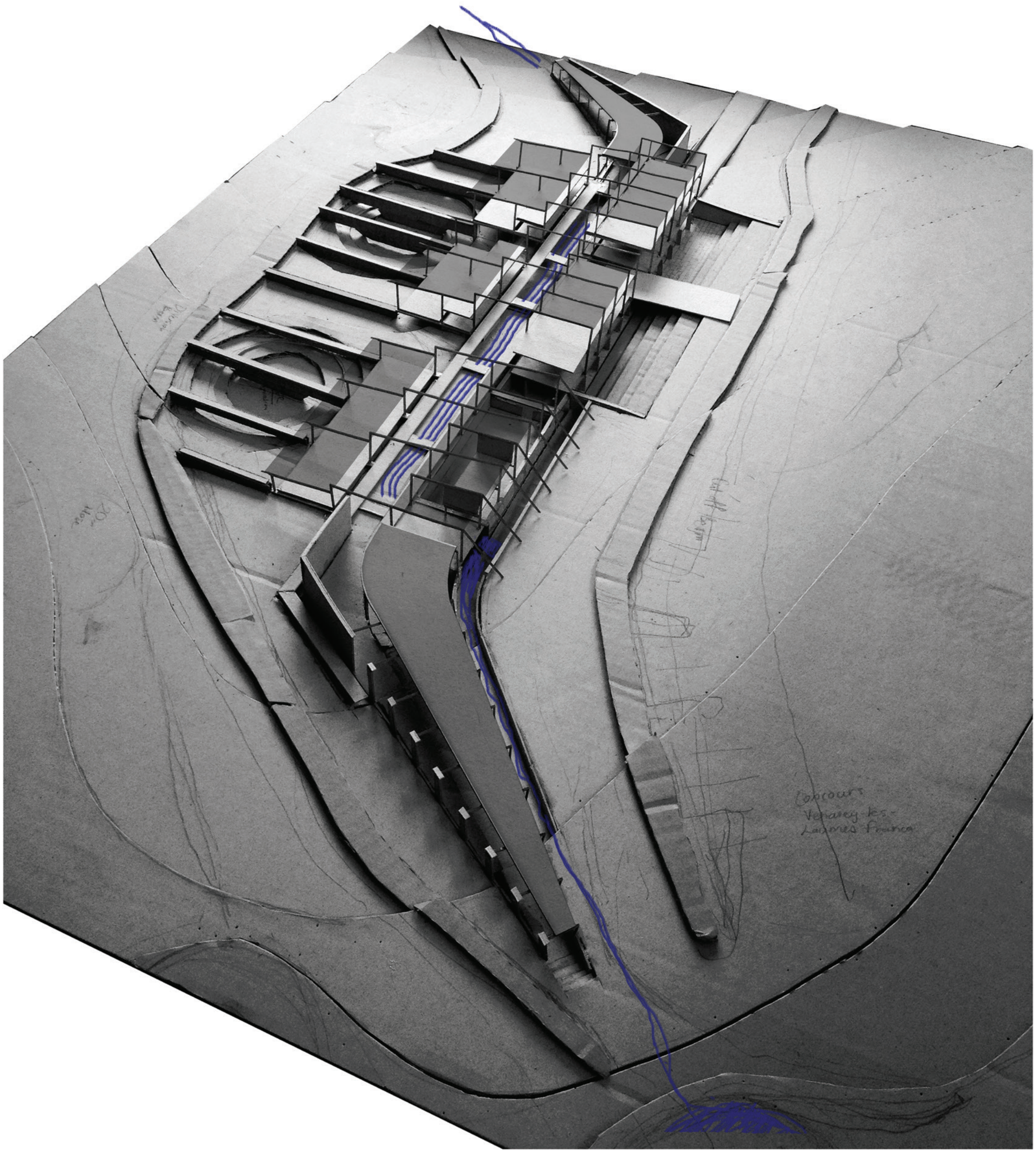


Figure 6.17: Model constructed for design summary. (Author,2016)

6.7

DESIGN SUMMARY
A SOCIO-ECOLOGICAL APPROACH

The final design's intention is to express the interconnected relationship between nature, the community and the remediation building. The walls gently rise from the ground creating a space for community involvement. The entrance has been placed on the existing foot route used by the Bophelong community. This is an informal entrance which allows community members easy access into the building to view exhibitions or sit in on talks. Ramps and walkways facilitate the visitor's freedom of movement through the facility, allowing them to seamlessly discover aspects of the entire treatment process, explore open spaces and utilise facilities such as the canteen and ablutions.

The exhibition hall is a space dedicated to the community, a tangible place for community to feel a sense of stewardship. The community art, photography, crafts and proposals can be presented in the exhibition hall.
The auditorium is intended as a meeting place where community members can discuss environmental issues and becomes a soapbox for the VEJA to share information with the community.

Figure 6.16: Model constructed community entrance for exhibition hall. (Author, 2016)

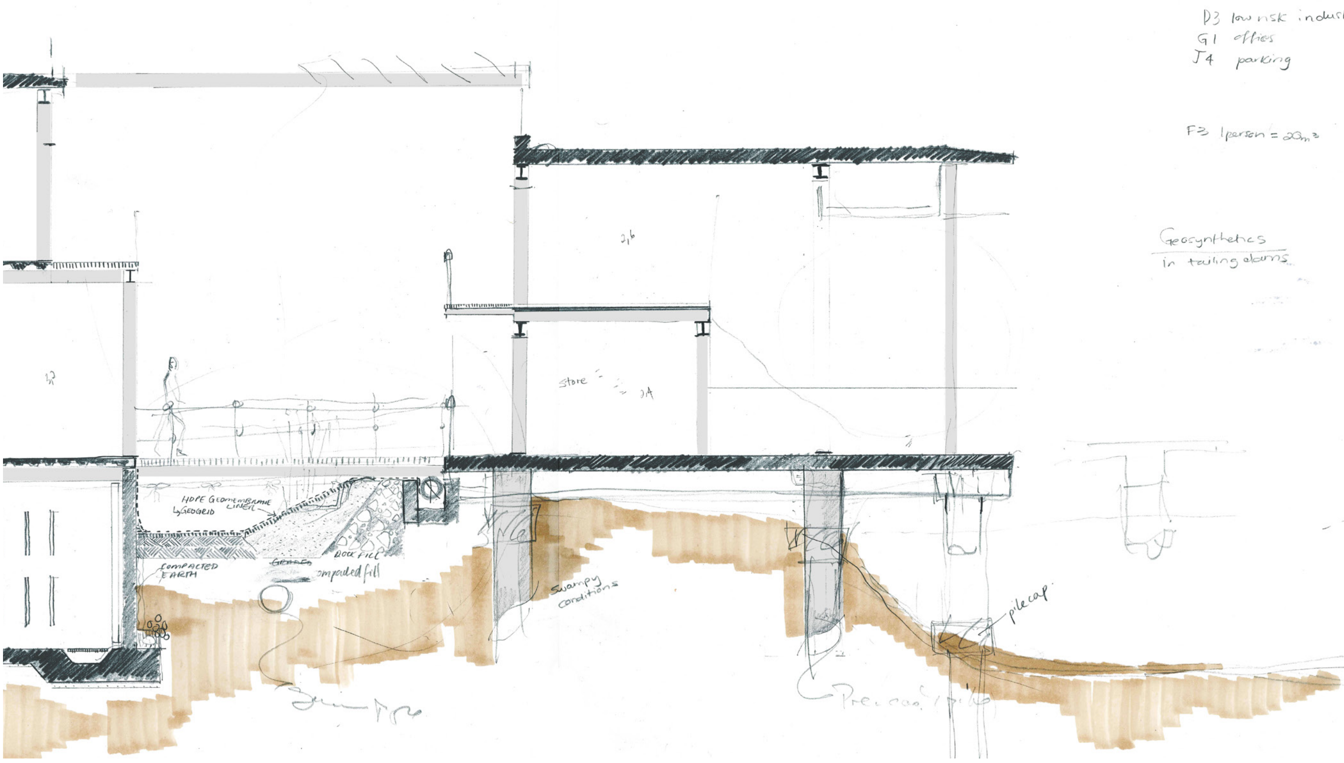


Figure 6.17: Section through wetland spine and laboratory .(Author, 2016)

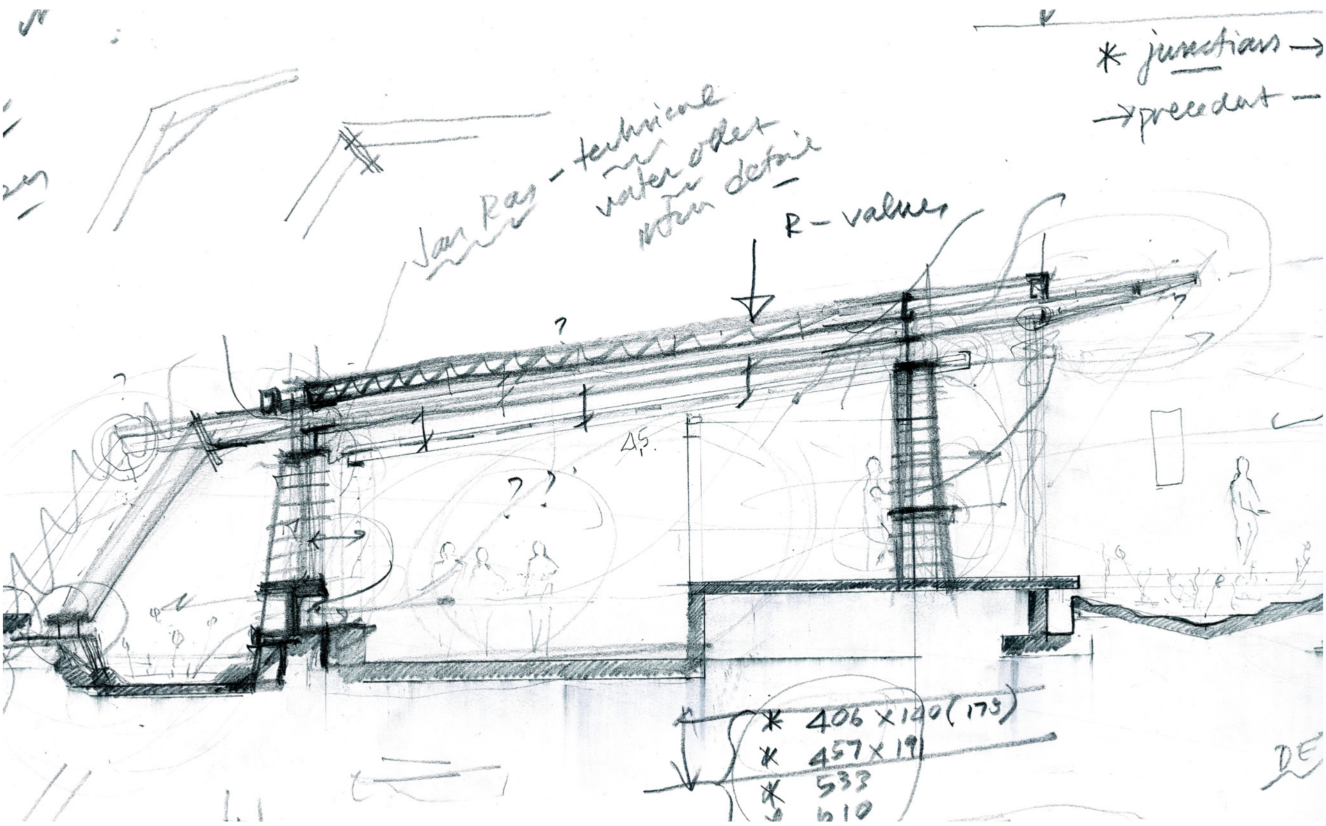


Figure 6.18: Silk fabrication and wetland section . (De Bruyn & Author, 2016)

MOVEMENT THROUGH THE FACILITY

The movement through the facility embraces both the flow of the contaminated water through the various remediation circulation channels, as well as community, visitor and staff pedestrian circulation through the facility.

Community member and visitor's entrance
The public's entrance is walking distance via pedestrian footpaths from the transport hub. Visitors enter with immediate access to the lounge and canteen with a view into the silk fabrication zone. The reception, auditorium, exhibition space and ablutions are all within immediate proximity.

Employees Entrance
The employees are divided into four groups:
1. The researchers/scientists
2. The algae workers and managers
3. The silkworm rearers and managers
4. The silk fabrication workers and managers

1.The researchers/scientists
Arrival in basement parking, stairs to reception on ground floor. Immediate access to laboratories, rearing hall, ablutions and canteen.

2.The algae workers and managers
Arrival at entrance on ground floor walking distance from transport hub. Immediate access to algae and wetland spine, ablutions and canteen. Open air meeting space. Manager's offices on upper level.

3. The silkworm rearers and managers
Arrival at entrance on ground floor walking distance from transport hub. Immediate access to change rooms, ablutions, rearing hall and canteen. Ramps connect all rearing hall spaces. Open air meeting space. Manager's offices on upper level.

4. The silk fabrication workers and managers
Arrival at entrance on ground floor walking distance from transport hub. Short walk to circulation core which provides access to silk workshop, ablutions and canteen. Manager's office's on mezzanine level.
Waste removal access

Services
Services are grouped and placed rhythmically along the spine. Separate services for visitors and employees. The canteen's service core includes the kitchen which produces waste which is removed and placed in a refuse bin yard to be collected by waste removal service. Organic waste is separated and added to the anaerobic bio digester. A ring road along the edge of the facility allows for the necessary waste removal and the anaerobic bio digesters sludge removal.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

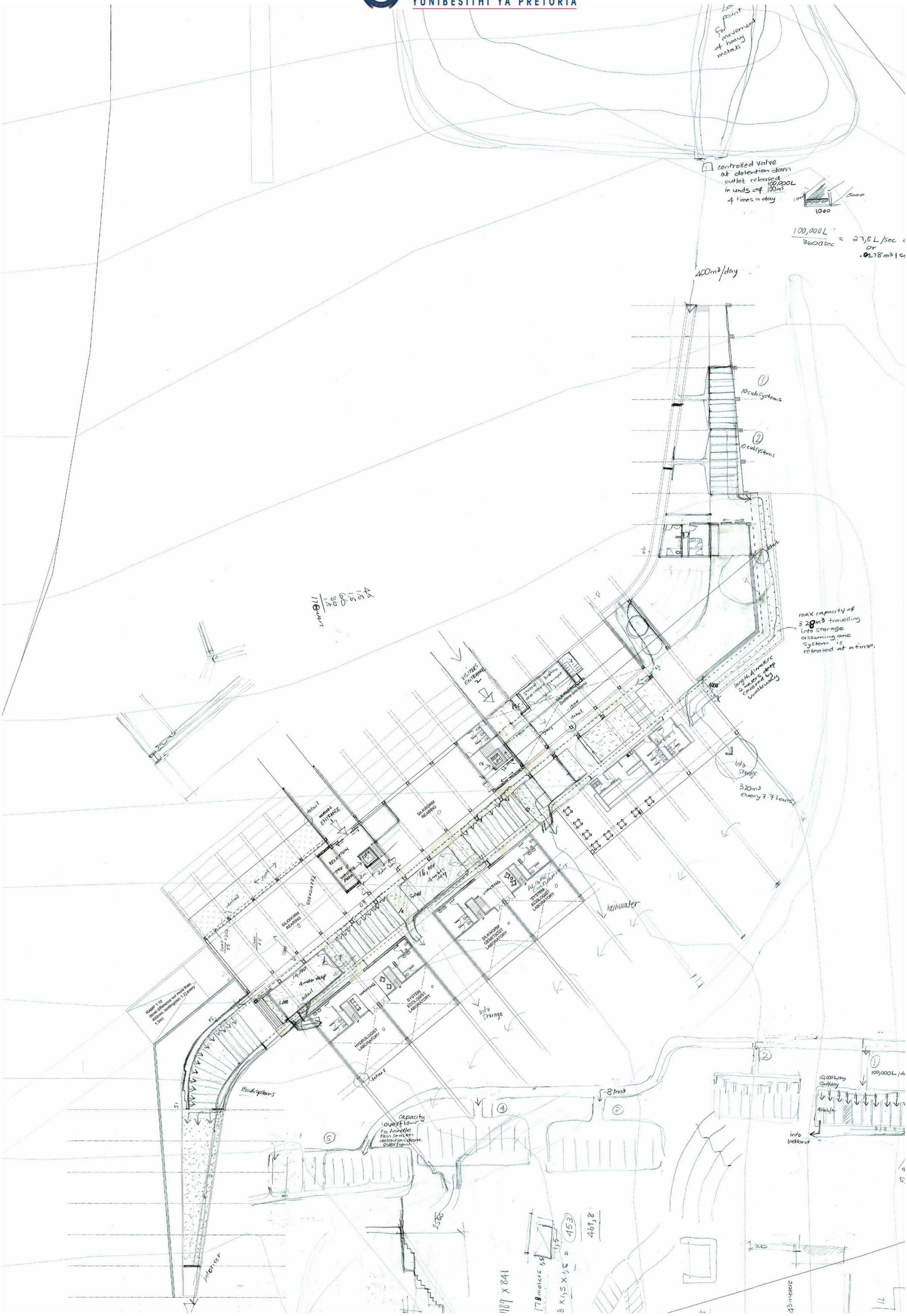


Figure 6.19: Ground floor plan showing the movement of the water through the processes. (Author, 2016)

