UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

REVEALING THE HIDDEN

THE CRADLE OF HUMANKIND

by Marli Swanepoel

REVEALING THE HIDDEN

LOCATION
Bolt's Farm,
R563, Sterkfontein,
Krugersdorp, 1739
GPS: -26.027694, 27.717387

PROGRAMME
Chiroptera Vivarium &
Visitor Centre

STUDY FIELDS
Environmental Potential,
Heritage & Cultural
Landscapes

-A.2-

REVEALING THE HIDDEN

OF THE CRADLE OF HUMANKIND

AUTHOR
Marli Swanepoel

Submitted in partial fulfillment of the requirements for the degree Masters in Architecture (Professional)

STUDY LEADER
Dr. Edna Peres

COURSE CO-ORDINATOR
Dr. Arthur Barker

Faculty of Engineering, Built Environment & Information Technology,
University of Pretoria,
2016

DECLARATION

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

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

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

_ _ _ _ _ _ _ _ _ _

Marli Swanepoel

-A.3-

ABSTRACT

Within our current society, humankind often separates 'human place' from 'natural place'. This alienation from nature leads human beings to believe that activities outside of protected natural areas have no effect on the areas demarcated as 'natural' (Mang 2007). This belief is evident within the landscape of the Cradle of Humankind, the only UNESCO-protected natural and cultural World Heritage Site, which is under threat from past and present social and economic activities, including acid mine drainage and poor farming practices. These activities within the Cradle are however not only threatening what is left of the historical landscape, but are also placing pressure on the hidden networks of the landscape. Among the networks which are hidden, is the vulnerable karst ecosystem, which hosts the endangered Schreiber's long-fingered bat colonies, which, in turn, impact on local farm production and the livelihoods of the community (Durand et al. 2010:74).

A significant, yet vulnerable area within the Cradle is Bolt's Farm, located south-west of the Sterkfontein Caves, and forms the focus of this dissertation. It hosts some of the oldest fossiliferous deposits discovered in the area, which offer modern humankind a view into the historical landscape of the Cradle. This historical layer of the landscape, together with the destruction caused by the economic layer, and the opportunities within the social layer, make up the landscape of Bolt's Farm.

Its existing networks are investigated, uncovering the threats to the landscape and using architecture as a way to reveal the opportunities inherent to the landscape. The proposed programme of a tourism route, linking archaeological and bat research facilities builds on the existing tourism network of the Cradle, while protecting the historical and natural landscapes, through the remediation of the destructive impact of the economic landscape.

-A.3-

OPSOMMING

In ons huidige samelewing, skei die mensdom dikwels 'menslike plek' van 'natuurlike plek'. Die vervreemding van die natuur bring mense onder die indruk dat aktiwiteite buite beskermde natuurlike areas geen effek het op die areas wat afgebaken is as 'natuurlik' nie (Mang 2007). Dié wanpersepsie word duidelik gesien in die landskap van die Wieg van die Mensdom, die enigste UNESCO-beskermde, natuurlike en kulturele Wêrelderfenisterrein wat in gedrang gebring word deur die sosiale en ekonomiese aktiwiteite van die verlede en hede, insluitend suur mynwater en onvanpaste boerderypraktyke. Dié aktiwiteite binne die grense van die Wieg is egter nie net besig om die historiese landskap in gedrang te bring nie, maar plaas ook druk op die verskuilde netwerke van die landskap. Dit sluit die kwesbare karts ekosisteem, waarvan die bedreigde Schreiber's lang-vinger vlermuis deel vorm in, wat op sy beurt die plaaslike boerderye en die lewensbestaan van die plaaslike gemeenskap beïnvloed (Durand et al. 2010:74).

'n Merkwaardige, maat tog kwesbare area in die Wieg is Bolt's se plaas. Dié area is suidwes geleë van die Sterkfontein Grotte, en vorm die basis van die verhandeling. Die area bevat van die oudste fossiel neerslae wat in die area ontdek is, wat die moderne mensdom insig in die historiese landskap van die Wieg bied. Saam met die historiese laag van die landskap, vorm die ekonomiese en sosiale lae, die landskap van Bolt se Plaas.

Die bestaande netwerke word ondersoek om die bedreigings van die landskap aan die lig te bring, en argitektuur as 'n middel te gebruik om die geleenthede wat eie aan die landskap is, te verbind. Die voorgestelde programme, in die vorm van 'n toerisme roete wat argeologiese en vlermuis navorsing fasiliteite verbind, bou op die bestaande toerisme netwerke wat gevind word in die Wieg. Terselfde tyd word die historiese en natuurlike lae van die landskap beskerm deur die remediëring van die vernietigende invloed van die ekonomiese landskap.

-A-

TABLE OF CONTENTS

A PREFACE

B BACKGROUND TO THE STUDY

C PERI-URBAN FRAMEWORK

01 INTRODUCTION TO THE DISSERTATION

02 CONTEXT

03 REGENERATIVE THINKING

04 SITE ANALYSIS

05 PROGRAMME

06 CONCEPT

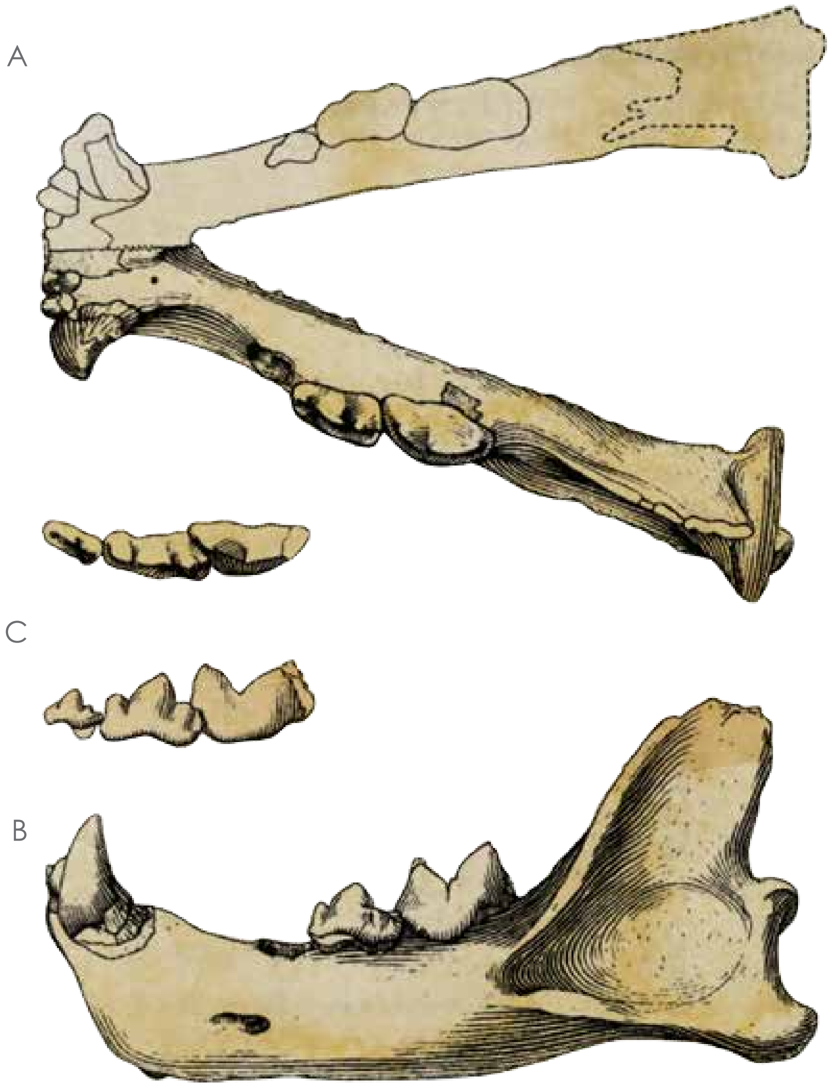
07 DESIGN DEVELOPMENT

08 TECHNICAL INVESTIGATION

09 CONCLUSION

BACKGROUND

THE LANDSCAPE OF THE
CRADLE OF HUMANKIND



▲
FIGURE B.1
DORSAL VIEW (A) & LEFT LATERAL VIEW (B) OF MADIBLE OF BOLT'S FARM 'A'. OCCLUSAL & OUTER LATERAL VIEW (C) OF LEFT CHEEK TEETH OF SPECIMEN 'C'
(Cooke 1991:18)