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

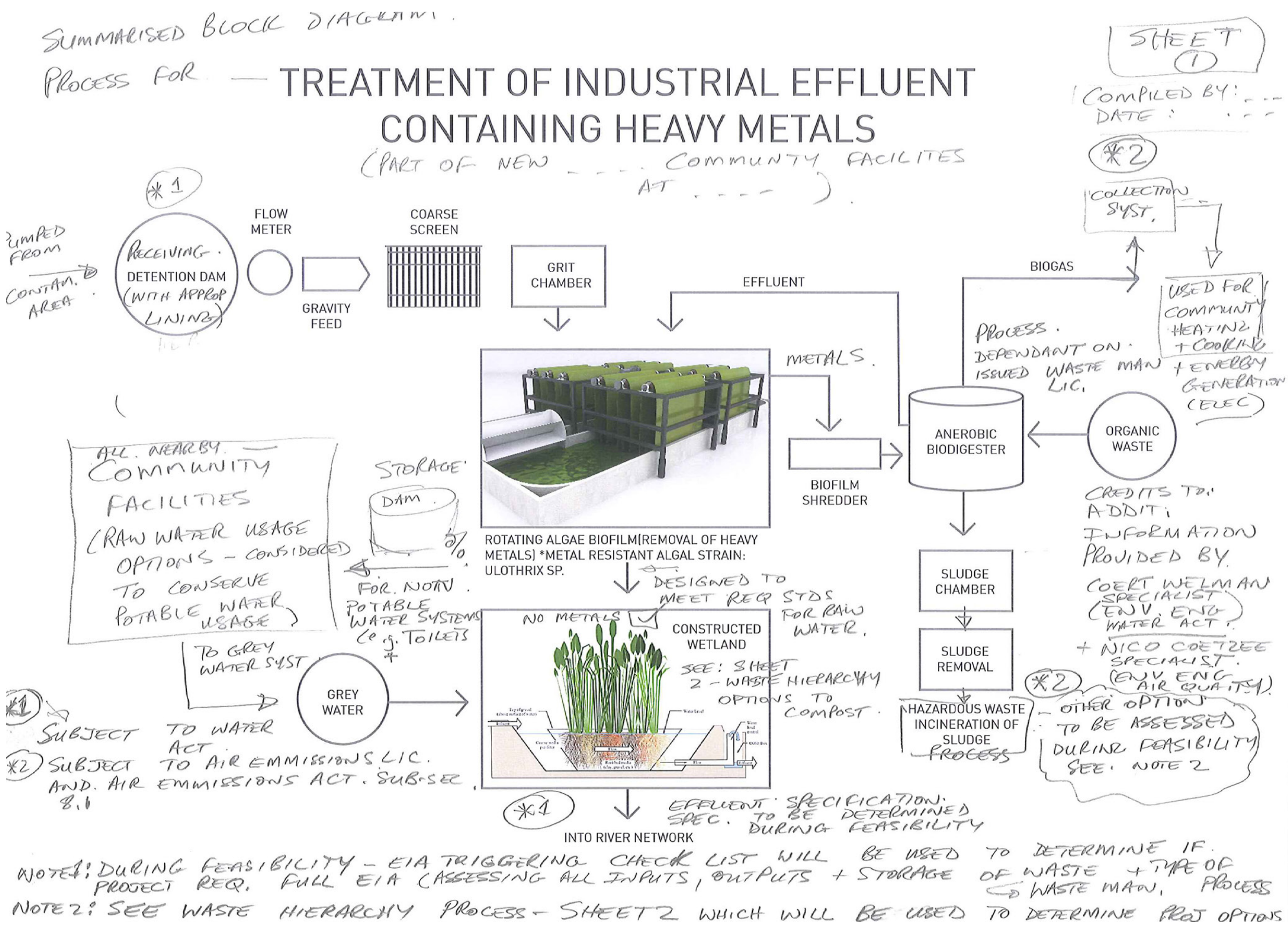
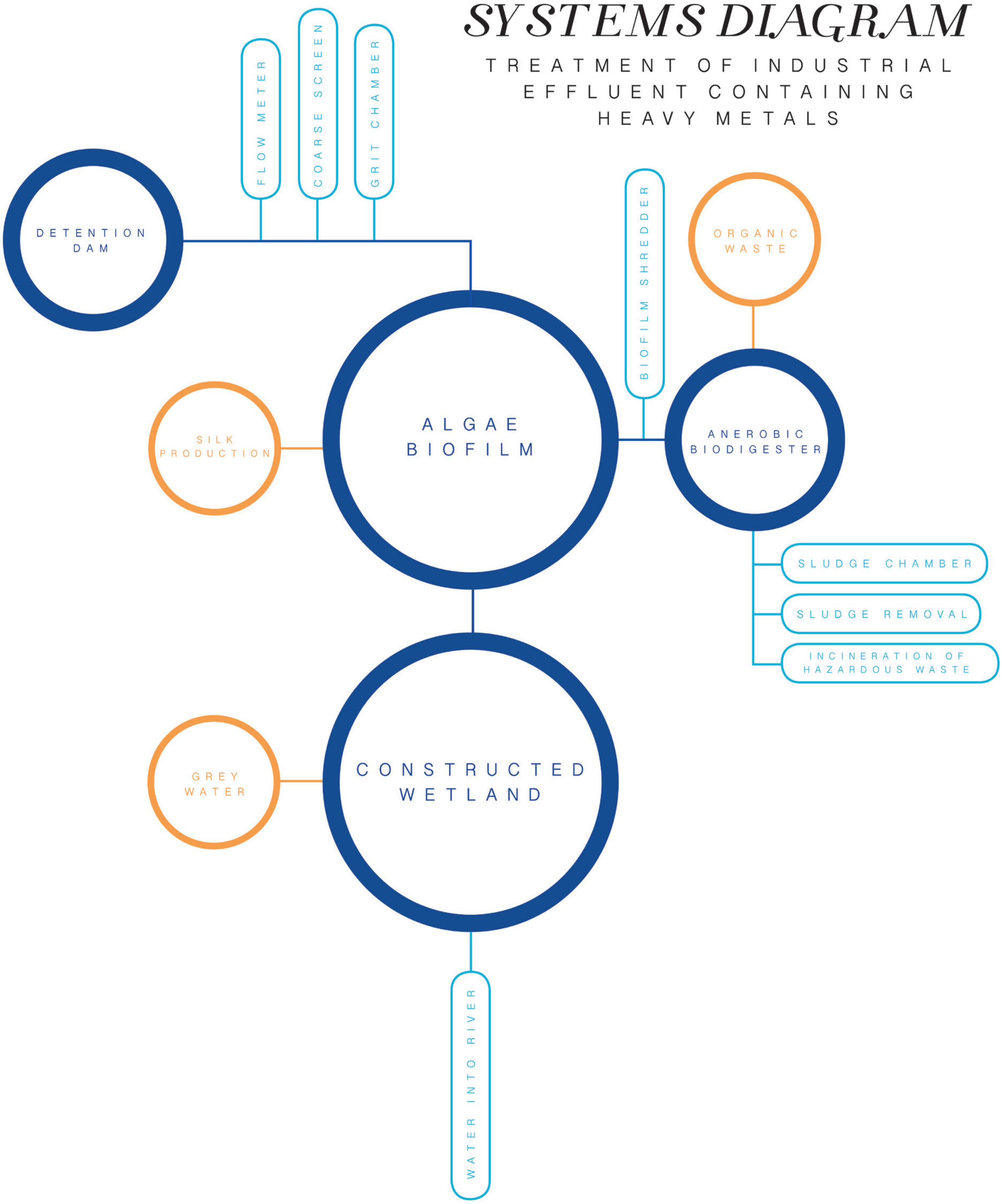


Figure 7.1: Treatment Diagram edited by environmental specialists. (Welman, Coetzee, Grala, 2016)

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.

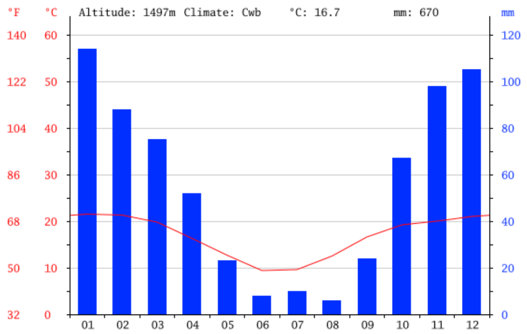


Figure 7.3: Annual rainfall graph (Climate-Data.Org,2016)

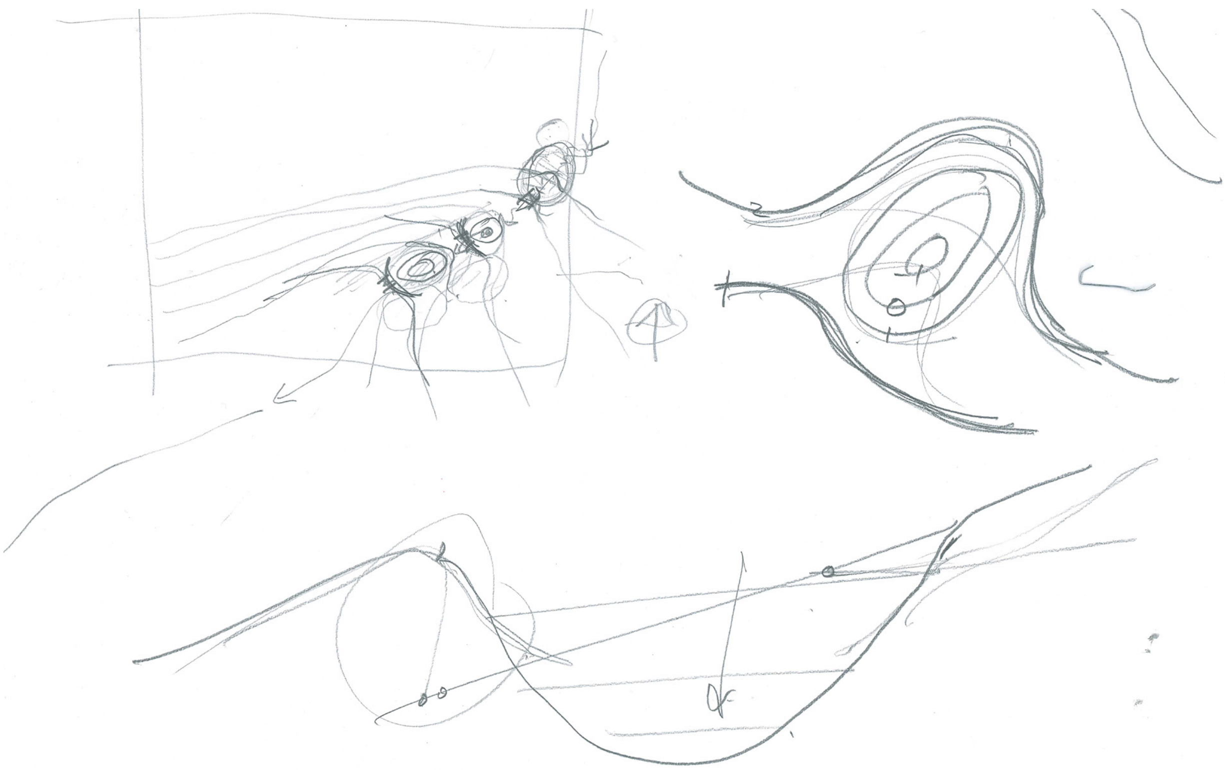


Figure 7.4: Conceptual sketch of detention dam. (Author,2016)

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

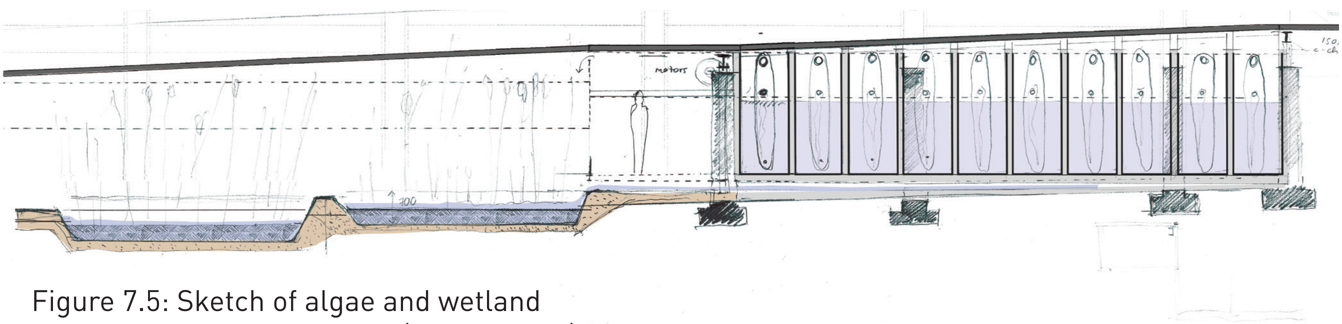


Figure 7.5: Sketch of algae and wetland system with walkway above. (Author,2016)

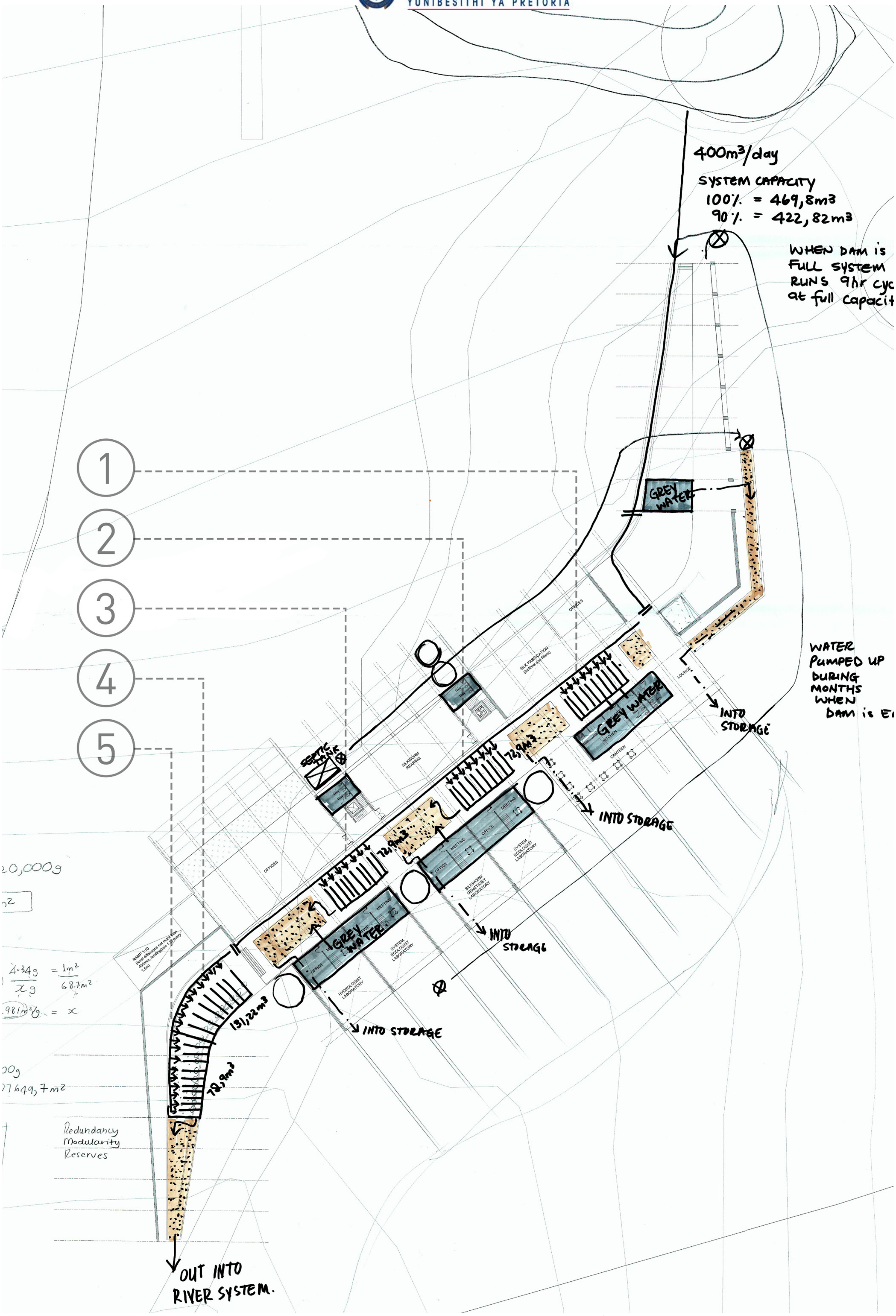


Figure 7.5: Algae and wetland treatment system. (Author,2016)

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.