-B-

THE LANDSCAPE

OF THE CRADLE OF HUMANKIND

B
THE LANDSCAPES OF THE CRADLE OF HUMANKIND

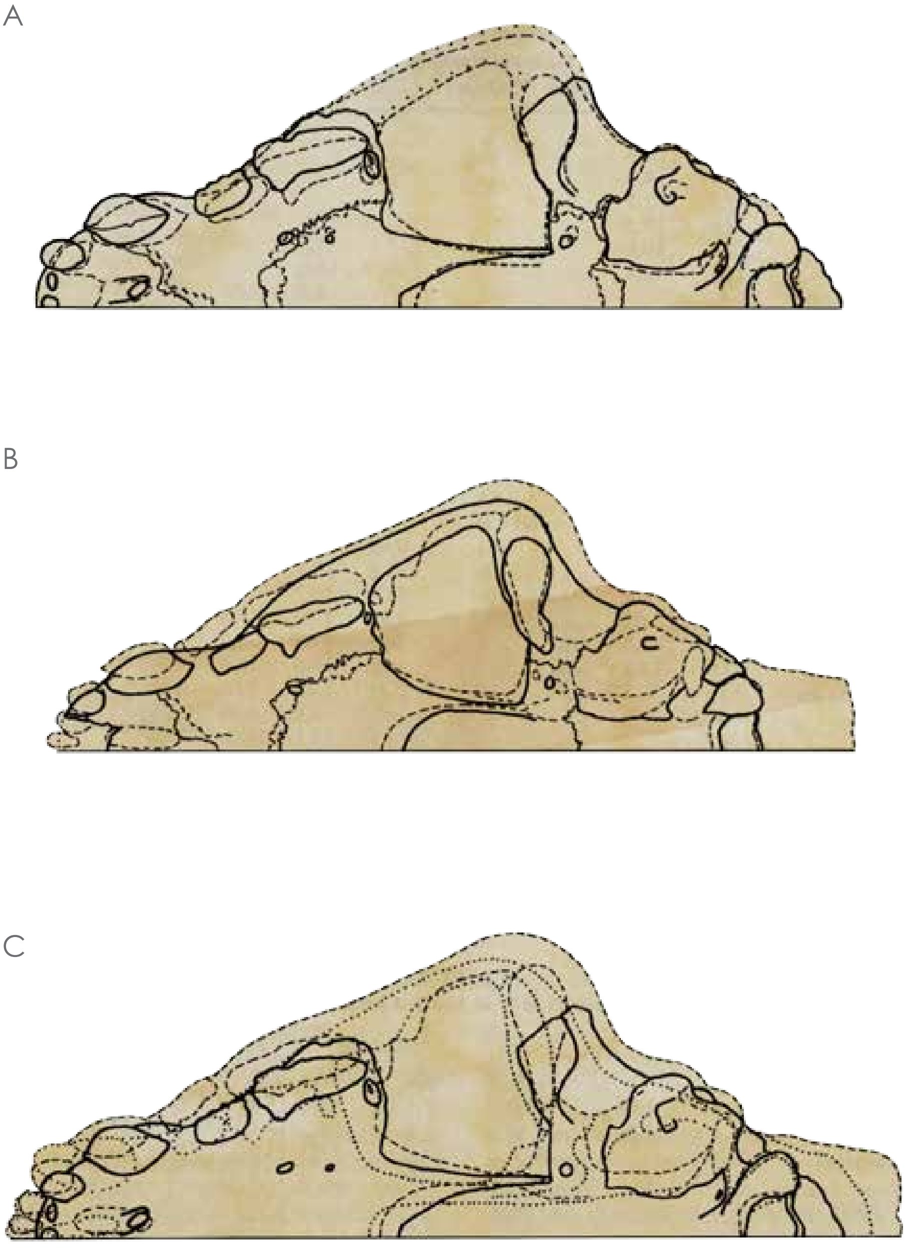
The Cradle of Humankind, located in the Gauteng and North West Provinces of South Africa, is home to a number of fossil-rich sites, including Sterkfontein, Swartkrans, Kromdraai and the Rising Star caves, where the fossiliferous deposits of Homo Naledi were recently discovered (Nhauro 2010:1). This view into the historical landscape of the Cradle offers only a small glimpse into the totality of this landscape, with the economic and social landscapes, together with the historical landscape, contributing to the current state of the Cradle of Humankind.

B.1
HISTORICAL LANDSCAPE

The Cradle of Humankind (hereafter 'the Cradle') is listed as both a natural and cultural world heritage site with the United Nations Educational Scientific and Cultural Organization (UNESCO) (The South African Karst Working Group 2010:14). The Cradle is, however, not only unique due its paleontological and archaeological significance, but also due to its morphology. It rests above a dolomitic karst system that host a unique ecosystem housing a variety of life, from micro-organisms to more than half of the known bat species in South Africa (The South African Karst Working Group 2010:16).

Together with the seminal fossil discoveries of what some believe to be pre-historic human-beings, the fossils of 13 Chiroptera families were discovered in the Cradle (Pretorius 2012:51). This fossil evidence suggests that bats existed in this landscape as far back as the Eocene era, placing these mammals in the landscape far earlier than humankind. It is this landscape where hominoid species once roamed and lived from the landscape, and the conditions within the subterranean layer of this landscape, which enabled the formation and preservation of the fossils of these species, bringing modern interest to this site through the archaeological record.

A
B
C



▲
FIGURE B.2
COMPARATIVE OUTLINES OF PAKATAL ASPECT OF DIFFERENT SPECIMENS OF *DINOFELIS*
(Cooke 1991:18)

B.2
ECONOMIC LANDSCAPE

The Cradle is located adjacent to one of the richest gold bearing ridges in the world, with a few early gold mines, like the Kromdraai Mine, being located within the Cradle itself (Whatley 2015). As a result of the discovery of gold on the Witwatersrand, the city of Johannesburg was established in 1886, and its economy, together with the broader economy of South Africa grew upon its mineral wealth. The existence of these mines of the past might however be detrimental to the preservation of Cradle of Humankind World Heritage Site in its current state.

When many of the gold mines on the Witwatersrand closed down, dewatered voids, some up to 3km underground where left behind. Over time, these voids slowly started filling with water, and in 2002, the springs on West Rand started to flow again. These springs where however contaminated with Acid Mine Drainage AMD.

The Tweelopiespruit is one of the major arteries affected by AMD. The Tweelopiespruit flows through the Krugersdorp Nature Reserve, connecting with the Rietspruit River, which in turn flows into the Blaauwbankspruit, running through the Cradle (Durand et al. 2010:80). The degradation of the structure of the karst system is not the only concern of AMD, as it is also responsible for the degradation of soil quality, which in turn affects both the fauna, including the Schreiber's long-fingered bat, and endemic flora in the immediate environment (Cobbing et al. 2007:622).

This degradation of the ecology and structure of the karst system will have a major impact on both archaeological and palaeontological heritage of the area, leading to the risk of this unique landscape losing it status as UNESCO World Heritage Site. This, in turn, will negatively affect the tourism, hospitality and education sectors of this site, ultimately leading to the loss of the a major part of the community's livelihood within the area (Durand et al. 2010:74).

B.3
SOCIAL LANDSCAPE

The Cradle serves as a popular tourist destination, not only for its archaeological and paleontological findings, but also for hosting a variety of adventure sports, game lodges and other tourist activities. The pressure tourism places on the area is, however, contradictory to the principle of conservation; a core principle of World Heritage Management. The principle states that World Heritage sites should ought to retain a function within the current community, while being conserved for future generations (Landorf 2009:53).

Eco-tourism is the fastest growing sector in the tourism industry, and is seen as a strategy to simultaneously promote nature conservation, as well as sustainable local development (Ross and Wall 1999 :123). Although the motivation for initiating eco-tourism initiatives varies greatly, the concept of eco-tourism introduces an alternative to traditional consumptive tourism. This concept starts to explore the possibility of tapping into existing tourism and recreational networks of the Cradle, implementing a strategy of preservation for the unique fossiliferous deposits of the historical landscape of the area, as well as a conservation strategy for the karst ecosystem, including a bat conservancy.

PERI-URBAN FRAMEWORK

THE CRADLE CORRIDOR

-C-

PERI-URBAN FRAMEWORK

THE CRADLE CORRIDOR

C.1
MANAGEMENT OF A WORLD HERITAGE SITE

World Heritage Sites, such as the Cradle of Humankind World Heritage Site, are often faced the with the predicament of managing the balance between short-term economic gain and long-term preservation (Wager 1995:517). The increase of tourism within a given area often places pressure on its artefact or heritage resources, contradicting the core principle of conservation. The World Heritage Management principle of conservation states that World Heritage sites should retain a function within the current community, while being conserved for future communities (Landorf 2009:53). The balance between tourism and conservation thus relies on the community, taking into account both the values of and threats to the economy, heritage and ecology of the World Heritage Site, and the surrounding environment.

C.2
STRATEGY

The Cradle of Humankind World Heritage Site and Dinokeng are initiatives of the Gauteng Provincial Government to establish geo-spatial tourism destinations, close to the densely populated metropolitan areas of Johannesburg, Tshwane and Ekurhuleni. If managed and planned properly, local and international tourism can be used to add immense value in the form of the appreciation of the prehistoric remains to the site, thereby provide contemporary worth to the area, helping to protect it. The area already boasts thousands of cyclists every weekend, and acts as a "garden" for the city.

Taking existing tourism networks into consideration (Annexure A), the framework focuses on developing a conservation strategy, which relies on the economic development of the Cradle, associated with tourism development. The rural nature of the Cradle and the richness its ecology holds within it is an opportunity for the area to become a heritage park, which is rich in memory and biodiversity. The group urban framework concentrates on the southern edge of the Cradle, which acts as the gateway to the larger world heritage site, and contains the highest known amount of discovered fossil sites. The framework not only aims to address the issue of conservation of the world heritage site, but also aims to address the unarticulated, commodified and fragmented nature of the Cradle of Humankind.

C.3
METHODOLOGY

The framework was developed for the Cradle of Humankind through determining a strategy for long term preservation, with short term gains. The dynamics of tourism and conservation were analysed, in order to draw on the positive qualities of each, while preventing possible economic, heritage and ecological threats.

FIGURE C.1
PROPOSED HERITAGE FRAMEWORK
(Author, 2016)

C.4
INTENTION

Owing to the location of the Cradle, an hour's drive away from two major cities, Pretoria and Johannesburg, the area is envisioned as a future tourism corridor, and as an escape from the city with activities, such as hiking, sporting activities and leisure.

C.4.1
HERITAGE & TOURISM
C.4.1.1
THE FOSSILS & OTHER TOURISM ACTIVITIES

The framework takes into account the location of the fossil findings within the boundaries of the Cradle. Due to the nature of the formation of fossils, the most fossils findings are clustered around the Riet Spruit and Blaauwbank Spruit. These water bodies run along the major vehicular routes, along which most other tourism activities are found, such as adventure sports facilities, sculpture gardens, and accommodation.

C.4.1.2
UNESCO HERITAGE CONSERVATION FRAMEWORK

The UNESCO strategy for managing tourism at World Heritage Sites include the following strategies (Pedersen 2002:96):

- reducing the number of visitors to a site;
- changing visitors' behaviour;
- dispersing or concentrating people to reduce use in a particular area;
- reducing conflicts between visitors;
- reducing conflict between local people and the communities;
- encouraging visitors to practise particular activities; and
- making the physical environment more resistant to impacts.

C.4.1.3
PROPOSED HERITAGE FRAMEWORK

With the development of the framework, the management strategies for World Heritage Sites, as proposed by UNESCO, which have a physical or spatial impact, were taken into consideration. The intention of the proposed framework is to cluster future commercial activates around existing commercial activities, with tourists moving along a "Cradle corridor". This corridor, with necessary infrastructure, accommodates tourism, while managing and limiting the extent to which the tourists are allowed to move within the Cradle. This approach protects existing sites, as well as future discoveries, and connects the site as one world heritage site. Information points, together with access to parking and transportation services, are placed at the entrances to the corridor, limiting vehicular activity in the area, and announcing the status of the site

C.4.2
ENVIRONMENTAL CONSERVATION
C.4.2.1
THE STATE OF THE ENVIRONMENT OF THE CRADLE OF HUMANKIND

Together with the seminal fossil discoveries of pre-historic humans, the Cradle also offers visitors to the area a view into the rich biodiversity of South Africa (Annexure A), spanning two biomes, including the grassland and bushveld biomes (Eloff 2010:19). The Cradle is also home to complex karst system, an underground network of rivers and cabins formed within carbonate rich rock such as limestone and dolomite (Leyland 2008:67). The surface of the landscape, as well as the hidden karst network, are, however, becoming increasingly threatened by a multitude of factors, such as mining, agriculture, tourism, and increased urbanisation of the area.

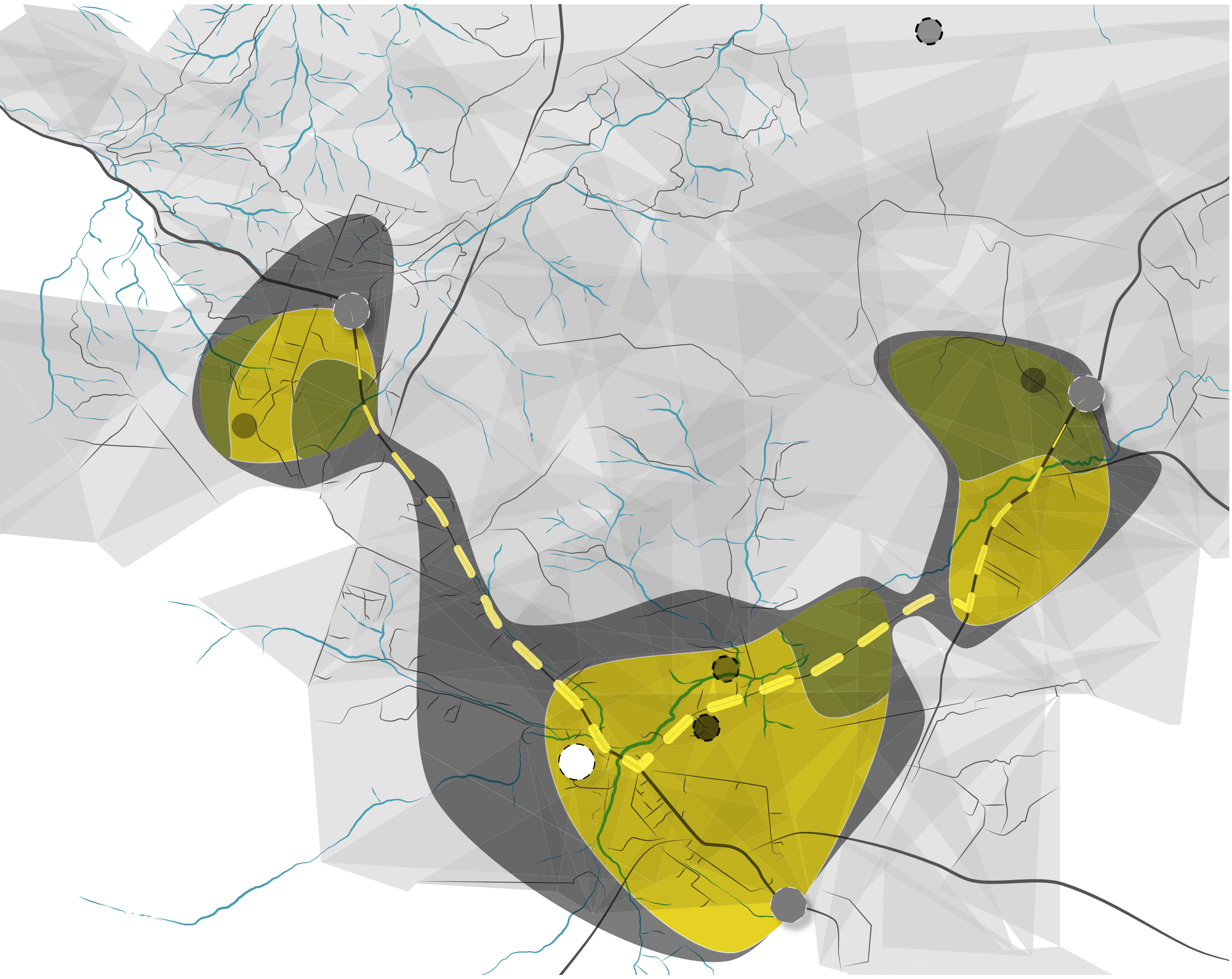
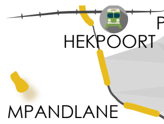


FIGURE C.2
PROPOSED ENVIRONMENTAL FRAMEWORK
(Author, 2016)



C.4.2.2
CLIMATE CHANGE ADAPTION FOR NATURAL WORLD HERITAGE SITES

As a response to the state of environment, Falzon and Perry (2014) developed a practical guide for climate change adaption for natural world heritage sites. The guide proposes a holistic approach to the protection of the heritage and bio24diversity, while retaining the site as a key for tourism. The strategy, as proposed by Falzon and Perry (2014) includes practical and strategic actions, such as creating buffer corridors, and the development of infrastructure.