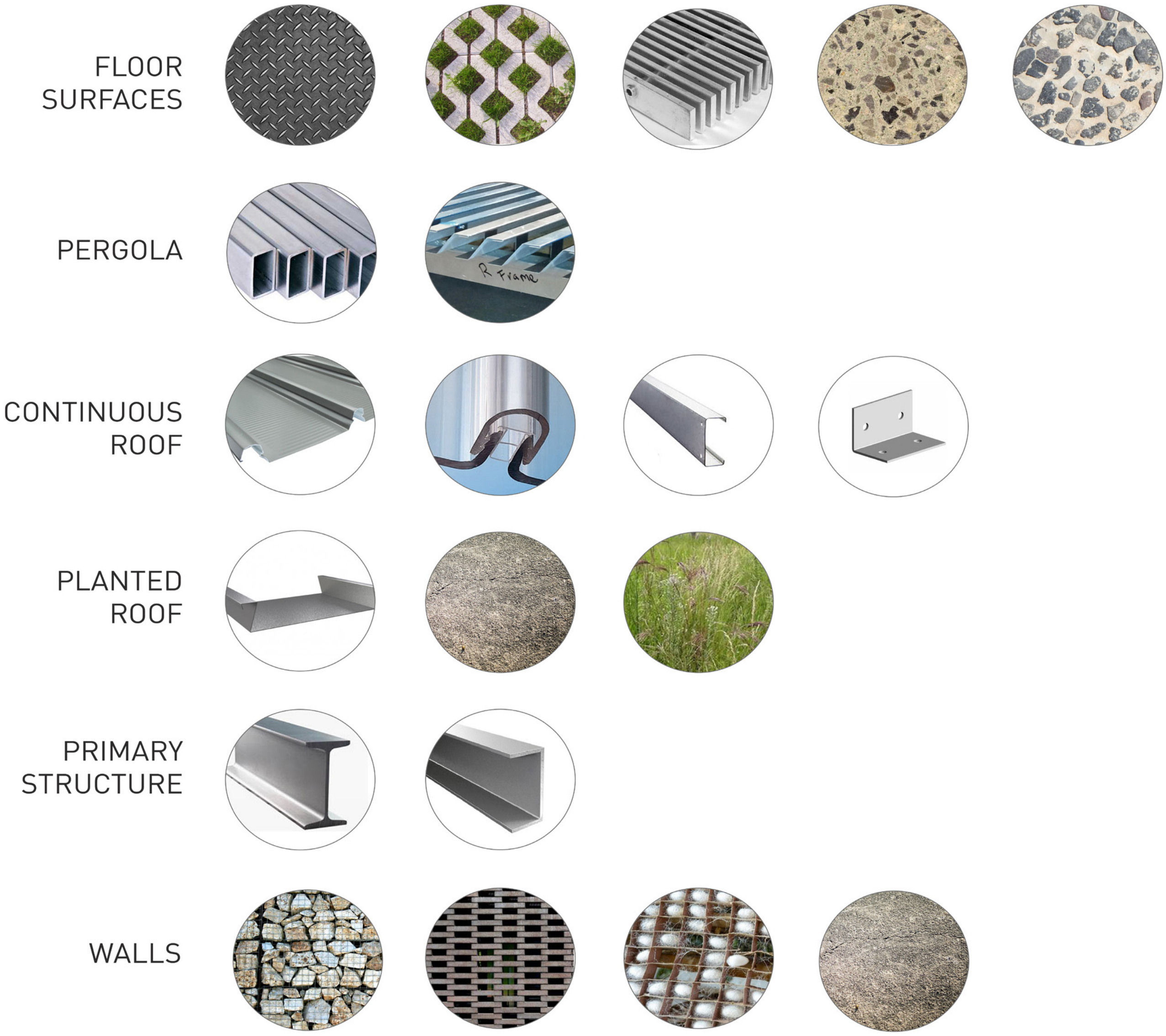
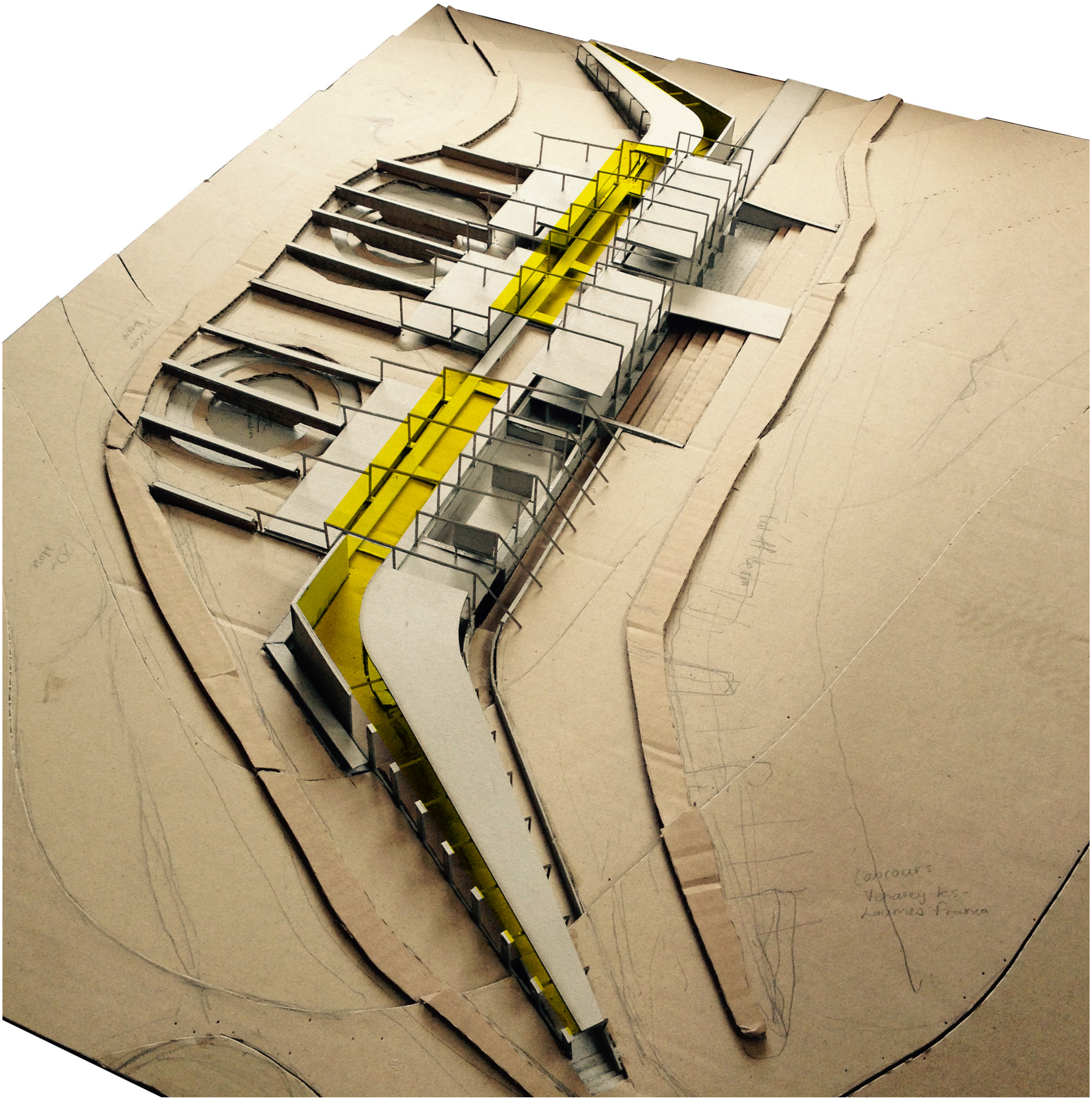


Figure 7.7: Materiality for low impact and durability. (Author,2016)

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.

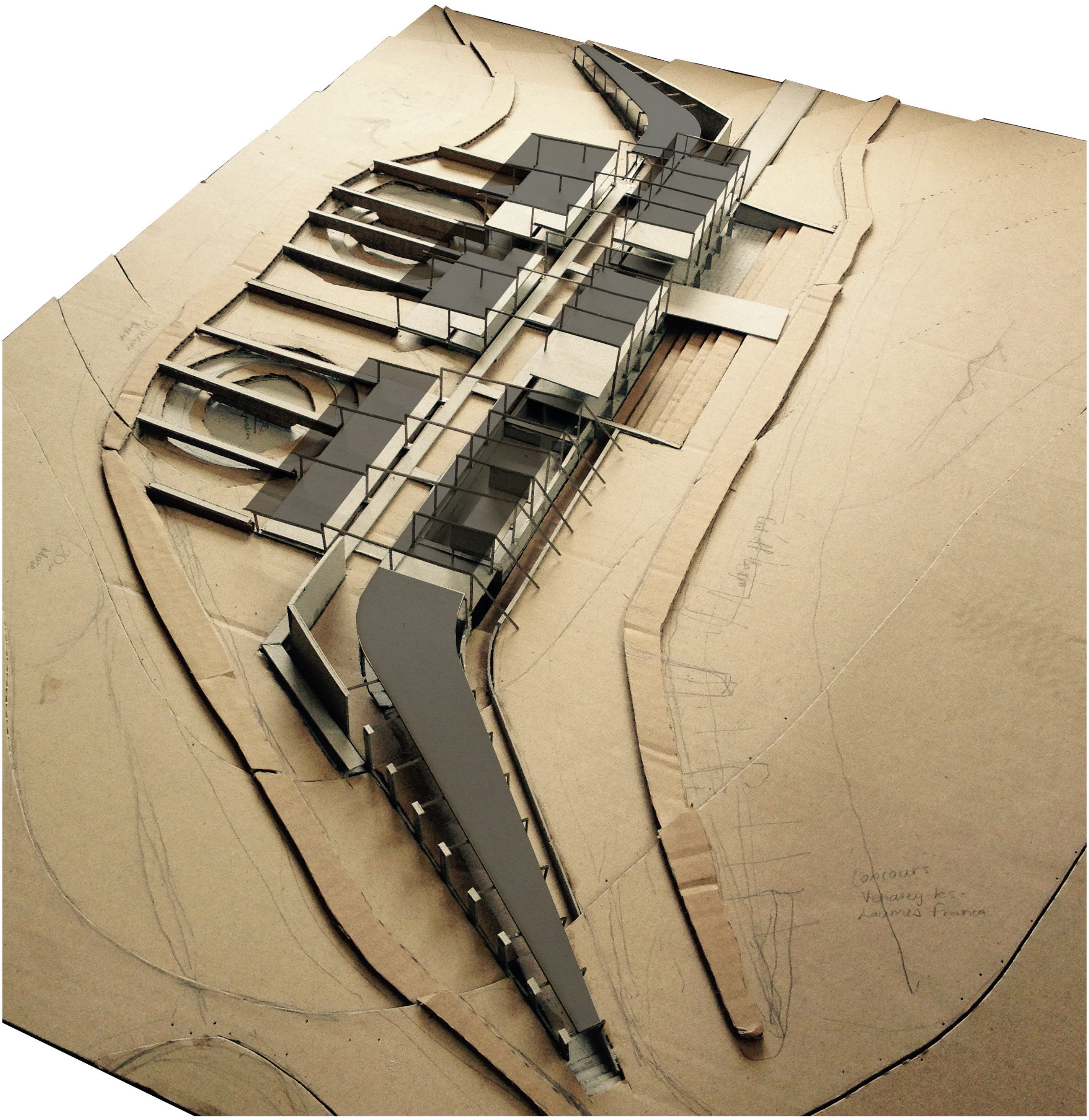


7.4.3

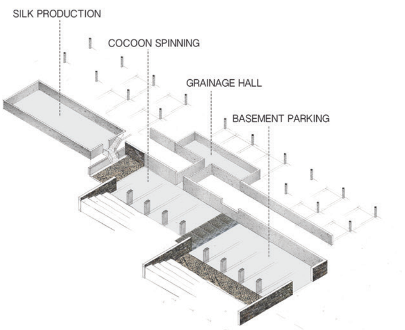
THE CONTINUOUS ROOF

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.

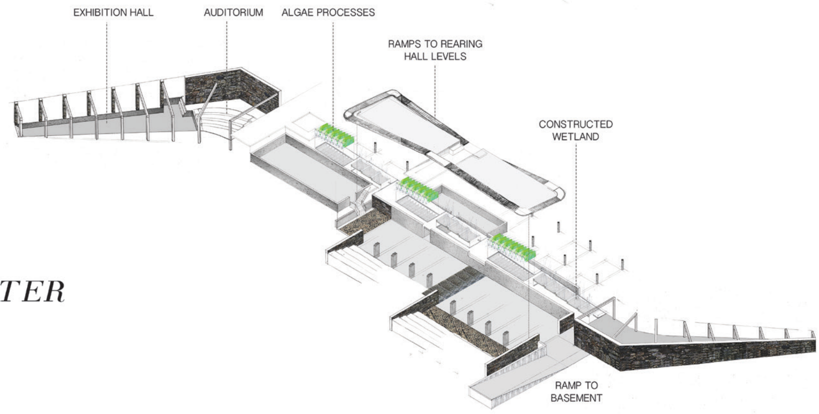
The planted steel roof continues back into the landscape which ends the cycle of the removal of heavy metals by releasing the water back into the river system.



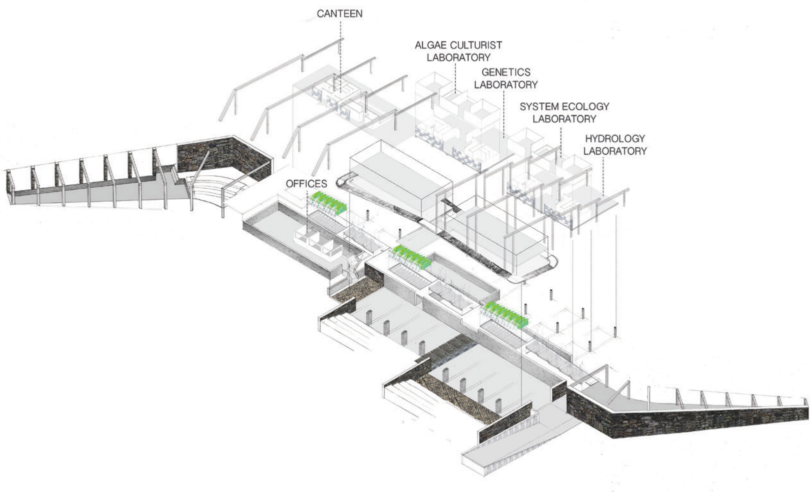
1 *BASE STRUCTURE*



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.

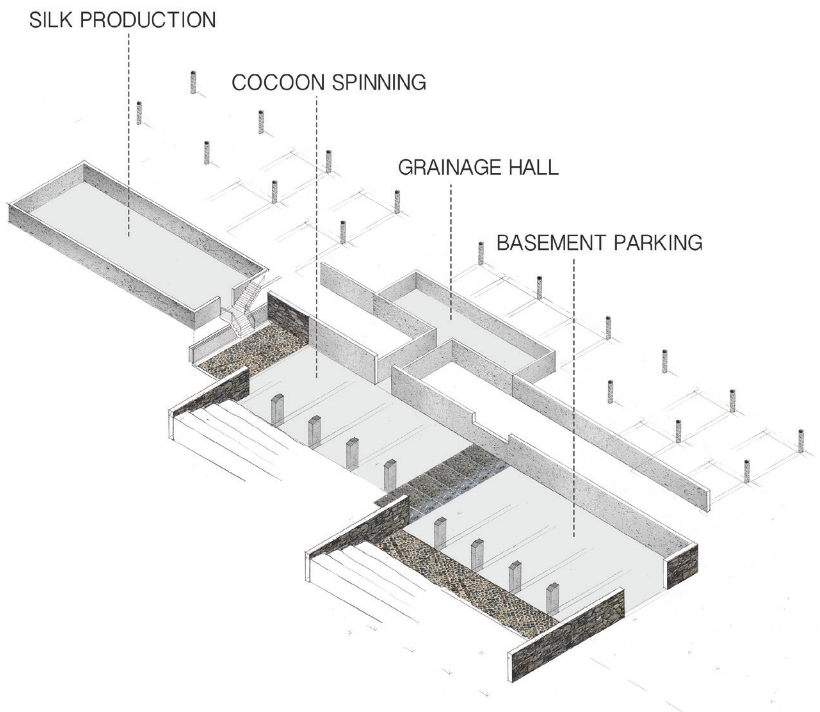


Figure 7.8: The base structure. (Author,2016)

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)

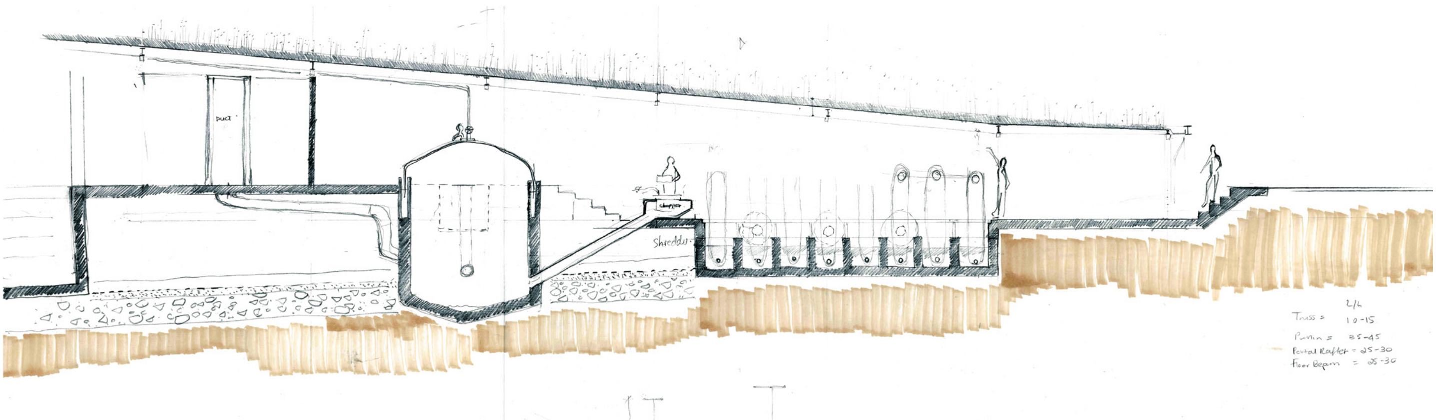


Figure 7.9: Planted roof and tapered gabion walls. (Author,2016)

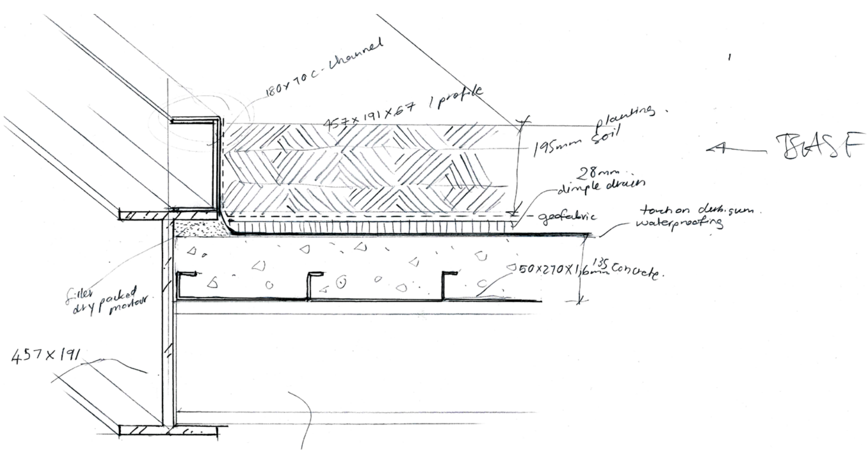
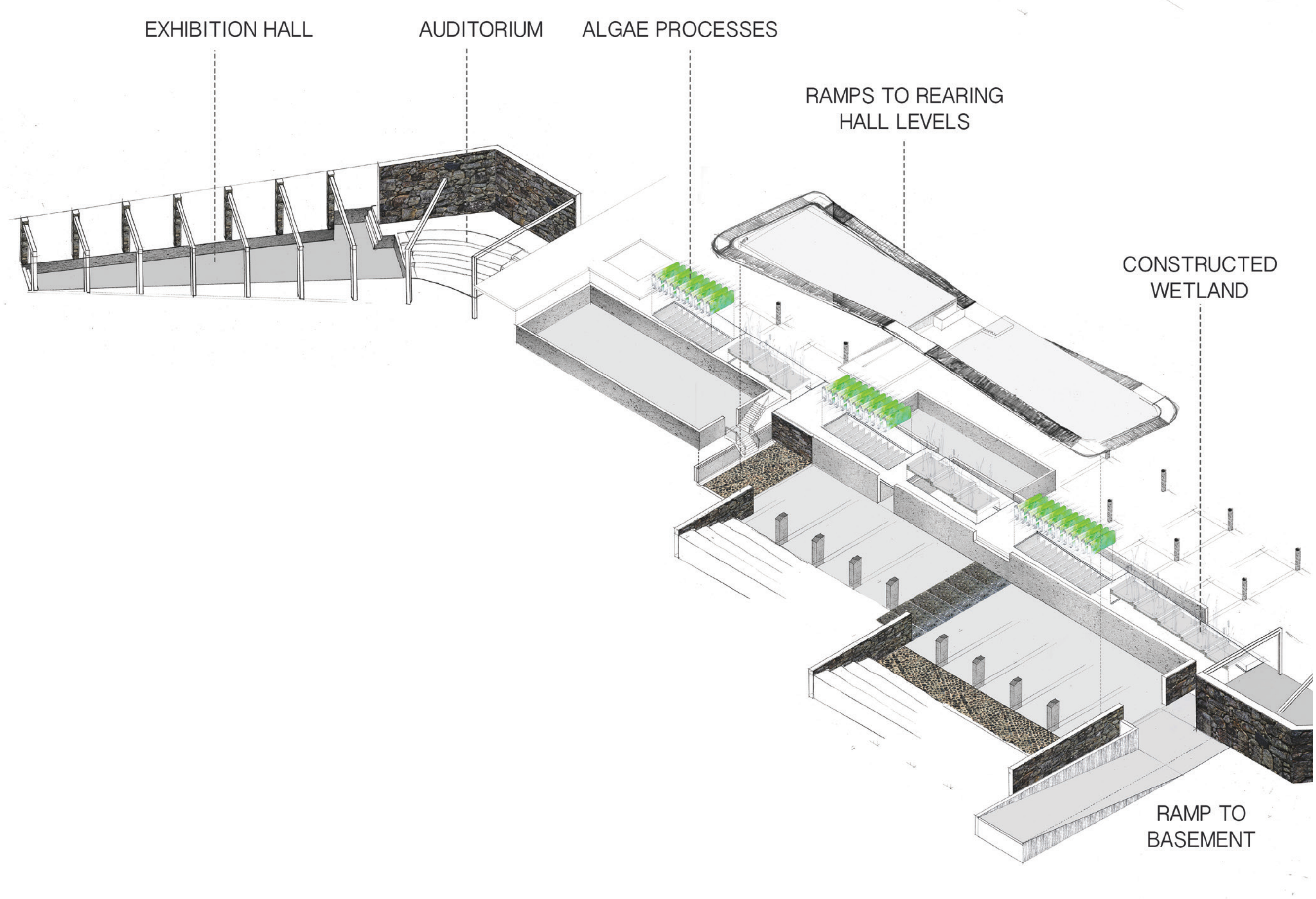


Figure 7.10: Planted steel roof detail. (Author,2016)



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.