C.4.2.3
PROPOSED ENVIRONMENTAL FRAMEWORK

Building on the proposed Heritage Framework for the Cradle, buffer zones are created around the commercial clusters, to limit public access into sensitive, undisturbed sites. The framework also builds on existing projects in the area, aiming at the removal of invasive species, the rehabilitation of the polluted river, and community uplifting and involvement. A sensitive intervention strategy is crucial, and therefore the strategy focuses more on long-term strategic interventions, with limited practical action.

0.4.3
COMMUNITY INVOLVEMENT
0.4.3.1
THE COMMUNITY OF THE CRADLE OF HUMANKIND

The majority of the community living within the border of the Cradle are employed in the agricultural sector, with more than three quarters of the community living in informal dwellings. The Panorama, Tweefontein and Kromdraai (Annexure A) informal settlements are the three major informal settlements found in the region, with many other small informal settlements dotting the landscape of the Cradle (Mogale City Local Municipality 2011).

C.4.3.2
COMMUNITY INVOLVEMENT & CURRENT STAKEHOLDERS

The Cradle of Humankind Trust aims to develop the region for the benefit of the tourism industry, together with the local community. The current stakeholders include the Mogale City local municipality, tourism establishment owner forums, and local community formations, amongst others. The COH trust aims to use tourism to uplift the community, through projects such as housing and skills development. The objectives of the trust include job creation, tourism job skills, and enterprise development (Mogale City Local Municipality 2011).

C.4.3.3
PROPOSED COMMUNITY FRAMEWORK

The proposed community framework aims to improve the access to the commercial clusters, providing local communities with the opportunity to engage with the tourism market, thus providing economic opportunities. The framework proposes a series of bus stops and routes connecting to existing train and bus stops, leading from the informal settlements along the "Cradle corridor".

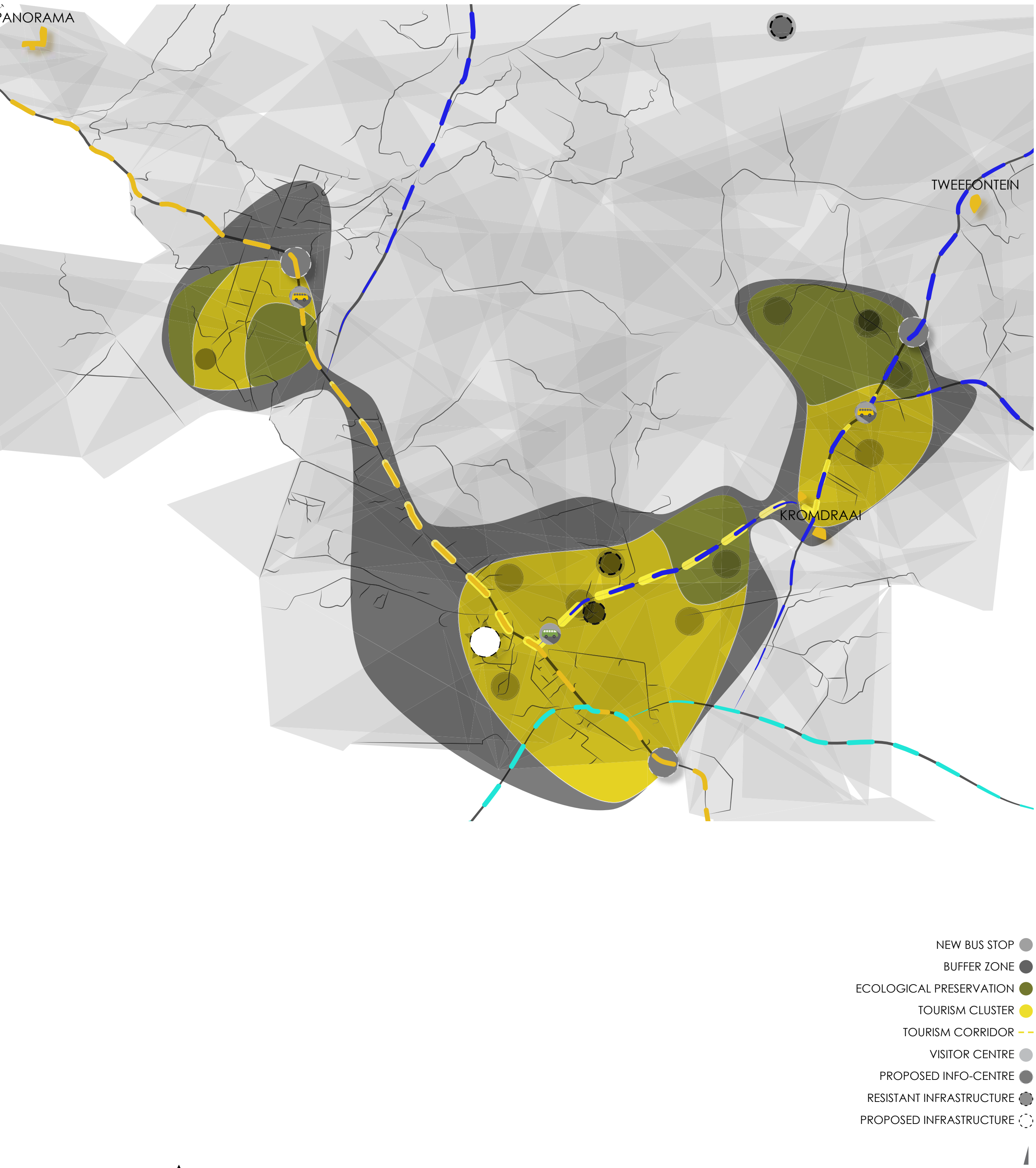


FIGURE C.3
PROPOSED COMMUNITY FRAMEWORK
(Author, 2016)

TOURISM BUS ROUTE

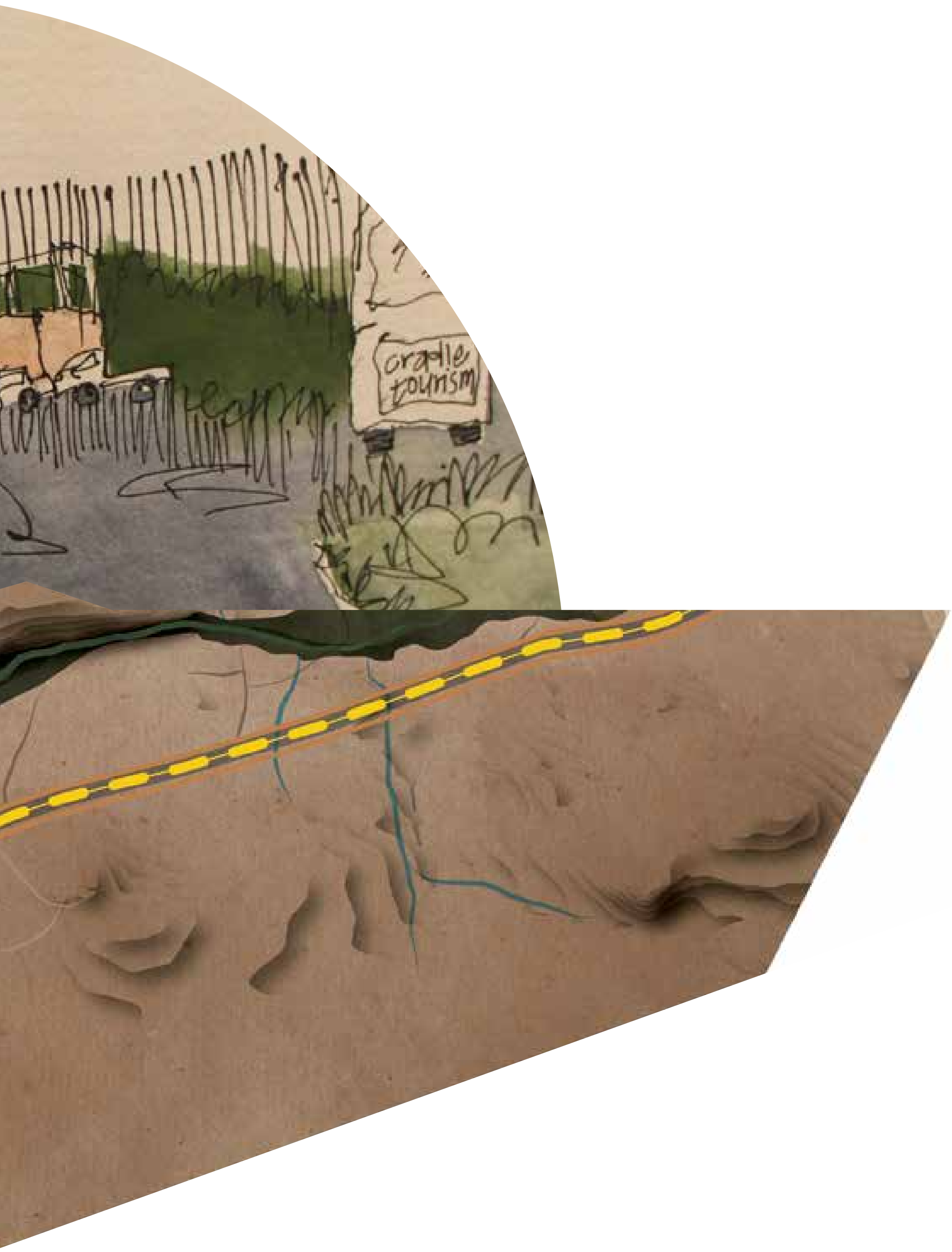
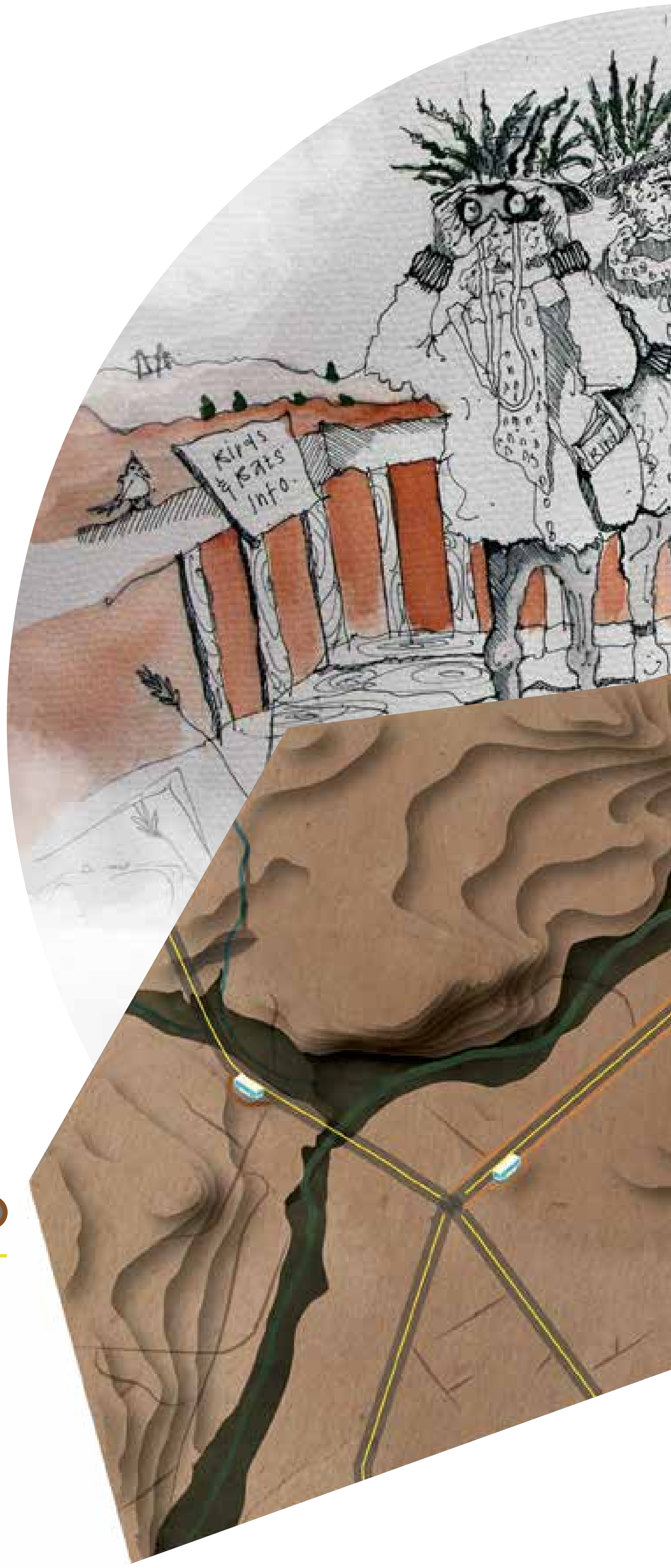


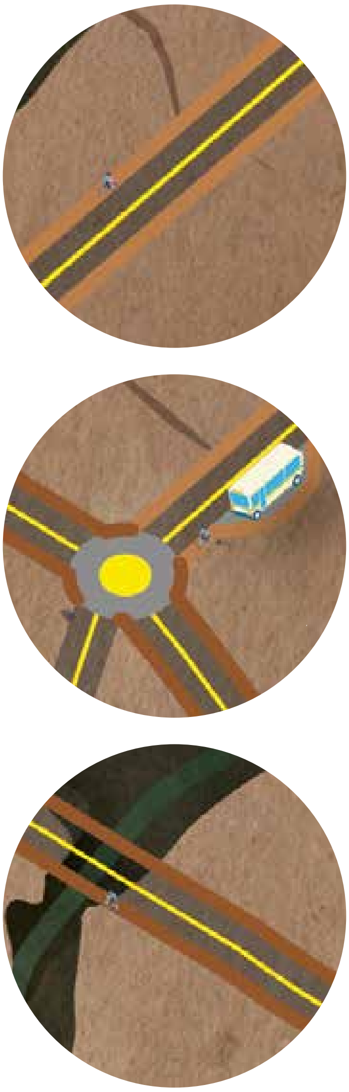
FIGURE C.4
BUS ROUTES
(Author & Barnard, AA, 2016)



BUS STOP [2km]