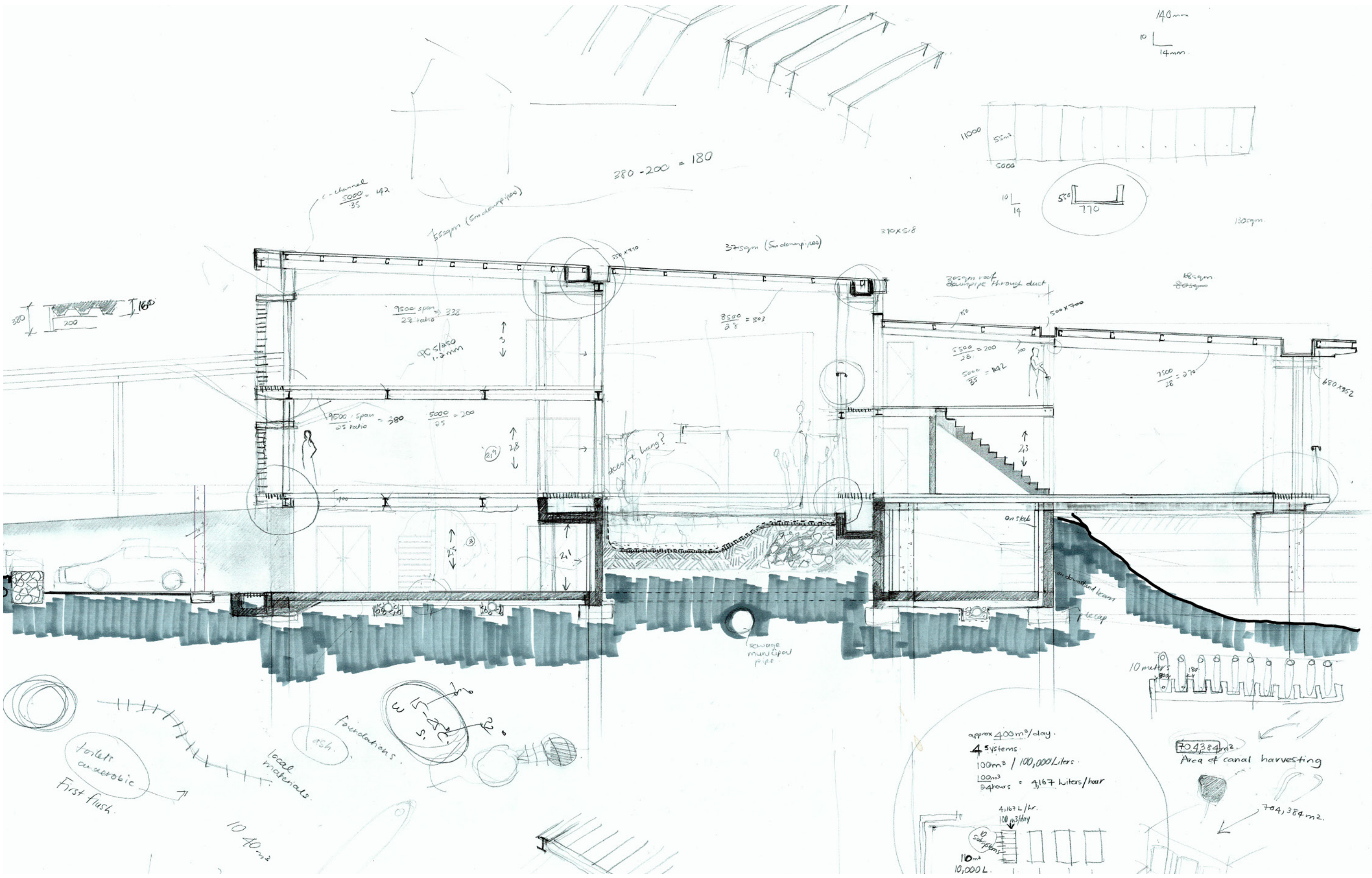


Figure 7.10: Section with base structure and steel frame. (Author,2016)

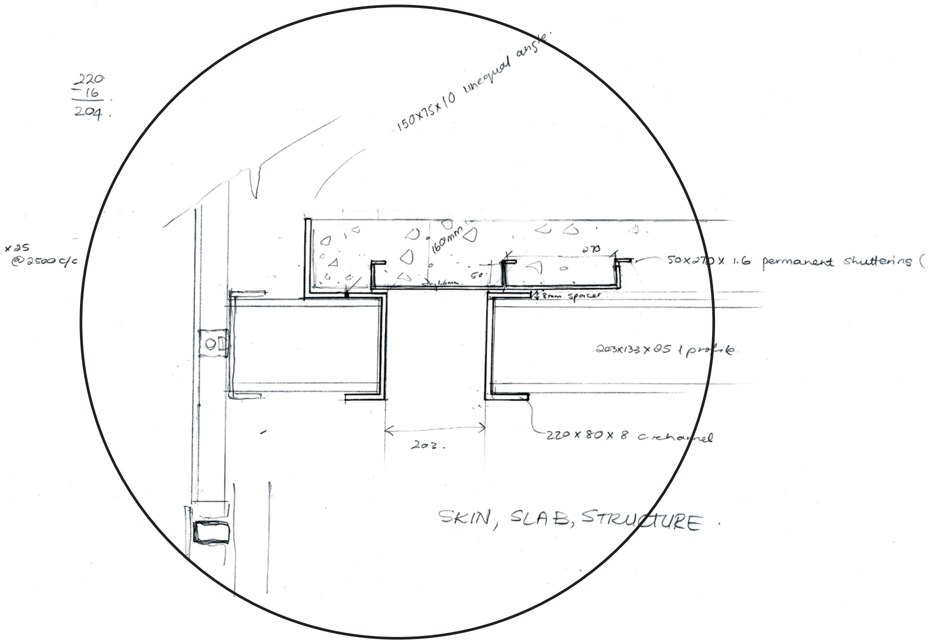


Figure 7.11: Bondlok fixed to I-profile joist (Author,2016)

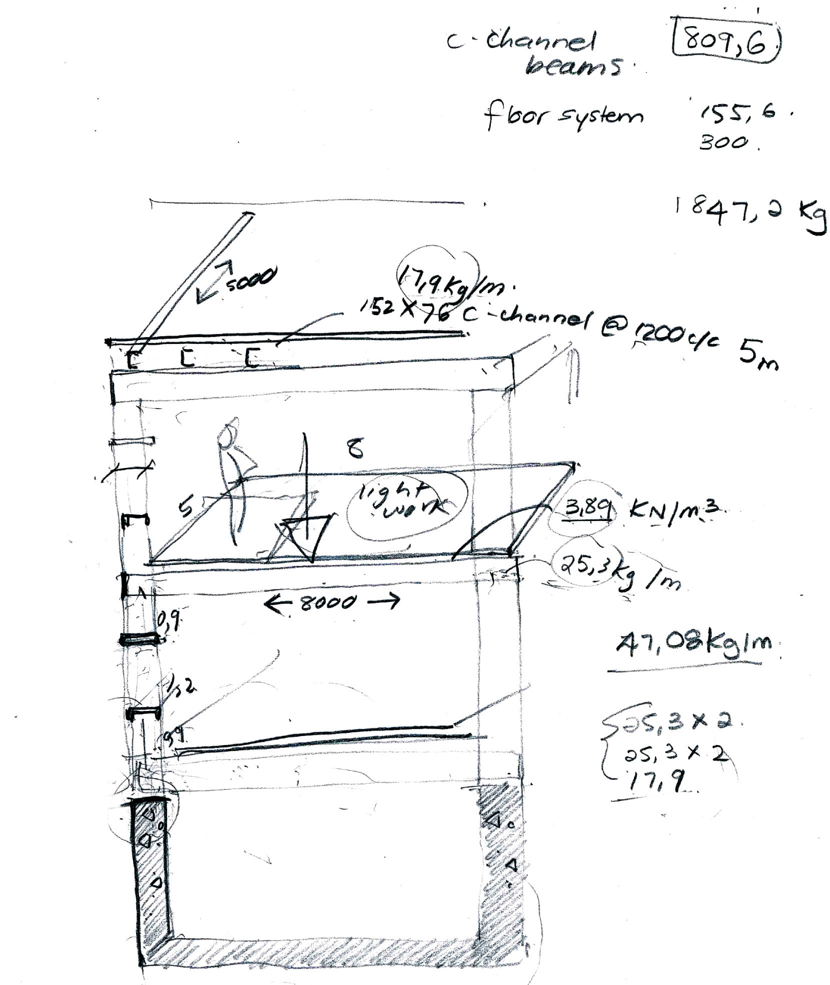


Figure 7.12: Sizing of steel structure. (Author,2016)

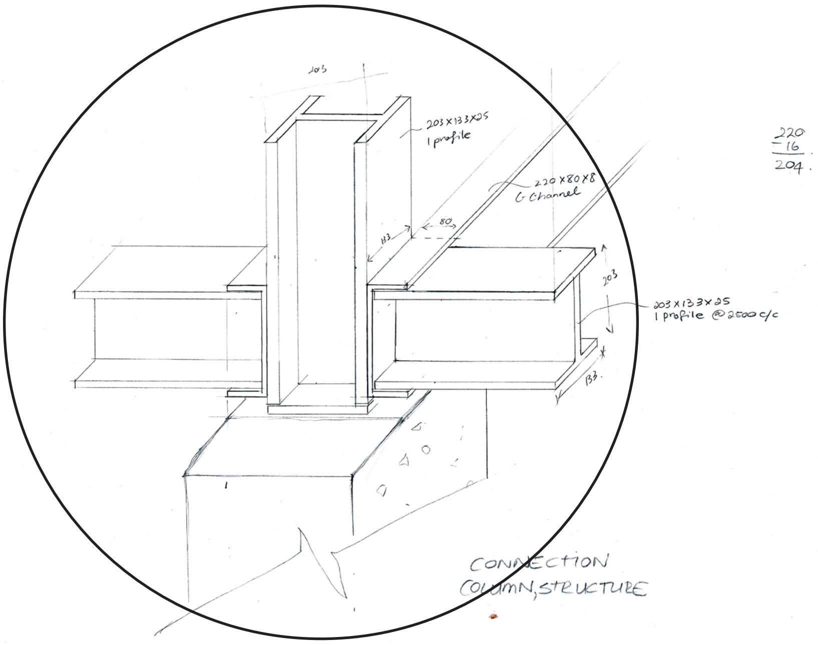
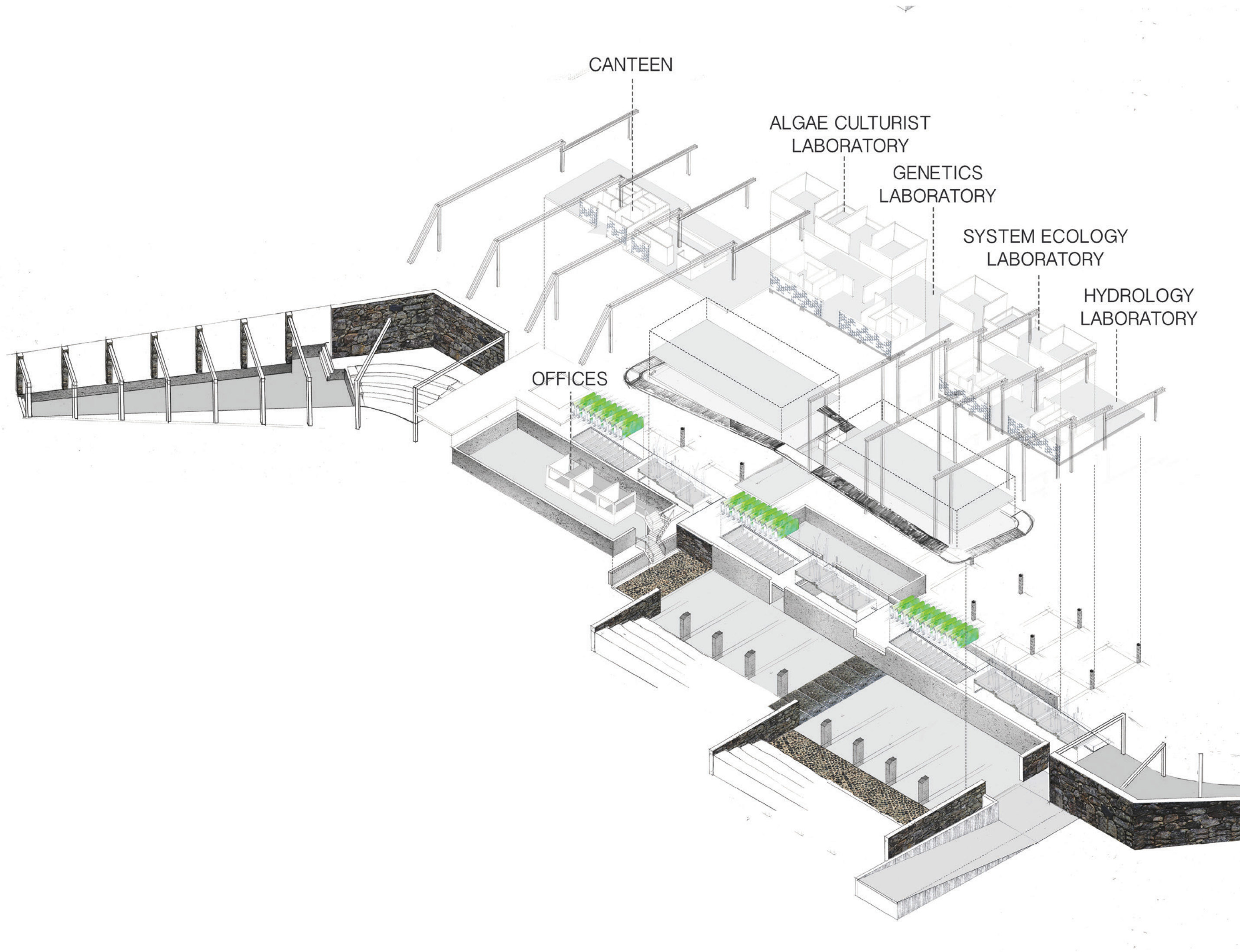
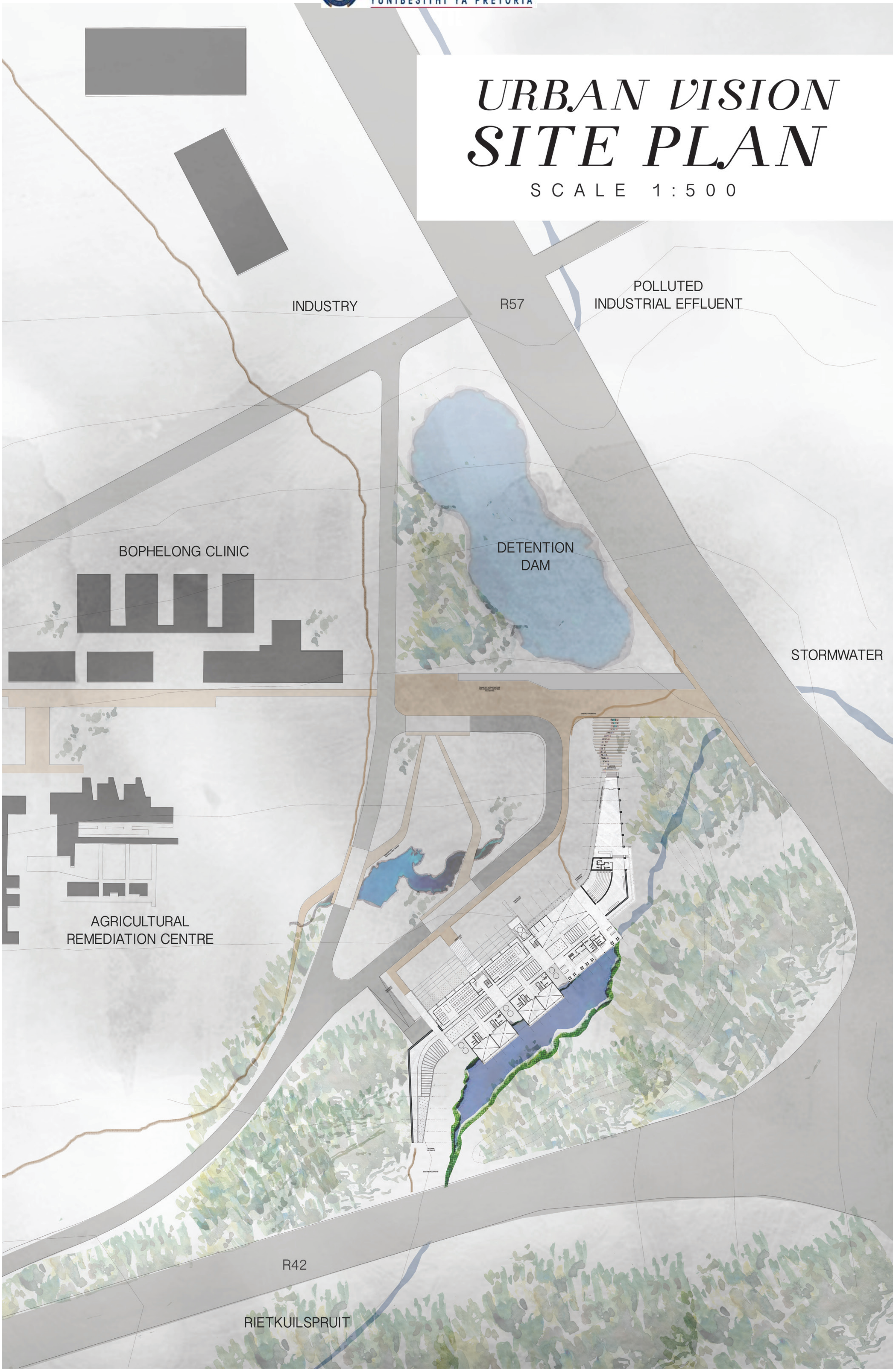