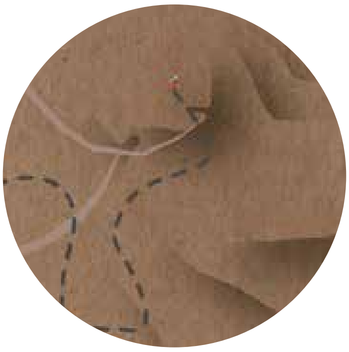
TOURISM BUS ROUTE

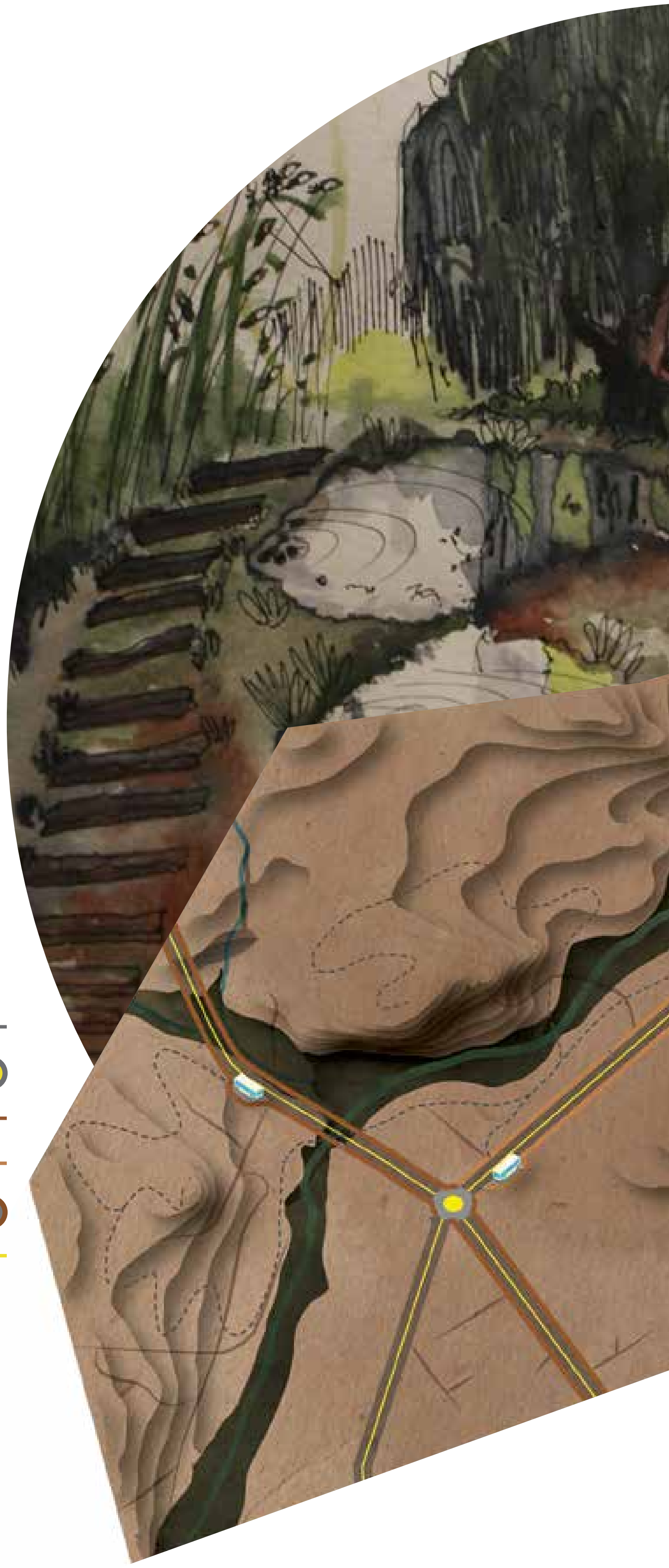
▲
FIGURE C.5
BUS STOPS
(Author & Barnard, AA, 2016)




TRAFFIC CALMING CIRCLE
NEW CYCLING LANE
EXISTING CYCLING LANE
BUS STOP [2km]
TOURISM BUS ROUTE

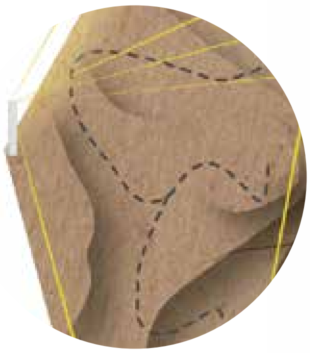
▲
FIGURE C.6
CYCLING LANES
(Author & Barnard, AA, 2016)

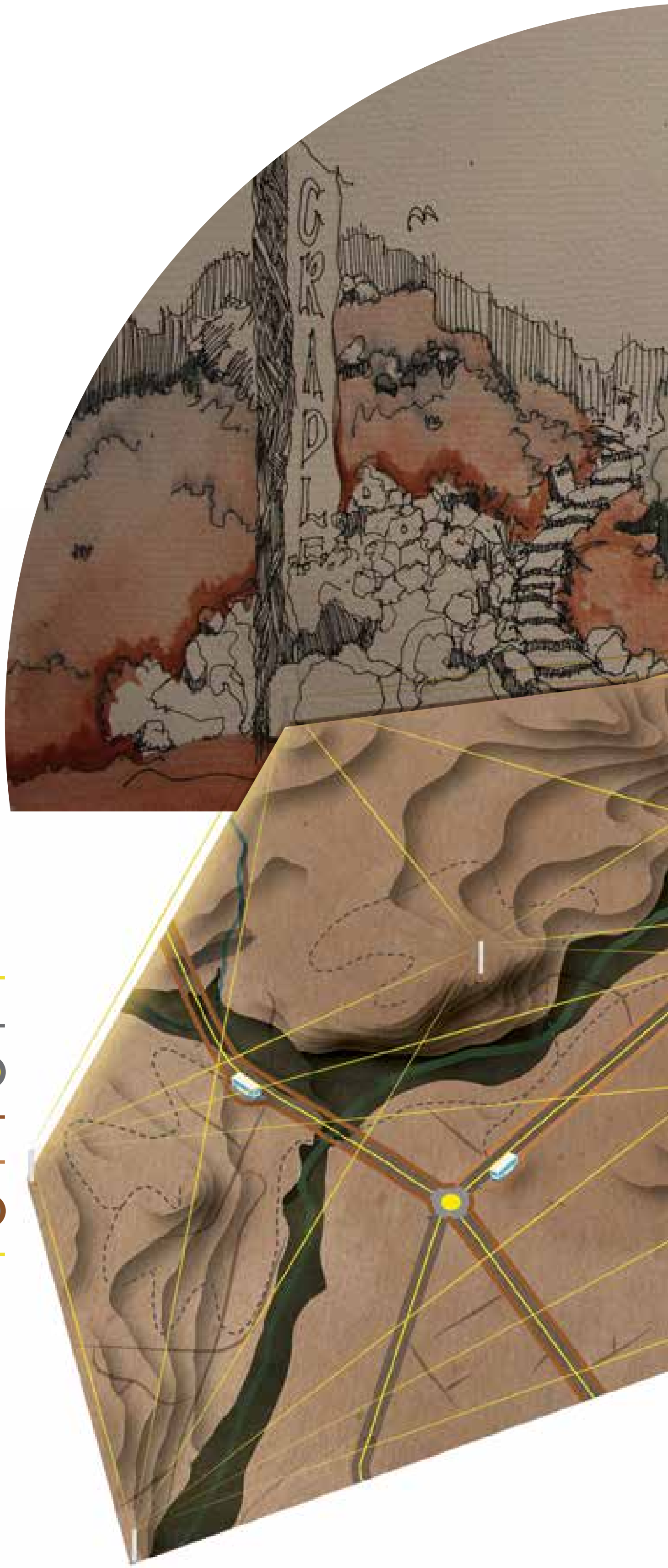




HIKING TRAIL
TRAFFIC CALMING CIRCLE
NEW CYCLING LANE
EXISTING CYCLING LANE
BUS STOP [2km]
TOURISM BUS ROUTE

FIGURE C.7
HIKING TRAILS
(Author & Barnard, AA, 2016)




MOMENT IN TIME
HIKING TRAIL
TRAFFIC CALMING CIRCLE
NEW CYCLING LANE
EXISTING CYCLING LANE
BUS STOP [2km]
TOURISM BUS ROUTE

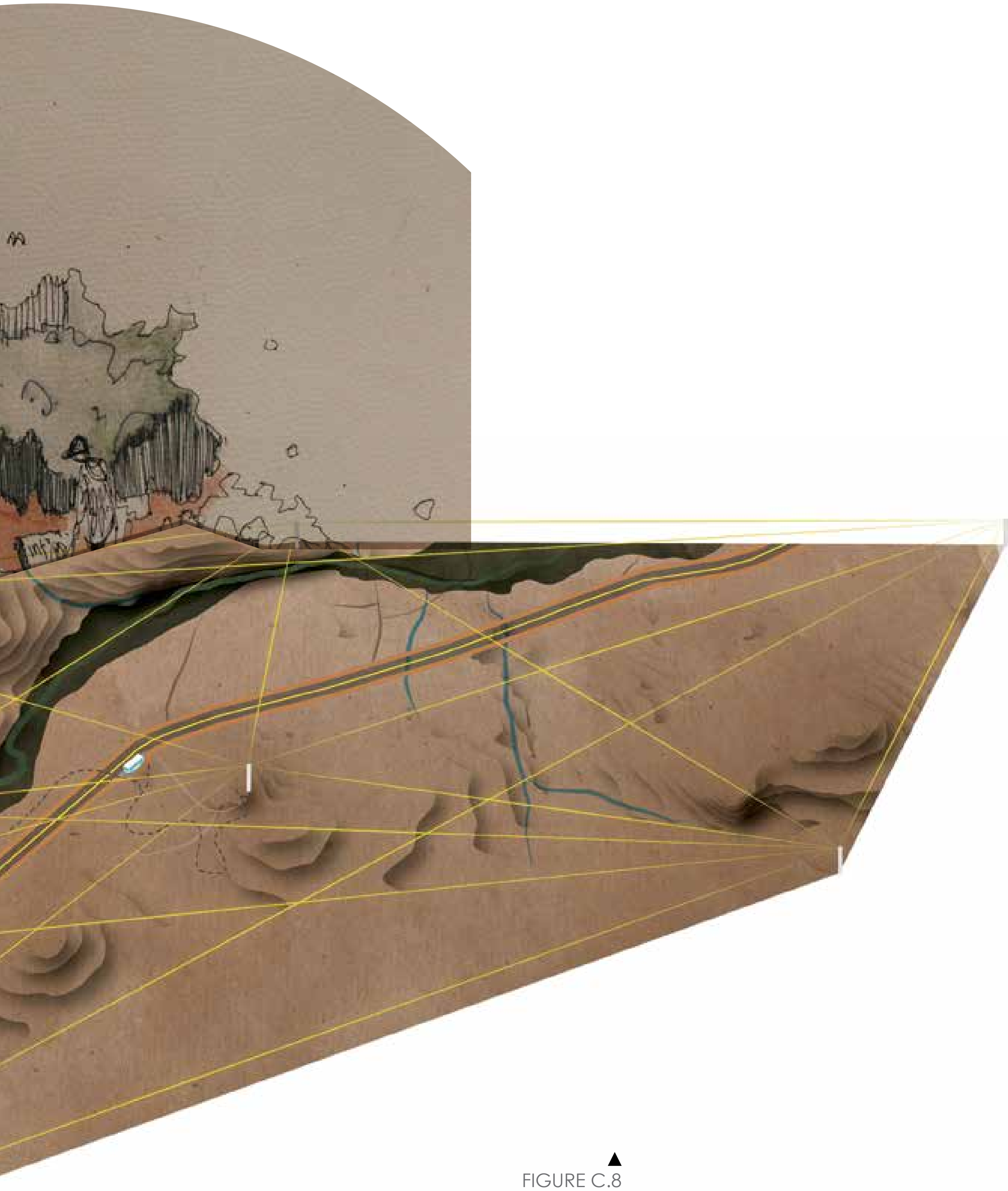


FIGURE C.8
ORIENTATION DEVICES
(Author & Barnard, AA, 2016)

INTRODUCTION

CONNECTIONS & PLACE

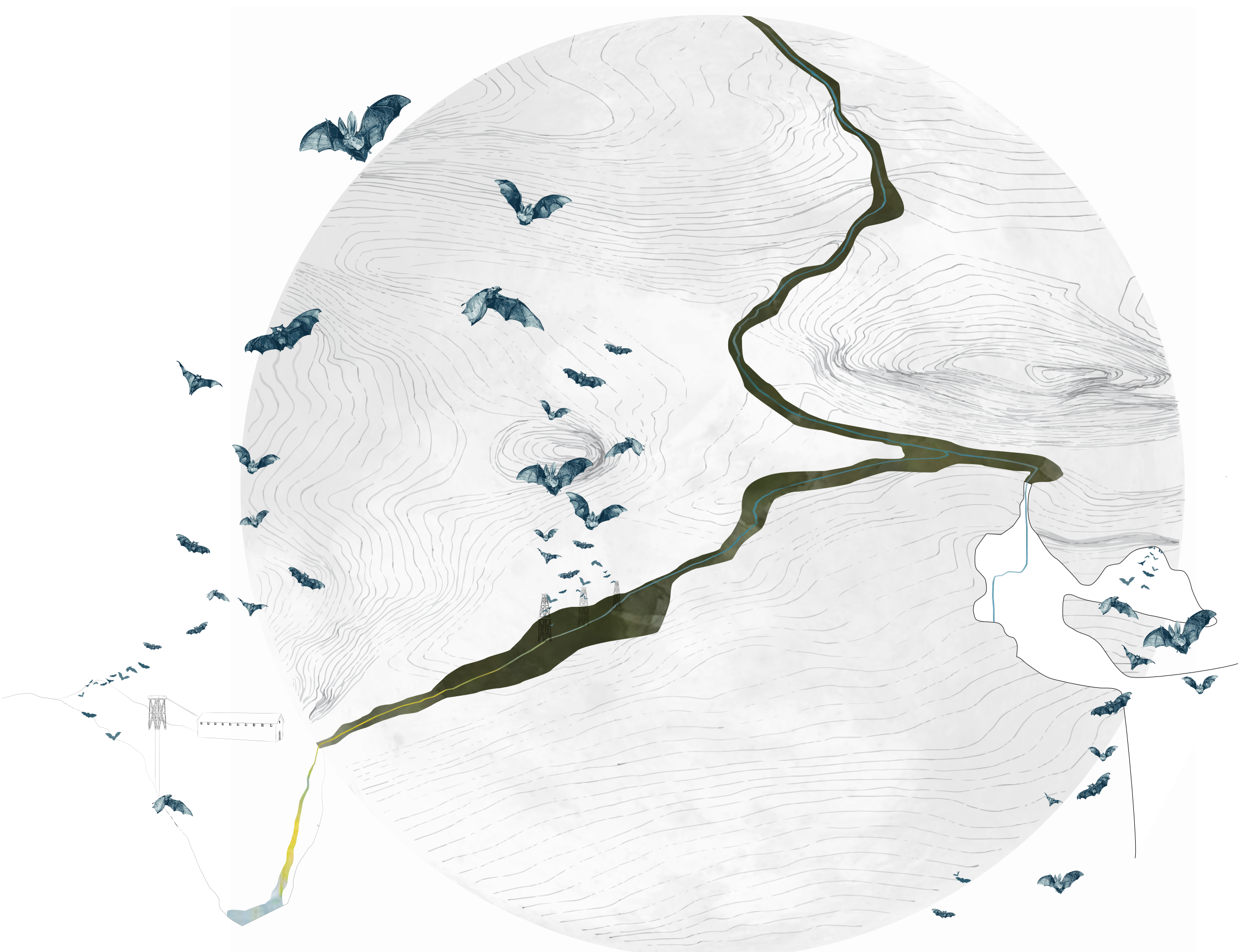


FIGURE 1.1
BOLT'S FARM CONNECTIONS
CONCEPT IMAGE
(Author , 2016)

-1-

CONNECTIONS

INTRODUCTION TO THE DISSERTATION

Within our current society, humankind often separates 'human place' from 'natural place'. This alienation from nature leads human beings to believe that activities outside of protected natural areas have no effect on the areas demarcated as natural (Mang 2007). This belief is evident within the landscape of the Cradle of Humankind, the only UNESCO-protected natural and cultural World Heritage Site, which is under threat from past and present social and economic activities, including acid mine drainage and poor farming practices. The social and economic activities within the Cradle are however not only threatening what is left of the historical landscape, but are also placing pressure on the hidden networks of the landscape. This includes the vulnerable karst ecosystem, hosting the Schreiber's long-fingered bat colonies, which, in turn, impacts local farms and the livelihoods of the community (Durand et al. 2010:74).