Figure 7.10: Typical steel connection (Author,2016)

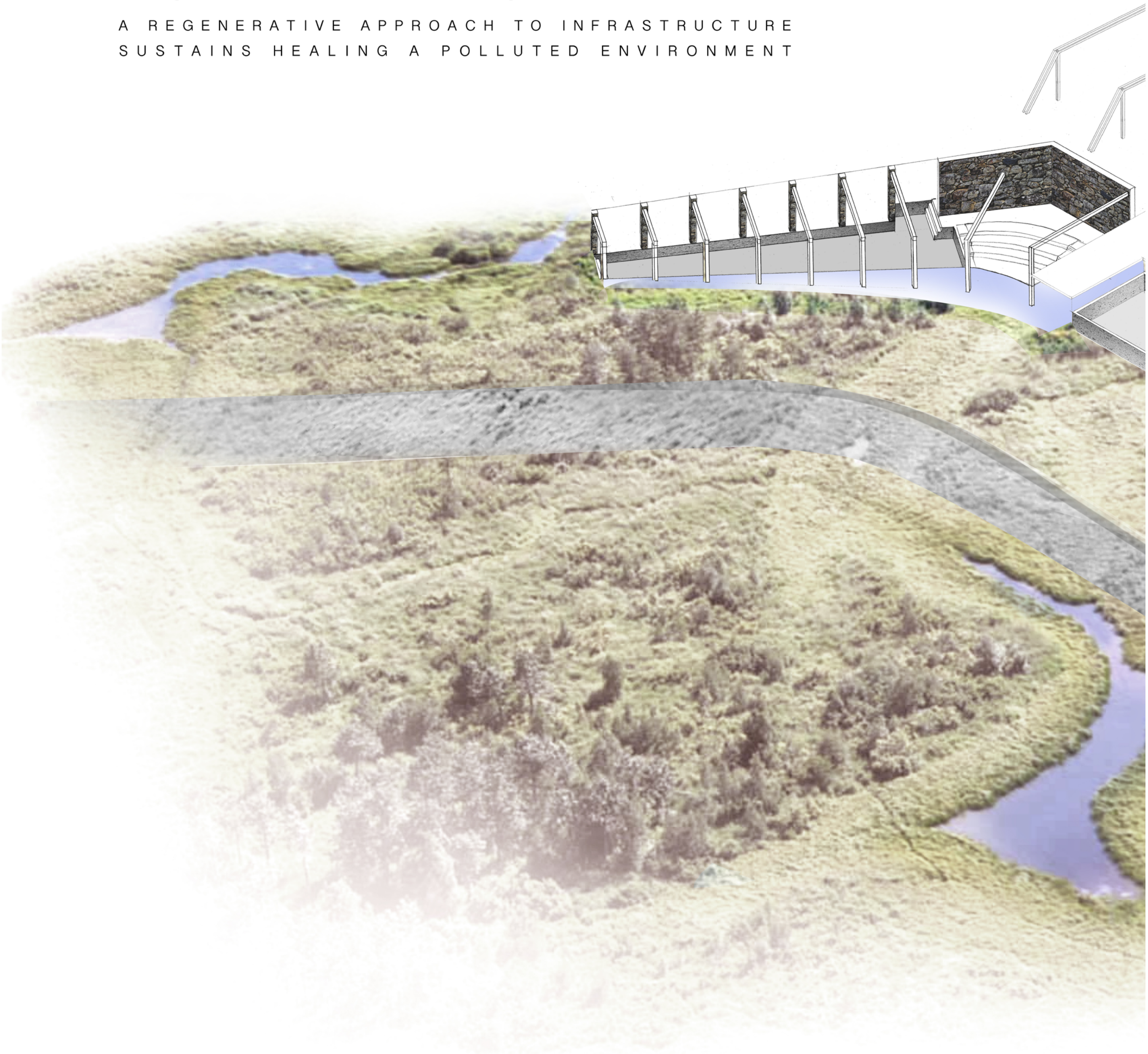


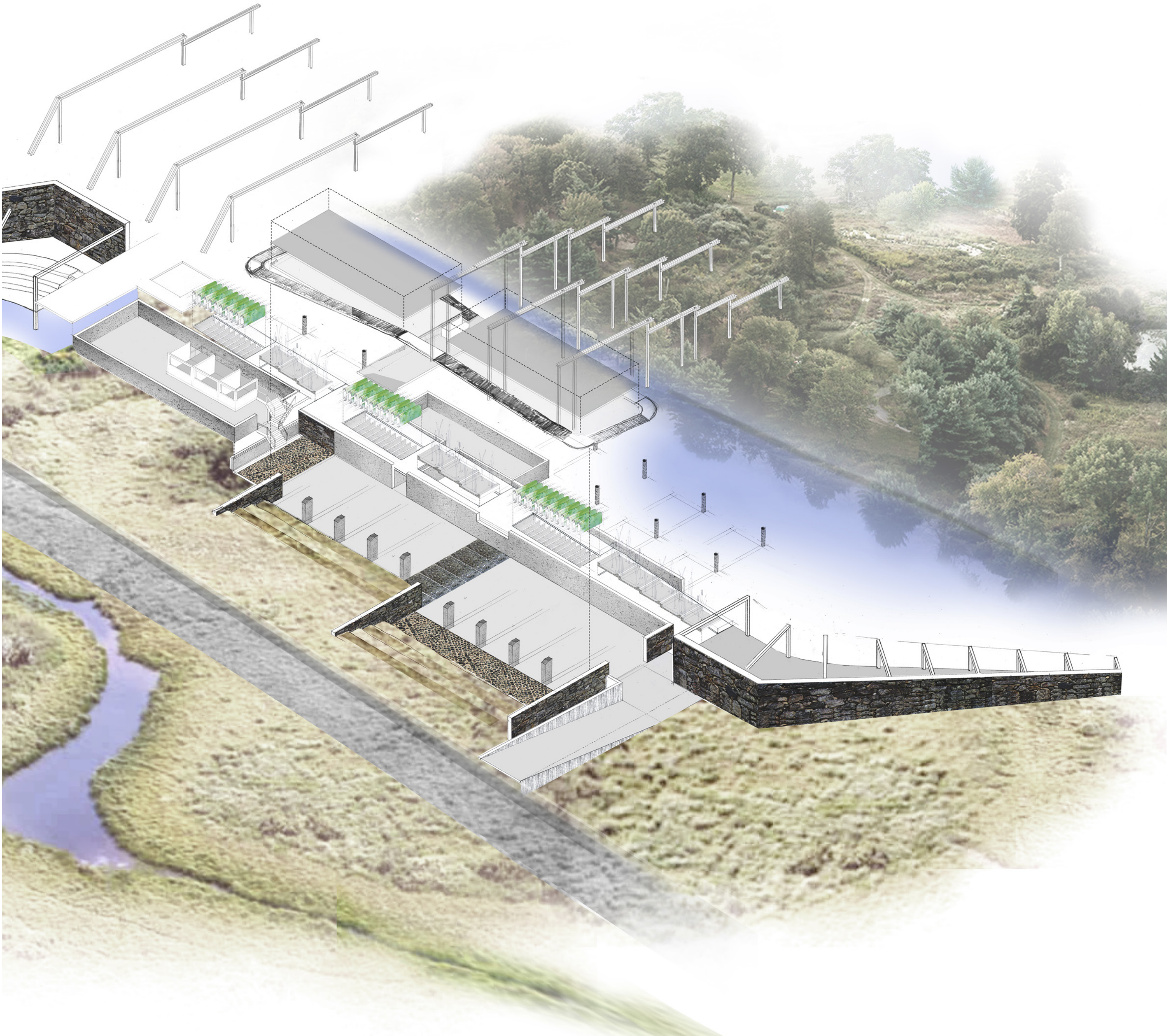
FINAL PRESENTATION

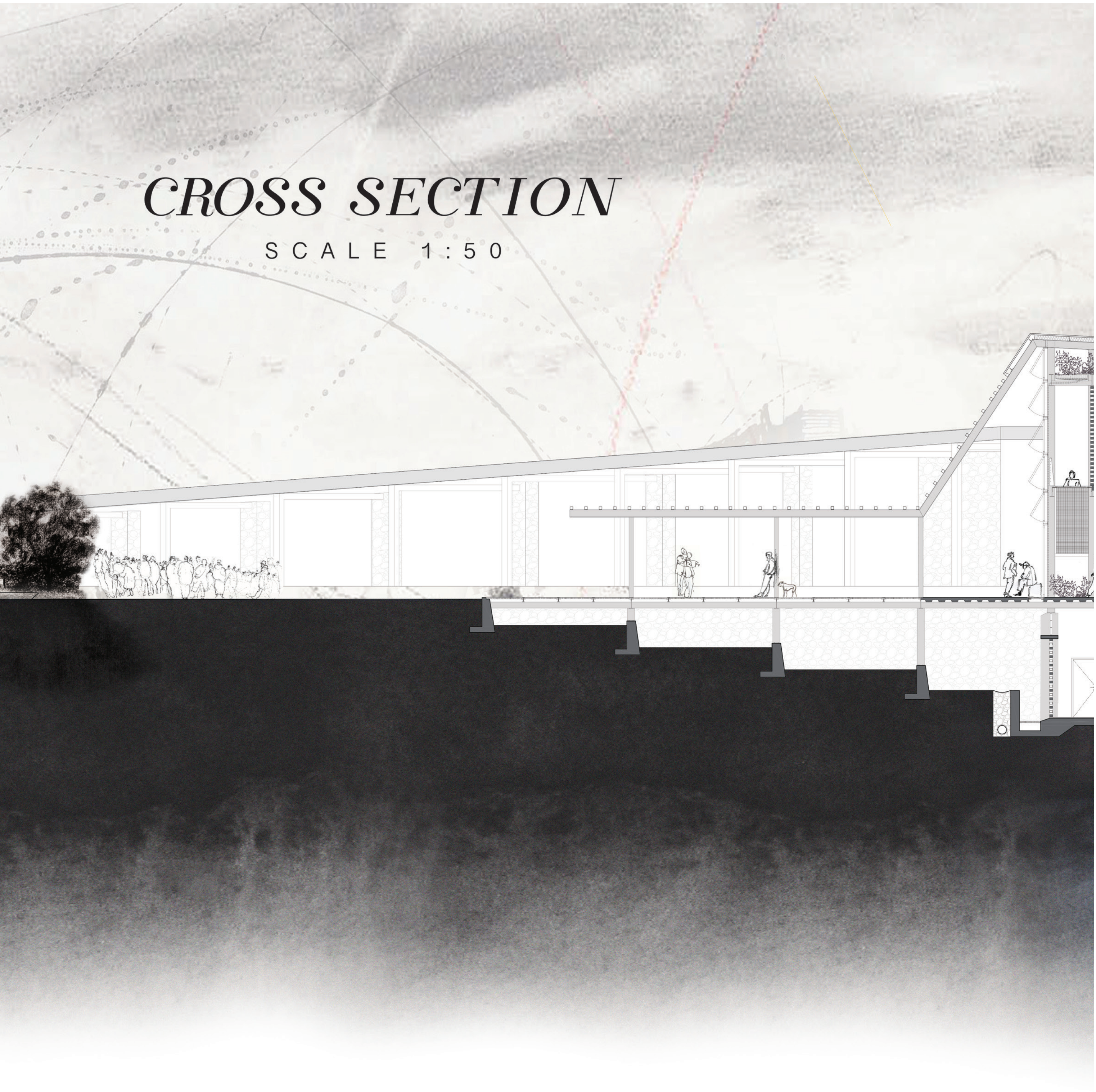

URBAN VISION
SITE PLAN
SCALE 1:500
INDUSTRY
R57
POLLUTED INDUSTRIAL EFFLUENT
BOPHELONG CLINIC
DETENTION DAM
STORMWATER
AGRICULTURAL REMEDIATION CENTRE
R42
RIETKUILSPRUIT

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

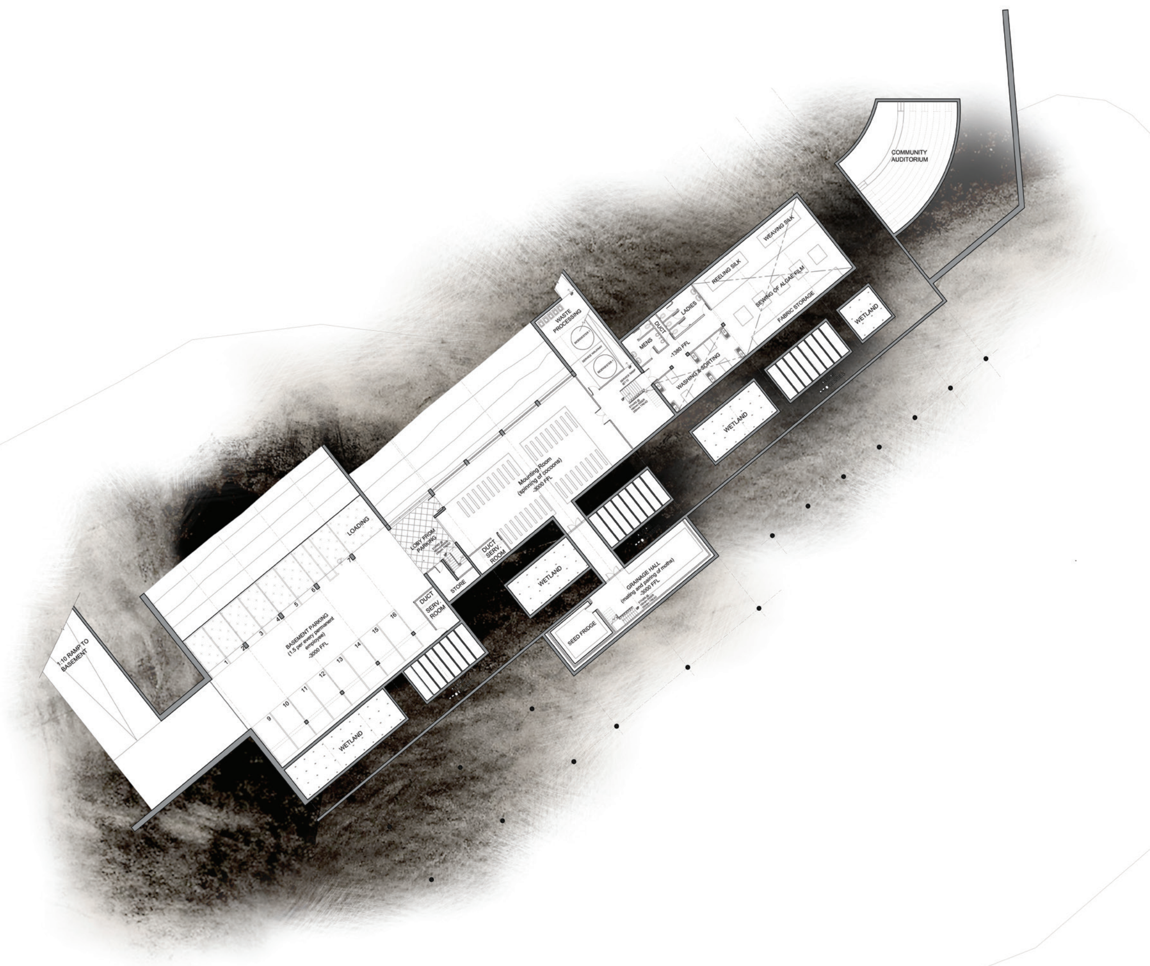
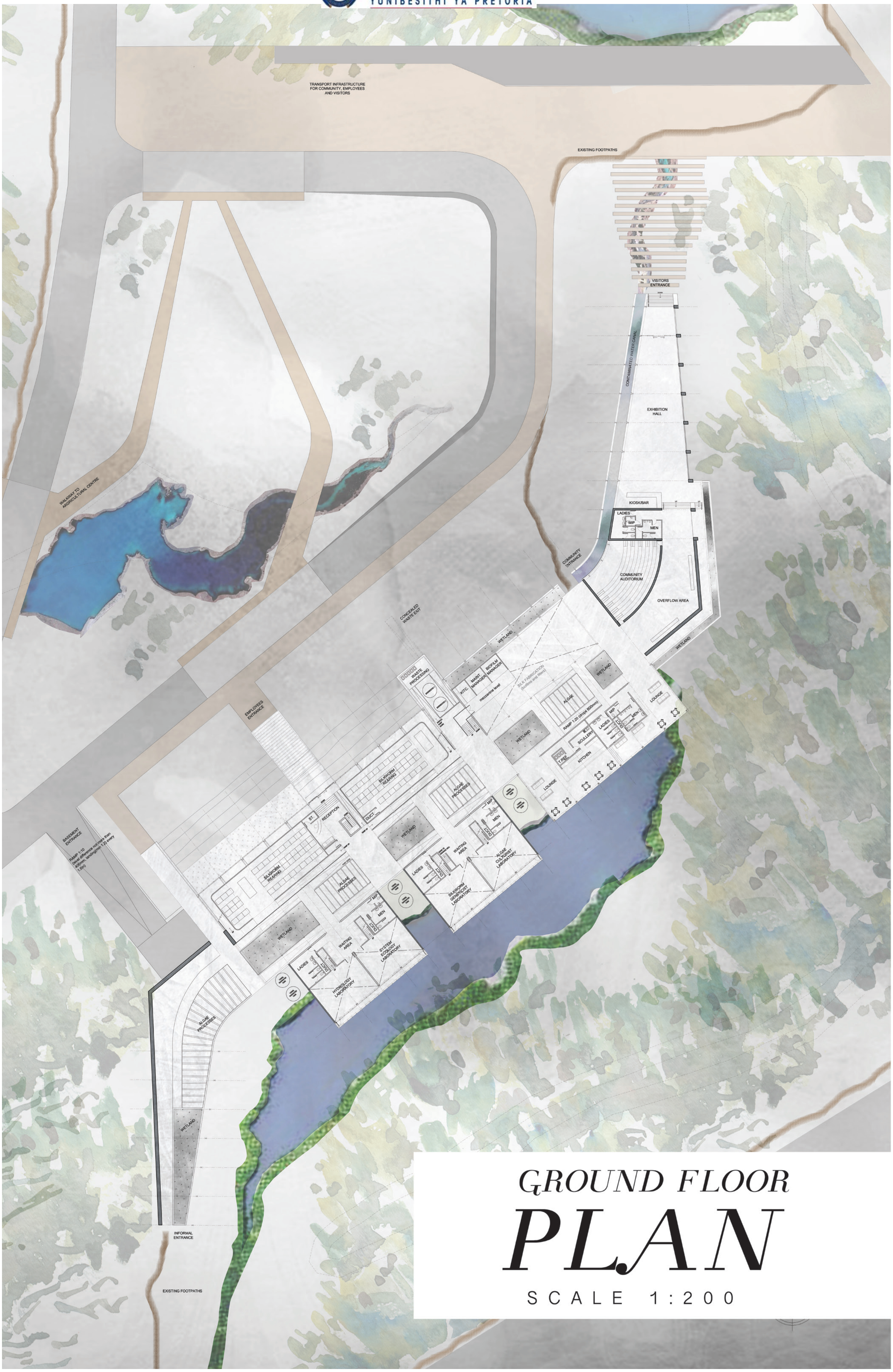


Figure 7.18: Basement plan of water treatment facility. (Author,2016)

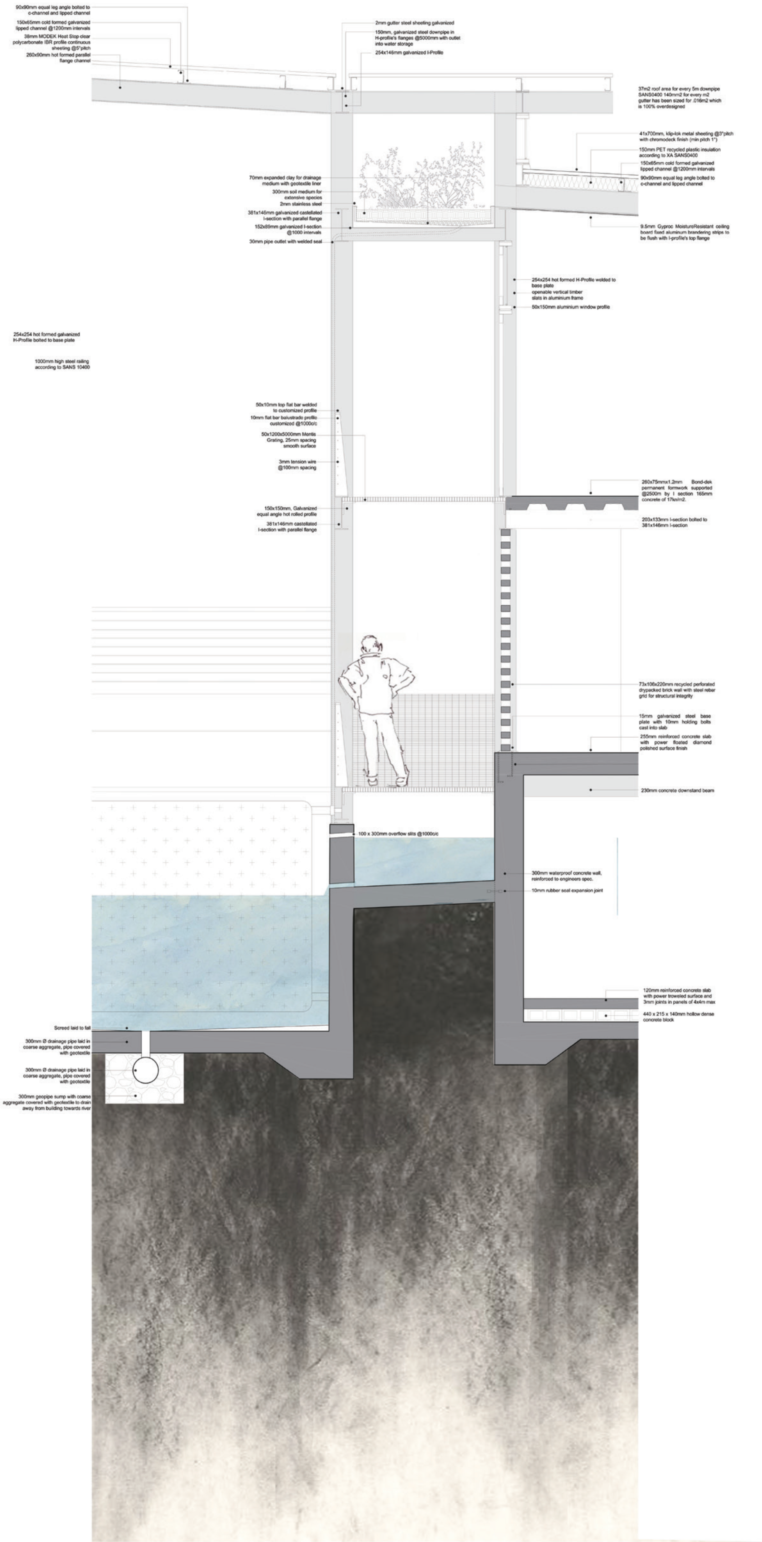


GROUND FLOOR PLAN

SCALE 1:200

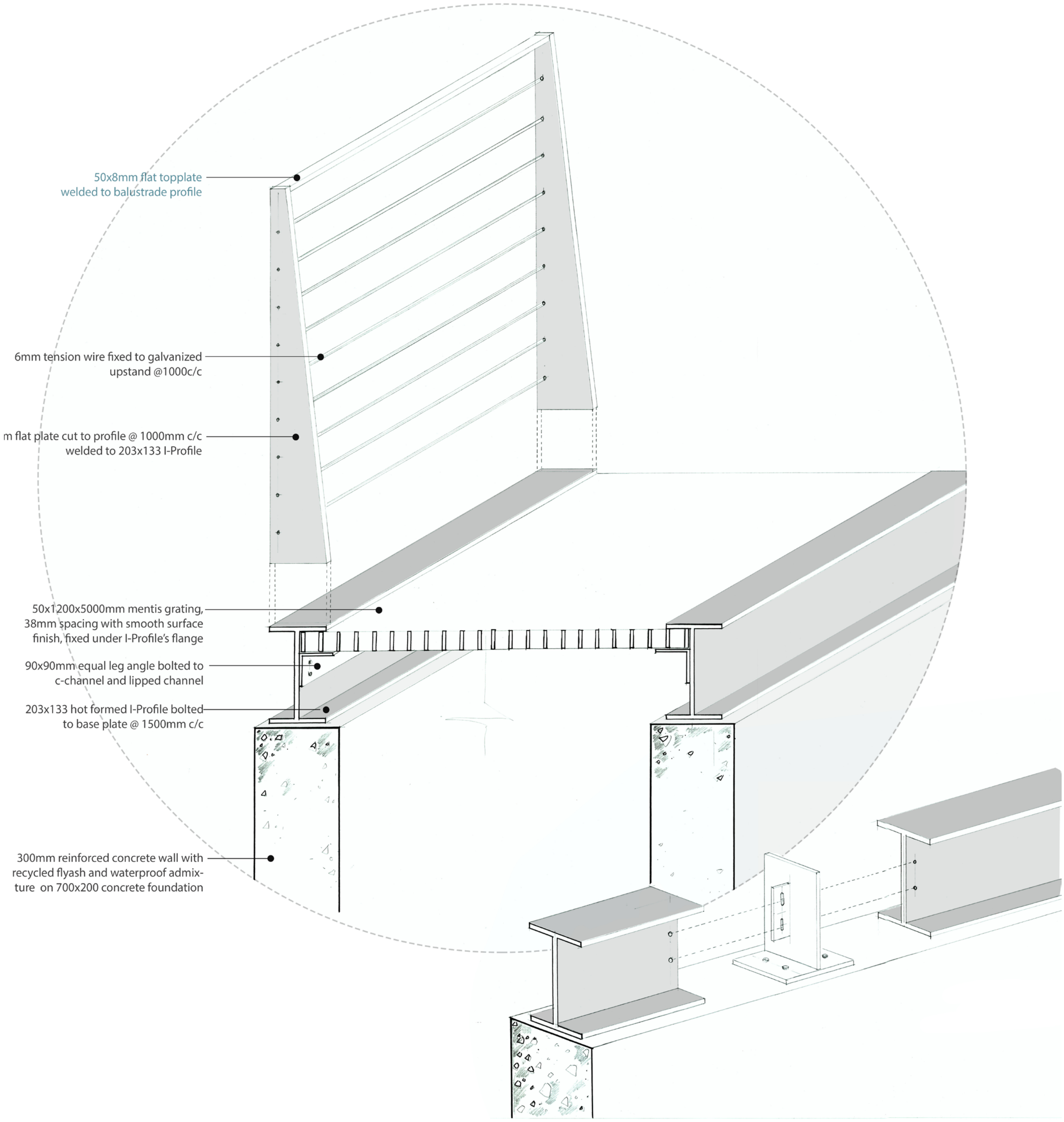
TECHNICAL SECTION

SCALE 1:20

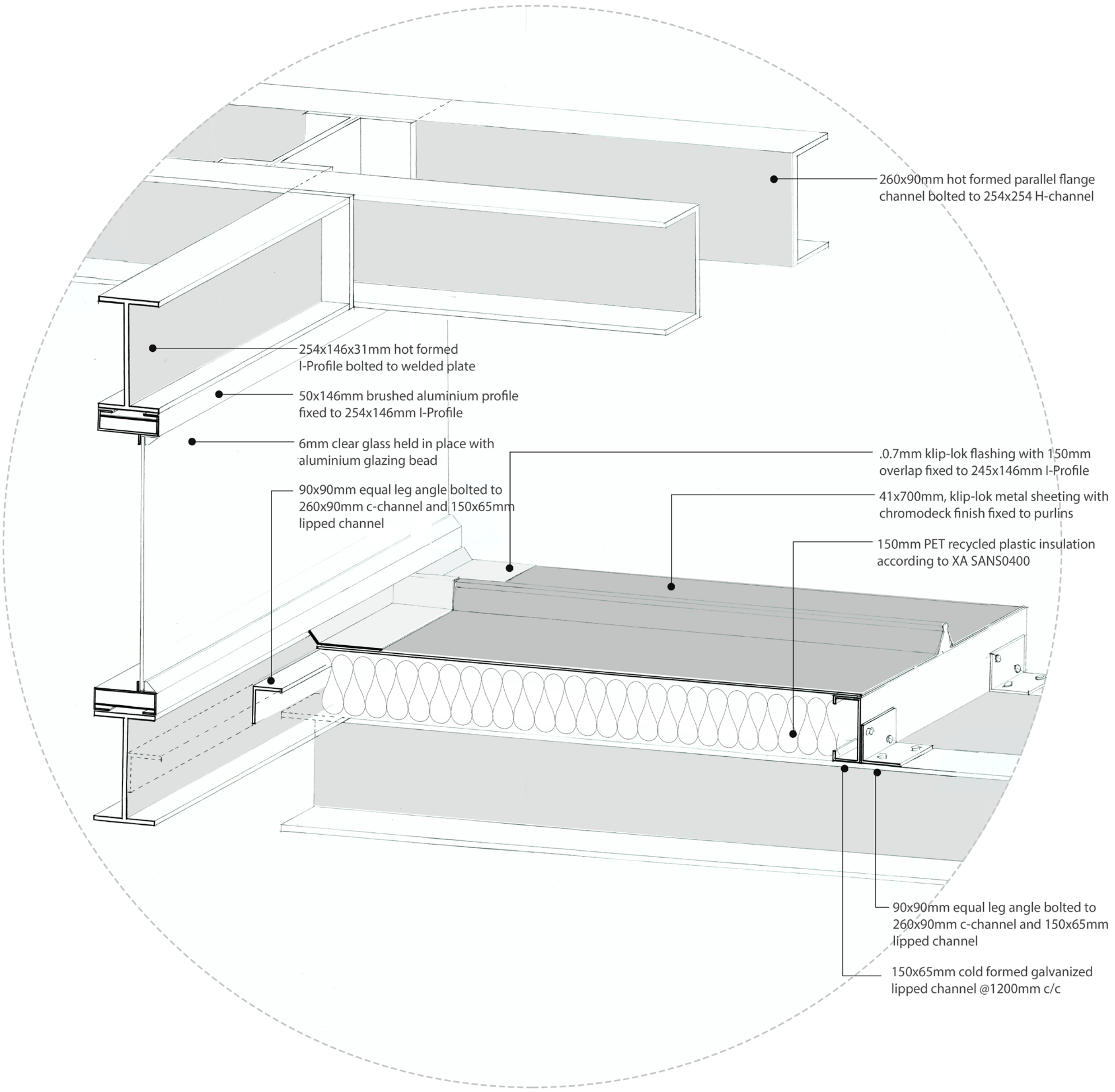


WALKWAY DETAIL

SCALE 1:5

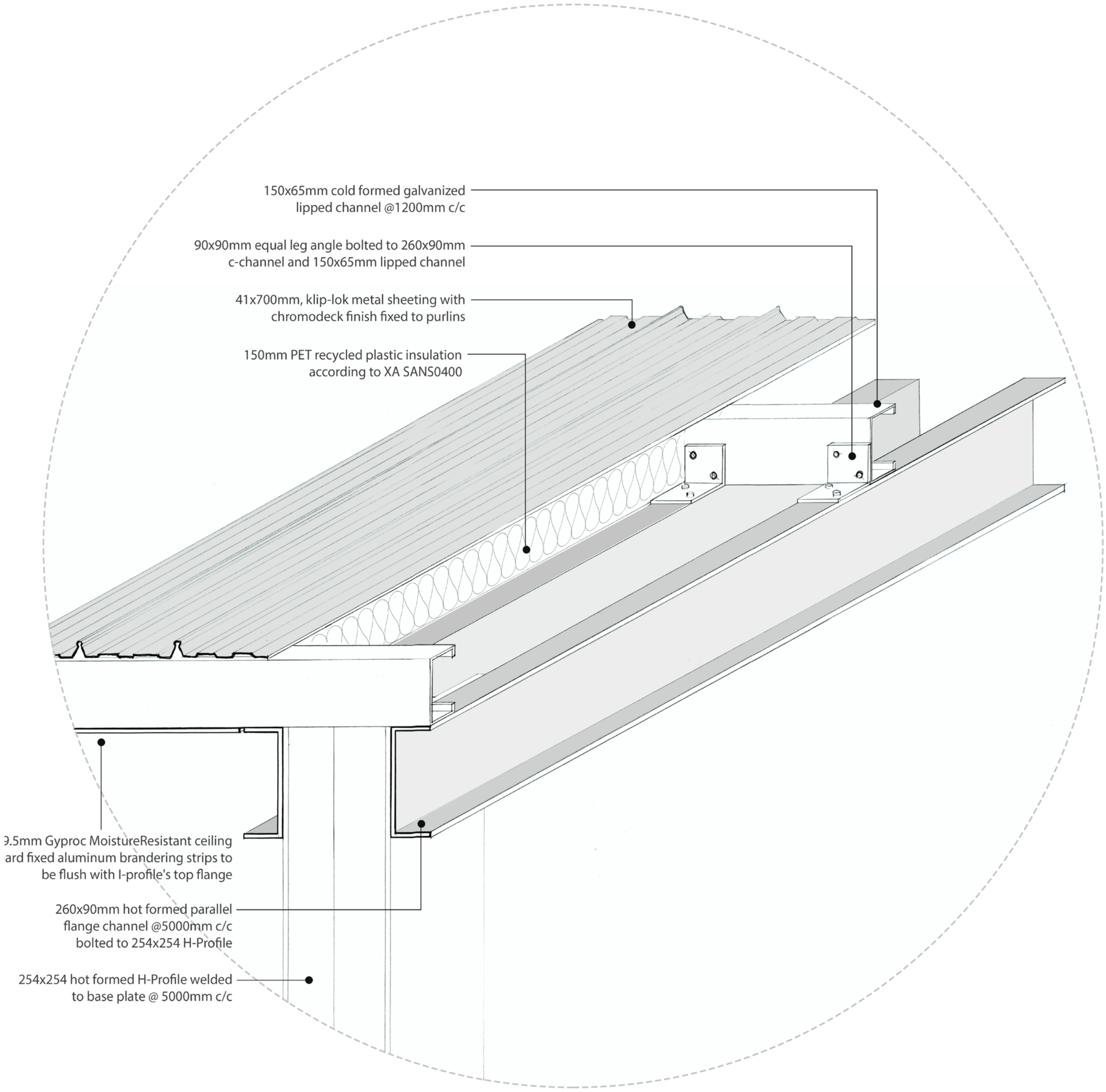


UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



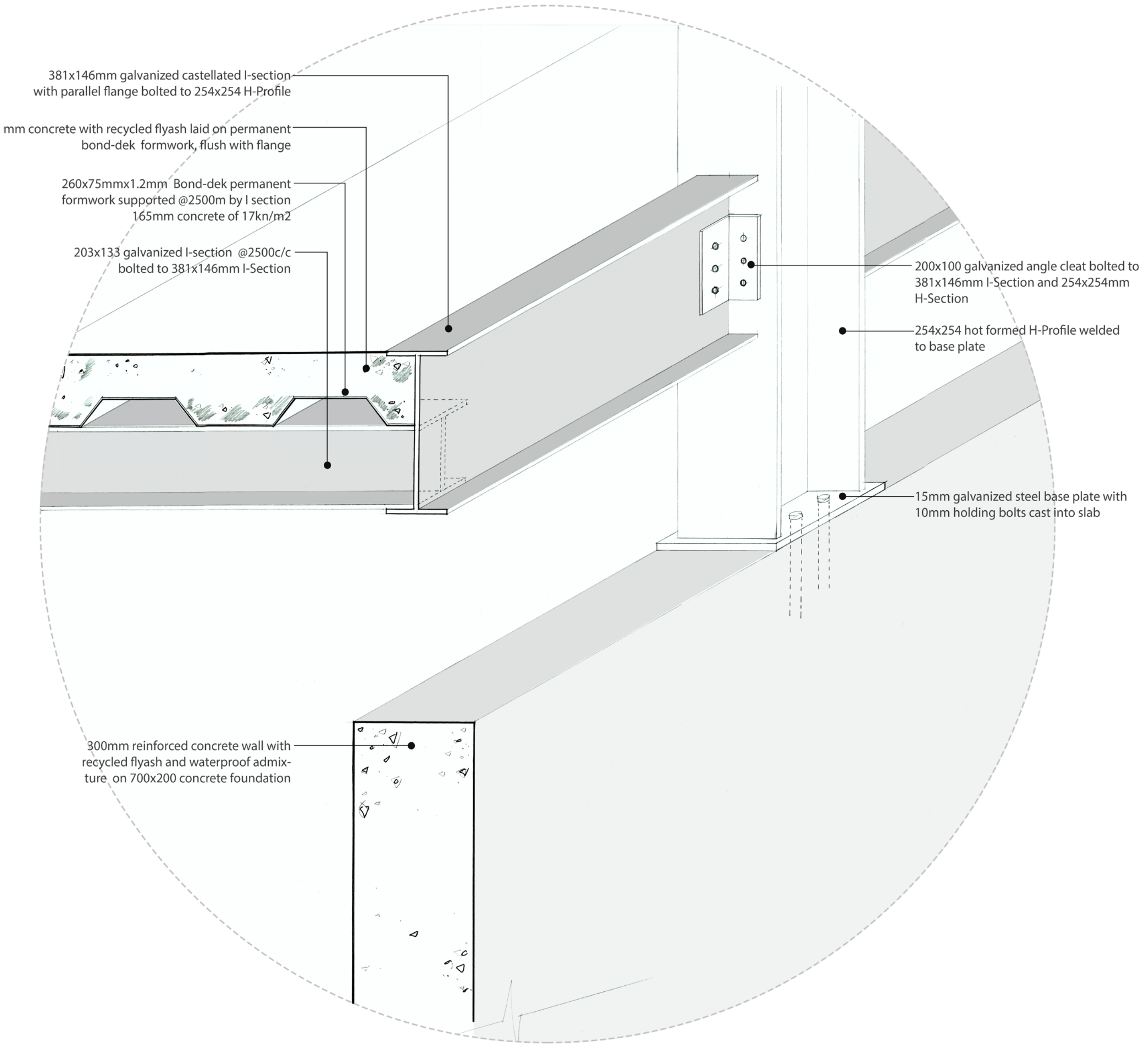
FLASHING DETAIL

SCALE 1:5



SHEETING DETAIL

SCALE 1:5



SLAB EDGE DETAIL

SCALE 1:5


ALTERNATIVE APPROACH

08

CHAPTER EIGHT

CONCLUSION

8.1
ENVIRONMENTAL IMPACT ASSESMENT

The EIA proved to be an appropriate method to evaluate the treatment of waste water as it provides a holistic overview for unique, specific projects which needs to be approved by appointed environmental consultants.

The following Environmental Impact Assesment report was compiled by the author. Environmental water specialist engineer, Coert Welman and waste specialist engineer, Nico Coetzee assessed and approved the EIA as a preliminary feasibility study. The principals of the water treatment process diagram (Figure 7.1) was approved by the environmental specialist and permission was hypothetically given to continue with the design of the facility.

8.2
THE SUSTAINABILITY BUILDING ASSESSMENT TOOL

The SBAT sustainable rating tool has been included for comparative research purposes to conclude the dissertations rating according to sustainability standards. The graph in Figure 8.1 indicates a low rating for the materials used in the project,yet the technical resolution of the project sets out to use recycled materials, steel off-cuts and renewable resources. The SBAT rating system is for residential application, but lacks adaptability and the understanding that each project has unique potential.

8.3

CONCLUSION

The months of research and exploration has led to an understanding of the extent of contamination entering our environment from the industrial and mining sector. The author's consultation with the environmental specialists Coert Welman and Nico Coetzee revealed the need for interventions such as the water treatment and research facility proposed by the author. The specialists recognized the academic contribution as valuable and advised that the project has potential to be used pilot plant which could be applied on larger scale at the point source. The specialists confirmed that the concept of intercepting contamination can be applied as an intensive on site remediation plan to address the more complex issue of contaminated groundwater.

Summarised Water Treatment and Research Facility with Community Development Interface Environmental Impact Assessment Information 21 October 2016

(Compiled as a planning document for early the Feasibility Phase assessment activity and discussion with Environmental Consultant Specialists – which are still to be appointed – ***Document For Internal use only)***

Section 1 – Information describing the project	Details
☐ **Purpose and physical characteristics of the property**	**Water Treatment and Research Facility with Community Development Interface** **Location:** North western quadrant of the intersection of the R42 and R57, Vanderbijlpark **Site:** 12.9 Hectare, Facility: 3768sqm **Objective:** Removal of heavy metals from industrial effluent – pilot facility for onsite water remediation for large industries. The facility is a small scale specialised environmental rehabilitation water treatment facility which intercepts and treats water (historically) known to be contaminated by industrial effluent containing heavy metals. The project allows for the collection of water which flows along natural storm waterway canals from contaminated land/ water sources), thus preventing known contaminated water from entering the Vaal River system. The site earmarked for the facility is situated at the intersection of the R42 and R57 in Vanderbijlpark.
☐ **Proposed access and transport arrangements**	New ring road access from existing R42 and R57 as well as adjoining Municipal roads will be included into the project. These access options are ideal for the initial Construction Phase and eventual operation of the overall facility on completion of the project. Public transport infrastructure options will provided and be utilised for the Construction and eventual operation phase of the development.
☐ **Numbers to be employed**	**Construction phase:** approximately 200 Employees at peak periods **Operating of the facility:** approximately 92 employees
☐ **Land use requirements and other physical features of the project**	The site is a proclaimed road reserve which has been rezone to a municipal servitude. There is evidence that landscape has been slightly disturbed, due to the proclaimed road excavations and back filling done a few decades back, but never completed. A portion of the facility's footprint sits on the disturbed landscape. Provincial and Municipal planning departments have indicated that there are no existing further plans with the current earmarked site.
☐ **Production process and the operational features of the project**	The facility will use an established algae treatment process as well as a natural wetland water treatment method (situated along the spine of the facility). The production of silk within the facility supplies fabric medium for the algae biofilm and forms part of the intended Community Development Interface.
☐ **Type and quantities of raw materials, energy and other resources consumed**	Methane (biogas) produced on site by the bio digesters will be used for cooking and heating requirements for the site. Construction materials include steel, concrete and gabion walls.
☐ **Residues and emissions by type, quantity, composition and strength**	The removal of heavy metals will be performed by the algae. Chromium, Lead and Copper have been identified and will be removed. The algae biofilms will be placed into an anaerobic bio digester generating Bio gas. Water from the sludge thickening process will enter the algae process again. Sludge containing traces of heavy metals will be removed and taken off site to be incinerated. Air Emissions need to comply with Section 8.1 of Air emissions act. *Note: The Feasibility Phase of the Project will consider the Waste Hierarchy options ensure waste disposal at a hazardous waste site is considered as a last option for this project.*
☐ **Main alternative sites and alternative processes considered**	An alternative site was considered closer to the industrial area, yet the flat topography didn't allow for gravity flow of the industrial effluent through the treatment processes. The current site's sloped gradient facilitates natural movement of the water is ideal for this project. Heavy metal removal through phytoremediation was considered as an alternative method, yet flash floods and storm water flow would wash all the heavy metals into the river network.
Section 2 – Information describing the site and its	**Details**

Summarised Water Treatment and Research Facility with Community Development Interface
Environmental Impact Assessment Information
21 October 2016

*(Compiled as a planning document for early the Feasibility Phase assessment activity and discussion with Environmental Consultant Specialists – which are still to be appointed – **Document For Internal use only)***

environment	
Physical features	
☐ **Population – proximity and number**	Currently uninhabited
☐ **Flora and fauna – in particular protected species and habitats**	High diversity, no protected species found
☐ **Soil – agricultural quality, geology and geomorphology**	Unknown
☐ **Water – aquifers, water courses and shorelines**	Existing natural wetland and stormwater canals
☐ **Air – climatic factors, air quality, etc.**	Airshed Priority Area in terms of the National Environmental Management Act (39/2004) – See Air Quality Act requirements listed at www.environment.gov.za
☐ **Architectural and historic heritage, archaeological sites and features**	None
☐ **Landscape and topography**	Natural gradient towards the river – via natural existing storm waterways
☐ **Recreational uses**	None
Policy framework	
Information considered in this section should include all relevant statutory designations such as sites of special scientific interest, areas of outstanding natural beauty, national parks, green belts, scheduled ancient monuments and listed buildings, etc. *Reference should also be made to national, regional and local planning policy, and relevant EC directives.*	The site's wetland is currently performing environmental tasks of water filtration and purification, yet the heavy metals remain untreated and are potentially entering the Vaal River network. The project intends to protect the existing wetland as well as the established natural diversity.
Section 3 – Assessment of effect	**Details**
Including direct and indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the project.	
Effects on humans, buildings and man-made features	
☐ **Change in population arising from the development**	The water treatment and research facility has an important focus on Community Development. The facility intends to create work for the women of the community through the production of silk on site. The facility has a community auditorium and exhibition hall, yet these are daily visitors/employees and not permanent residents.
☐ **Visual effects of the development on the surrounding area and landscape**	The facility has been submerged into the disturbed landscape. The landscaped architectural form has been designed to be modest and simple. The roof level of the facility does not exceed the existing tree's heights of 10meters.
☐ **Levels and effects of emissions from the development during normal operation**	Incineration of the sludge with traces of heavy metals will take place off site according to regulation. The latest Technology (meeting all the requirements of the Air Quality Act) may allow for onsite incineration facility, which provides the benefit of utilising the onsite bio gas as fuel gas. This will be determined during the Feasibility phase of the Project.
☐ **Levels and effects of noise from the development**	Minor noise from the fabrication of silk. The facility is within close proximity to the R42 and R57. The nearby township of Bophelong township's edge is 1km from the facility.
☐ **Effects of the development on local roads and transport**	A new road has been proposed which links the original town of Vanderbijlpark to the facility. The new road claims an unmanaged series of parks 500meters from R42 and R57 intersection. An existing service road is widened for two way traffic to the facility. The facility will make provision for transport infrastructure on site for employees and community access to the public facilities & spaces on the site.
☐ **Effects of the development on buildings, architectural and historic heritage, archaeological feature and human artefacts**	None
Effects on flora, fauna and geology	

Summarised Water Treatment and Research Facility with Community Development Interface Environmental Impact Assessment Information 21 October 2016

*(Compiled as a planning document for early the Feasibility Phase assessment activity and discussion with Environmental Consultant Specialists – which are still to be appointed – **Document For Internal use only)***

☐ **Loss of, and damage to, habitats and plant and animal species**	The site is 12.9 hectare. 2.6 hectare or 20% of the site has been disturbed. The detention dam (7600sqm) and portion of the facility (3768sqm) will be constructed on disturbed land. The project proposes to keep 75% of the site as conservation area for natural biodiversity. Which leaves the remainder for the optional development of the public facilities, a clinic and an agricultural land remediation centre.
☐ **Loss of, and damage to, geological, paleontological and physiographic features**	None
☐ **Other ecological consequences**	The intention is for the existing ecology to be strengthened by the facility – the facility eventually becoming a micro ecosystem with organisms, plants and insects which uses natural systems to support the process of removal of heavy metals.
Effects on land	
☐ **Physical effects of the development**	The facility is located on the edge of a low lying wetland basin and requires a diversion berm and cut off berm to protect it from extreme flooding conditions.
☐ **Effects of chemical emissions and deposits on site and surrounding land**	Heavy metal hazardous waste will be removed from site and treated according to regulations as a last resort. *Note: Waste Hierarchy viable options will assessed during Feasibility.*
Effects on water	
☐ **Effects of the development on drainage pattern in the area**	The industrial effluent containing heavy metals flowing in the open storm canals will be intercepted and stored in a detention dam before treatment. The stormwater from the eastern residential area and south east Vaal Mall will be directed into the existing wetland via gabion canal.
☐ **Changes to hydrographical characteristics**	Improvement of the quality of water entering the Vaal River via existing natural water ways
☐ **Effects on coastal or estuarine characteristics**	None
☐ **Effects of pollutants, waste, etc. on water quality**	Improvement of the quality of water entering the Vaal River as well as removal of water contaminants
Effects on air and climate	
☐ **Level and concentration of chemical emissions and their environmental effects**	None on site
☐ **Particulate matter**	None – All processes will meet Air Quality Act
☐ **Offensive odours**	None
☐ **Any other climatic effects**	None
Other indirect and secondary effects associated with the project	
☐ **Effects from traffic related to the development**	Unknown :Early logistics study to be done for Feasibility Phase
☐ **Effects arising from the extraction and consumption of materials, water, energy or other resources by the development**	Consumption of Materials The onsite fabrication of silk for the algae biofilm improves the environmental footprint of the treatment facility. A renewable, biodegradable material. Water The monthly rainwater is harvested to use directly for washing of hands, cooking and drinking. Clean raw water from the treatment process and the site grey water will enter the treatment wetland and flow into river network. Clean raw water will be used for the flushing of toilets and cleaning of equipment. Any domestic solid waste from the site will be handled according to Municipal requirements. Energy The methane from the bio digesters is used for the staff canteen and heating requirements. All organic waste is fed into the bio digester. Minimal Electrical power would have to be established to manage and

	control the overall facility. An option to generate electrical power on site by using Bio gas remains an option for this project.
☐ **Effects of other developments associated with the project**	impact on the environmental issues of contaminated land, water and community health will be addressed through developing the agricultural soil remediation centre and Bophelong clinic.
Section 4 – Mitigating factors	**Details**
Where significant adverse effects are identified, a description of the measures to be taken to avoid, reduce or remedy those effects	
☐ **Site planning**	Will be dealt with during EIA planning, activities and interaction with the District community communication sessions.
☐ **Technical measures:** – Process selection – Recycling – Pollution control and treatment – Containment	All these aspects of Technology Selection and alternative options according to the Waste management Hierarchy will be addressed during the Feasibility phase to ensure the Project as a whole is sustainable and successful for the community of Bophelong as a whole.
☐ **Aesthetic and ecological measures:** – Mounding – Design, colour, etc. – Landscaping – Tree planting – Measures to preserve habitats – Recording of archaeological sites – Measures to safeguard historic buildings	Final design and aesthetic options will be presented to the Client – to all decision making & assessment at the end of the Feasibility Phase.
Section 5 – Risk of accidents and hazardous developments	**Details**
When the proposed development involves materials that could be harmful to the environment in the event of an accident, the environmental statement should include an indication of the preventative measures that will be adopted so that such an occurrence is not likely to have a significant effect.	Full formal Project and Technical Risk studies will be undertaken during the early stages of the Feasibility Phase (for the entire Water Treatment and Research Facility with Community Development Interface). Risk reports will be communicated to Client, Local and Provincial Environmental Departments – to ensure all are informed and approvals and support for this positive environmental remediation type project is expedited.

Document assembled by: Jani Grala, Peter Grala (Process and Project Management Engineer), Nico Coetzee (Waste Treatment Specialist Engineer), Coert Welman (Environmental Water Act Specialist Engineer)

SUSTAINABLE BUILDING ASSESSMENT TOOL RESIDENTIAL
1.04

		Achieved
SB	**SBAT REPORT**	**4.7**

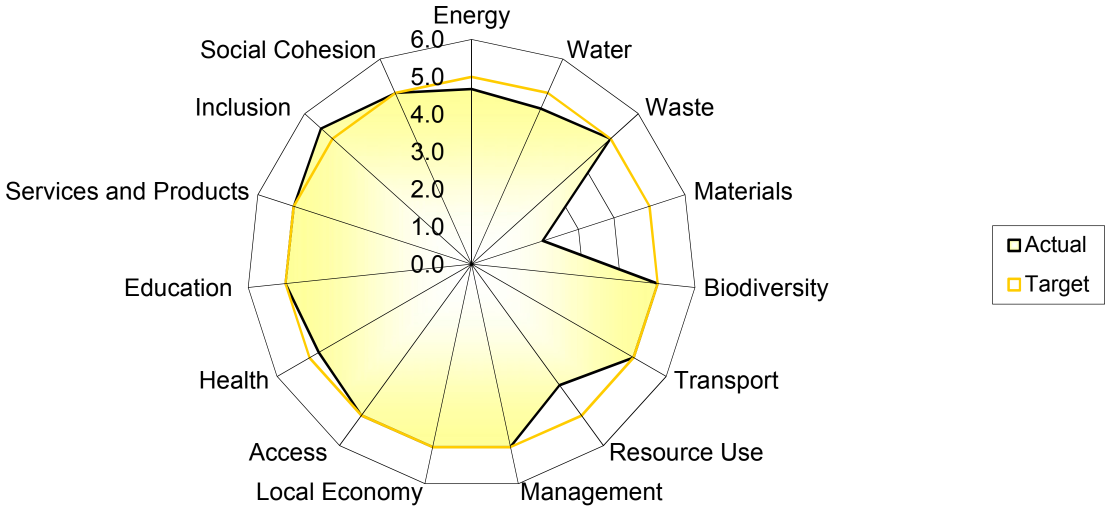
SB1 Project

Water Treatment and Research Facility with Community Development Interface

SB2 Address

North western quadrant of the intersection of the R42 and R57, Vanderbijlpark

SB3 SBAT Graph



SB4 Environmental, Social and Economic Performance	Score
Environmental	4.2
Economic	4.8
Social	5.0
SBAT Rating	4.7

SB5 EF and HDI Factors	Score
EF Factor	4.4
HDI Factor	5.0

SB6 Targets	Percentage
Environmental	85
Economic	96
Social	101

Figure 8.1: SBAT rating for the water treatment facility. (Author,2016)

8.4
LIST OF FIGURES

CHAPTER 1 - INTRODUCTION

CHAPTER 2- A VISION FOR THE PEOPLE

CHAPTER 3 - CONTEXTUAL UNDERSTANDING

CHAPTER 4 - REGENERATIVE THINKING

CHAPTER 5 - PROGRAMME

CHAPTER 6 - DESIGN DEVELOPMENT

CHAPTER 7 - TECHNICAL EXPLORATION

CHAPTER 8 - CONCLUSION

8.5
BIBLIOGRAPHY

Amoroso, N. 2010. The exposed city: mapping the Urban Invisibles. Grafos SA, Barcelona, Spain

BDLive: report questions steel firm ArcelorMittal's social responsibility. 2013. Online:www.bdlive.co.za/business/industrials/2013/11/29/report [accessed 20 April 2016]

Bergstedt, M. 2013. ChEnG: Rotating Algal Biofilm Reactor. Online: www.aiche.org [Accessed 26 August 2016]

Brockett, L. 1996. The History of planning South African new towns: Political influences and social principles adopted. Department of Town and Regional Planning, University of Witwatersrand. Online: dspace.nwu.ac.za/bitstream/handle/10394/5351/No_40 (1996 [Accessed 14th of April 2016]

Central Sericultural Research & Training Institute (CSRTI) :Women in Sericulture. Online: http://www.csrtimys.res.in/women-sericulture (Accessed 22 October)

Chemical Forum: Sizing of Anaerobic Digester Online: http://www.chemicalforums.com/index.php?topic=36925.0 [Accessed 08 September 2016]

ChEnected: Rotating Algal Biofilm Reactor. Online: http://www.aiche.org/chenected/2013/11/rotating-algal-biofilm-reactor-on-location. (Accessed 22 October 2016)

Climate-Data.Org. Climate: Vanderbijlpark. Online: http://en.climate-data.org/location/27392/ (Accessed 21 April 2016)

Divisare: Institute for forestry and nature research. Online: http://divisare.com projects/16701 (Accessed May 2016)

DotMap: Mapping South Africa with dot distribution. Online: https://dotmap.adrianfrith.com/ (Accessed 20 February 2016)

Emfuleni Local Municipality. 2014. Emfuleni Spatial Development Framework 2014/15 Online:http://www.emfuleni.gov.za/index.php/documents-77289/list-of-documents/spatial-development-framework-sdf.html [Accessed 24th of February 2016]

Emfuleni Local Municipality. Online: http://www.emfuleni.gov.za/ (Accessed 02 March 2016)
Engineering News: Anaerobic digestion in wastewater treatment. Online: http://www.engineeringnews.co.za/article/anaerobic-digestion-in-wastewater-treatment-2012-03-30 (Ac-cessed 20 August)

Environmental Affairs and Tourism. 2007. The Vaal Triangle Priority area baseline assessment findings and proposed air quality management interventions. Online: http://www.deat.gov.za.vaal [Accessed 24th of February 2016]

Fazal, S. 2013. Conceptualizing Peri-urban Interface: land use dynamics in a developing country: regional perspectives from India

Gibbons, D. Consultancy to the Mekong Wetlands Biodiversity Program

Groenewald, M. 2000. Bioaccumulation of metals and the general health of fish from the Vaal dam and Vaal river barrage. Magister scientiae in zoology in the Faculty of Science, Rand Afrikaans University.

Hallowes, D. Toxic Futures: South Africa in the Crises of Energy, Environment and Capital

Health Budget Speech: MEC for Health MS QEDANI MAHLANGU AT THE GAUTENG LEGISLATURE. 2015

John, G., Clements-Croome, D. & Jeronimidis, G. 2005. Sustainable building solutions: a review of lessons from the natural world. Building and Environment, 40(3), pp.319-328.

Kiron, M. 2011. Textiles: Characteristics of Silk Fabrics| Properties of silk fabrics. Online: textilelearner.blogspot.co.za [Accessed 26 August 2016]

Littman, J. 2009. Regenerative Architecture: A Pathway beyond Sustainability. Masters Theses. University of Massachusetts

Lucas, R. 2016, Research Methods for Architecture, Laurence King Publishing: London, p.45

Malik, A. 2004. Environmental International: Metal bioremediation through growing cells. Department of applied chemistry, faculty of engineering, utsunomity University. Issue 30 (261-278)

Meadows, D. 2009. Thinking in systems a primer. Online: http://www.ess.inpe.br/courses/lib/exe/fetch.php?media=wiki:user:andre.zopelari:thinking_in_systems_a_primer.pdf [Accessed 05 October 2016]

Meadows, D., Meadows, D.L. & Randers, J. 2004. A Synopsis Limits to Growth the 30 year update. Online: http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf [Accessed 05 October 2016]

Munnik, A. 2012. Discursive power and Environmental justice in the new South Africa: the steel valley struggle against pollution. University of the Witwatersrand.

O'Flaherty, P. 2015. IOL: The hard reality about SA steel industry. Online: www.iol.co.za/business/opinion [Accessed 17 April 2016]

Online: Engineering http://news.mit.edu/2016/silk-based-filtration-material-breaks-barriers-0623 [Accessed 24 July 2016]

Orandi, S. 2012. Biofilm establishment and heavy metal removal capacity of an indigenous mining algal-microbial consortium in a photo-rotating biological contactor. Online: http://www.ncbi.nlm.nih.gov/pubmed/22644382 [Accessed 02 September 2016]

Peres, E. 2016. The translation of ecological resilience theory into urban systems. University of Pretoria

Planet trading. Online: https://www.4colored.com/en/content/10-silk (Accessed 07 October 2016)

Priority area baseline assessment findings and proposed air quality management interventions. 2007
Quodlibet, G. 2005. Manifesto del Terzo Paesaggio, Macerata

Rahmathulla, V. 2012. Journal of Entomology: management of climatic Factors for Successful Silkworm (Bombyx Mori) crop and higher silk production: A Review. Online: www.hindawi.com [Accessed April 2016]

ResearchGate: Use of Algae for Removing Heavy Metal Ions From Wastewater: Progress and Prospects. Online: https://www.researchgate.net/publication/7473476_Use_of_Algae_for_Removing_Heavy_Metal_Ions_From_Wastewater_Progress_and_Prospects (Accessed 22 October 2016)

Saier, M. 2010. Phytoremediation. Water, Air and soil pollution, supplement Issue 205 (61-63)
SANS 10400 : South African Standard Code of Practice for the National Building Regulations. 2011. THE COUNCIL OF THE SOUTH AFRICAN BUREAU OF STANDARDS

Siderwicz, M. 2016. Silk-based filtration material breaks barriers: Engineers find Nano sized building blocks of silk hold the secrets to improved filtration membranes.

The Bench Marks Foundation. 2013. Steel at any cost: a community voice perspective on impacts of ArcelorMittal's operations in Vanderbijlpark, South Africa. Online: http://www.bench-marks.org.za/press/arcelor_mittal_report_nov2013.pdf [Accessed April 2016]

The RIBA President's Medals Student Awards: The Living dam. Online: http://www.presidentsmedals.com/Entry-36301 (Accessed May 2016)

Typical soil properties. Online: https://elibrary.asabe.org/data/pdf/7/sd2009/chap3_cdfiles/Guidelines_for_spreadsheets.pdf (Accessed 24 October 2016)

Vaal Environmental Justice Alliance, 2015. Women Paying the Price for Stolen Tomorrows – The impacts of mineral based industrialization in the Vaal.

Vaal triangle Air shed Priority Area Air Quality Management Plan _Final Plan Government Gazette, 28 May 2009 No.32263

Van der Ryn, S., Cowan, S. 1996. Ecological Design. Washngton, DC:Island Press

Wang, R. 2015. Ecotoxicology and Environmental Safety: evaluation of silkworm excrement and mushroom dreg for the remediation of multiple heavy metal/metalloid contaminated soil using pakchoi. Issue 124 (239-247)

Watkins, D. Shaft No.2: Rescripting the future of Johannesburg's 3rd landscape's through Architecture of the Terraine Vague. Faculty of Art, Design and Architecture University of Johannesburg.

WebMD: Serrepeptase, 2009. Online: www.webmd.com [Accessed April 2016]

ANNEXURE A_
USER'S ACCOMODATION SCHEDULE

Silkworm Rearers (6 trays per a person)
1st Instar (3-4days): 18 trays (50dfl each) – 3 workers
2nd Instar (2-3days): 54 trays – 9 workers
3rd instar (2-3days): 108 trays – 18 workers
4th instar (3-4days): 180 trays – 30 workers
5th instar (6-8days): 360 trays – 60 workers
Total – 60 workers for highest work load
The Rearers will also be responsible for the mulberry plantation.
Biofilm Fabrication
2 cocoon sorters
2 boilers
5 reelers
2 waste removal
1 fabrication manager
Total permanent staff – 11 people
Algae and Wetland System
5 biofilm workers
3 waste removal workers
1 manager
Total permanent staff - 8 people
Researcher Department
1 Algae Culturist Laboratory
1 Silkworm Geneticist Laboratory
1 System Ecologist Laboratory
1 Hydrologist Laboratory
1 Receptionist
Total permanent staff – 5 people
Canteen/Leisure
1 Receptionist
3 Canteen Staff
4 Cleaners
Total permanent staff – 8 people
Auditorium
Max 50 Student visitors/ Students attending lectures/ Community members attending lectures

ANNEXURE B_ DETENTION DAM

Size of the Detention dam calculation	June	July	August	September	October	November	December	January	February	March	April	May
Ave Temperature - Celsius	9.4	9.6	12.5	16.6	19.2	20.0	21.0	21.5	21.3	19.8	16.3	12.7
Base flow - industrial run off												
Daily	400	400	400	400	400	400	400	400	400	400	400	400
Month	12000	12400	12400	12000	12400	12000	12400	12400	11200	12400	12000	12400
Rainfall												
mm	8	10	6	24	67	98	105	114	88	75	52	23
Catchment area m2	704384	704384	704384	704384	704384	704384	704384	704384	704384	704384	704384	704384
Total ave Daily rainfall m3	187.8	234.8	140.9	563.5	1573.1	2301.0	2465.3	2676.7	2066.2	1761.0	1220.9	540.0
Ground & Catchment absorption of rainfall 50%	93.9	117.4	70.4	281.8	786.6	1 150.5	1 232.7	1 338.3	1 033.1	880.5	610.5	270.0
Evaporation 2%-10% based on heat pattern	4.0	5.1	4.0	21.3	68.6	104.6	117.7	130.8	100.0	79.2	45.2	15.6
	-97.9	-122.5	-74.4	-303.0	-855.2	-1 255.1	-1 350.3	-1 469.1	-1 133.1	-959.7	-655.7	-285.6
Ave Daily rain run off entering dam	90	112	66	260	718	1 046	1 115	1 208	933	801	565	254
Ave Daily total water entering dam	490	512	466	660	1 118	1 446	1 515	1 608	1 333	1 201	965	654
Processing Capacity												
9 hours processing time @100% capacity												
18 min to fill/empty system=36min	469.88	469.88	469.88	469.88	469.88	469.88	469.88	469.88	469.88	469.88	469.88	469.88
Daily 2.5 cycles per day	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7	1174.7
Daily water storage requirment												
Only positive amounts require storage	-685	-662	-708	-514	-57	271	340	433	158	27	-209	-520
Excess/(adtional processed) water in the month	-21 228.64	-20 535.19	-21 956.18	-15 940.39	-1 760.28	8 407.31	10 549.54	13 417.99	4 909.59	822.64	-6 493.38	-16 128.47
Total cumulative water in system	-	-	-	-	-	8 407.31	18 956.85	32 374.84	37 284.43	38 107.07	31 613.70	15 485.22
Size of detention dam (m3)										**7 621.41**		

Summary	June	July	August	September	October	November	December	January	February	March	April	May
Daily ave Base flow - industrial run off	400	400	400	400	400	400	400	400	400	400	400	400
Daily ave Rainfall	188	235	141	564	1 573	2 301	2 465	2 677	2 066	1 761	1 221	540
Daily ave total water entering dam	490	512	466	660	1 118	1 446	1 515	1 608	1 333	1 201	965	654
Daily ave processing capacity	1 175	1 175	1 175	1 175	1 175	1 175	1 175	1 175	1 175	1 175	1 175	1 175
	June	July	August	September	October	November	December	January	February	March	April	May
Excess water processing capacity	21 228.64	20 535.19	21 956.18	15 940.39	1 760.28	-	-	-	-	-	6 493.38	16 128.47
Dam capacity	15 485.22	-	-	-	-	8 407.31	18 956.85	32 374.84	37 284.43	38 107.07	31 613.70	15 485.22

ANNEXURE C_ RAINWATER HARVESTING

Rain Water Havesting Information

	June	July	August	September	October	November	December	January	February	March	April	May
Ave Temperature - Celsius	9.4	9.6	12.5	16.6	19.2	20.0	21.0	21.5	21.3	19.8	16.3	12.7
Area of roof catchment												
Planted roof (Noth)	349	349	349	349	349	349	349	349	349	349	349	349
Planted roof (South)	288	288	288	288	288	288	288	288	288	288	288	288
Silk fabrication	238	238	238	238	238	238	238	238	238	238	238	238
Canteen	277	277	277	277	277	277	277	277	277	277	277	277
Rearing hall (North)	190	190	190	190	190	190	190	190	190	190	190	190
Rearing hall (South)	236	236	236	236	236	236	236	236	236	236	236	236
Labs (North)	285	285	285	285	285	285	285	285	285	285	285	285
Labs (South)	285	285	285	285	285	285	285	285	285	285	285	285
Rainfall Data												
mm	**8**	**10**	**6**	**24**	**67**	**98**	**105**	**114**	**88**	**75**	**52**	**23**
Total roof Catchment area m_2	2148	2148	2148	2148	2148	2148	2148	2148	2148	2148	2148	2148
Total ave Daily rainfall m3	0.57	0.72	0.43	1.72	4.80	7.02	7.52	8.16	6.30	5.37	3.72	1.65
Planted roof absorption of rainfall 50% m3	0.08	0.11	0.06	0.25	0.71	1.04	1.11	1.21	0.93	0.80	0.55	0.24
Evaporation 2%-10% based on heat pattern m3	0.02	0.03	0.02	0.13	0.42	0.64	0.72	0.80	0.61	0.48	0.28	0.10
	-0.11	-0.14	-0.09	-0.38	-1.13	-1.68	-1.83	-2.01	-1.54	-1.28	-0.83	-0.34
Ave Daily rain harvested in tanks m3	0.46	0.58	0.34	1.33	3.67	5.34	5.69	6.15	4.76	4.09	2.90	1.31
Ave Daily total harvested m3	0.46	0.58	0.34	1.33	3.67	5.34	5.69	6.15	4.76	4.09	2.90	1.31
Water Demand Requirements												
Water consumption based on per person usage m3	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Daily water excess/(shortage)												
Only positive amounts require storage	-0.67	-0.56	-0.80	0.20	2.53	4.20	4.55	5.02	3.62	2.95	1.76	0.17
Excess water in the month	-20.91	-17.34	-24.69	6.08	78.41	130.22	140.98	155.51	112.18	91.53	54.48	5.26

ANNEXURE D_
USER'S WATER DEMAND

KOHLER.

Home : Water Calculators : Commercial Water Calculator

Commercial Water Calculator

This calculator will assist in estimating your commercial building's water usage in comparison to the U.S. average and the LEED baseline. This tool is for illustration purposes only.

Building Information

Choose your calculation unit:	Liters
Days per year the building is occupied:	250
Number of male occupants:	50
Number of female occupants:	42

	Your Building	US Average	LEED Baseline
Toilets			
Liters per flush:	4.2	7.6	6.1
Flushes per person per day (men):	1	1	1
Flushes per person per day (women):	3	3	3
Water use (liters/day):	739.2	1,337.6	1,073.6
Urinals			
Liters per flush:	0.49	5.7	3.8
Uses per males per day:	2	2	2
Water use (liters/day):	49.0	570.0	380.0
Bathroom Sink Faucets			
Liters per minute:	1.9	7.6	1.9
Minutes per person per day:	.5	.5	.5
Water use (liters/day):	87.4	349.6	87.4
Showers			
Liters per minute:	N/A	7.5	9.5
Average shower duration per person (min.):	0.0	0.0	0.0
% of staff using showers:	0	0	0
Water use (liters/day):	0.0	0.0	0.0
Kitchen/Dining Area Faucets			
Liters per minute:	5.7	7.6	8.3
Minutes per person per day:	.5	.5	.5
Water use (liters/day):	262.2	349.6	381.8

	Your Building	US Average	LEED Baseline
Calculation Results			
Liters per person per day:	12.4	28.3	20.9
Liters per day:	1,137.8	2,606.8	1,922.8
Liters per month:	34,608.5	79,291.0	58,485.8
Liters per year:	284,450.0	651,700.0	480,700.0
% Reduction vs. average:	56.4%		
% Reduction vs. LEED Baseline:	40.8%		

In accordance with Regulation 4(e) of the General Regulations (G.57) for dissertations and theses, I declare that this thesis, which I submit for the Master of Architectural (Professional) at the University of Pretoria, is my own work and has not been submitted by me for a degree at this or any other institution.

I further state that no part of my thesis has already been or is currently being, submitted for any degree, diploma or other qualification.

I further declare that this thesis is my own work. Where reference is made to the work of others, the extent to which that work has been used is indicated and fully acknowledged in the text and list of references.

I further declare that the information in this document is recorded as perceived by the author and combine in its various parts to create a narrative of a polluted environment with no specific mention of the polluter, rather refering to the polluter as the collective heavy industry.

Jani Grala
2016