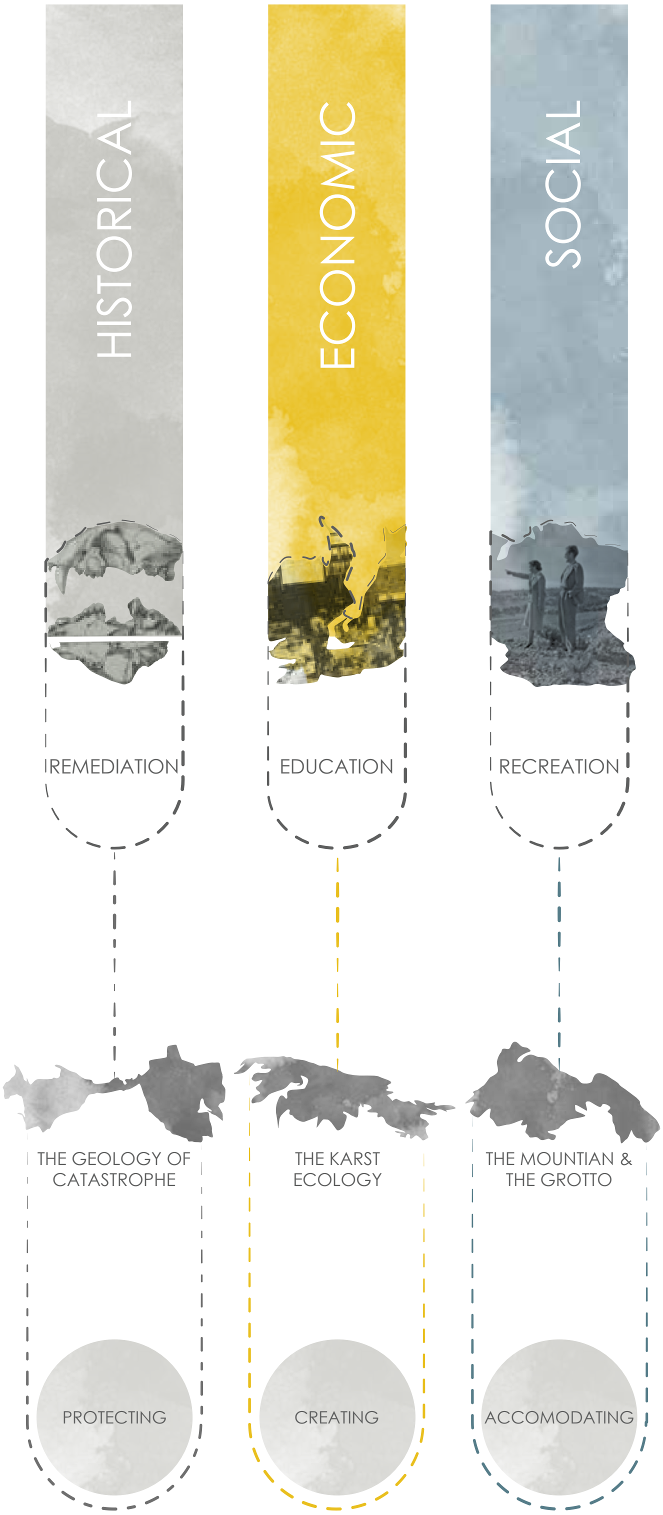


FIGURE 1.2
DESIGN FRAMEWORK
(Author , 2016)

1.1 PROBLEM STATEMENT

The Cradle allows modern human-beings a view into the past landscape of the region. This view into the past, and the future of the landscape, is however under threat, due to past and present activities by humankind in and surrounding the Cradle. Not only is a disconnect between humankind and nature evident, but so too is a disconnect between the three layers of the landscape of the Cradle, namely the historical, economic, and social landscapes.

The rich pre-historical history, together with the geological and ecological significance, contributes to the unique character of the Cradle of Humankind. The tourism industry of the Cradle is, however, often viewed as a commodified heritage experience, removing the objects and artefacts from the context that give it meaning (Naidu 2008:190).

The challenge lies in the development of an appropriate architectural response to landscape, developing a tourism-based intervention, which aims to serve all three layers of the landscape, and reveals and connects the hidden and forgotten layers and networks of this landscape.

1.2 PROPOSED CONTEXT

The study area is situated towards the Krugersdorp border of the Cradle. The Cradle is most well-known for the series of fossil rich sites, including the Sterkfontein and Rising Star caves, where the fossiliferous deposits of Ms Pless and Homo Naledi were respectively uncovered (Nhauro 2010:1). The specific site is located in the North Eastern quadrant of Bolt's Farm, a site comprising the largest collection of fossiliferous deposits, ranging from between 1.5 and 4.5 million years ago (Gommery and Potze 2013, :2).

The fossiliferous deposits of Bolt's Farm are not only some of the oldest fossils discovered in the Cradle, but were discovered in the area of karst system most severely impacted by acid mine drainage (AMD) and sewage effluent from the West Rand (The South African Karst Working Group 2010:23). The influence of these two epochs of the landscape, the historical and economic ages, is seen in the current state of the landscape. These two layers of the landscape, together with the social landscape, determine the future of the Bolt's Farm.

1.3 RESEARCH QUESTIONS

What is the current relationship between humankind and nature, and how has the structure of this relationship influenced the way in which the landscape has been formed by humankind?

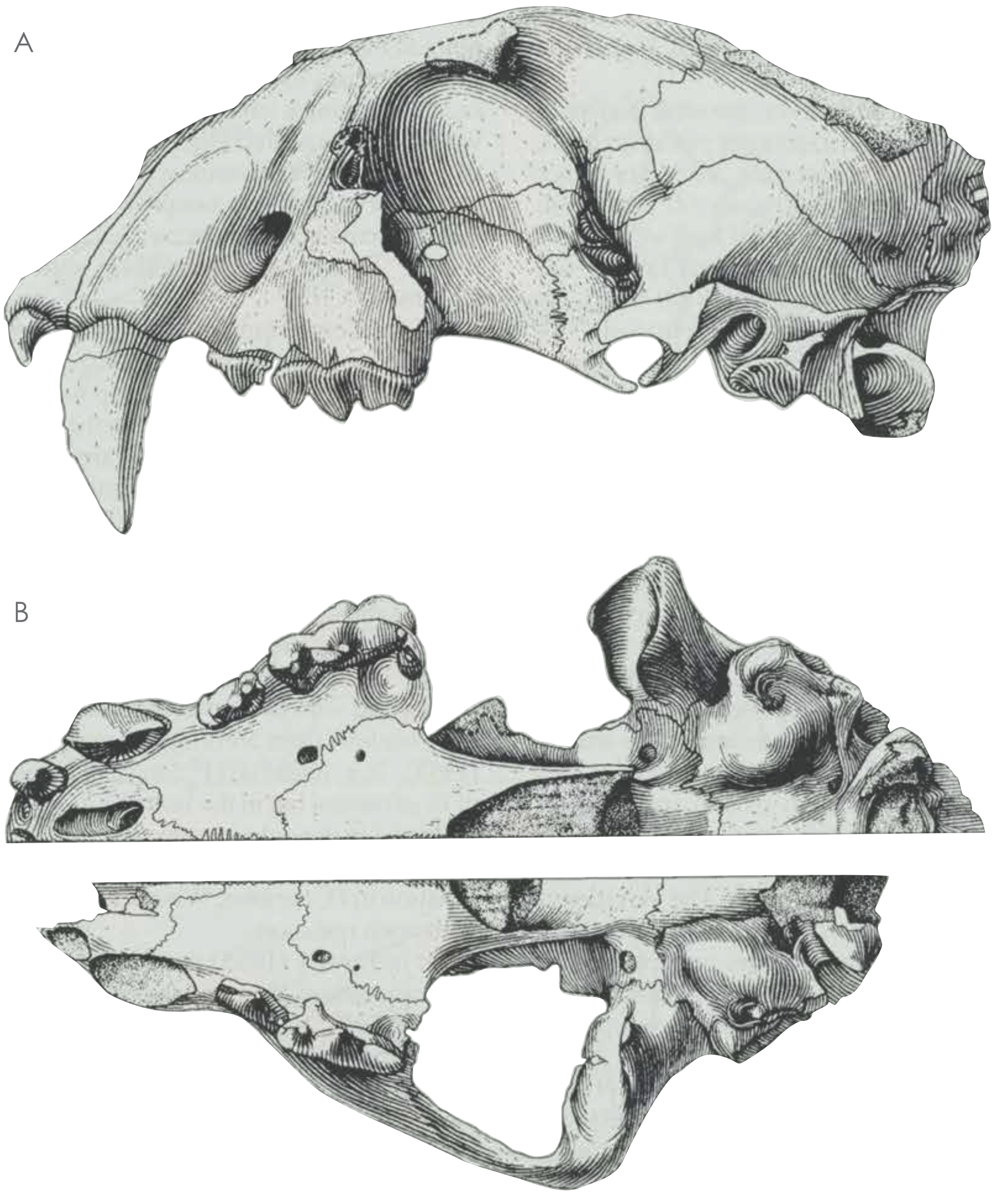
What methods can be utilised to determine the existing networks of a place in order to understand the uniqueness and inherent potential of a place, as a way through which a scarred landscape can be remediated, local and visiting communities can be informed about the ongoing threats to the landscape, and all layers of the landscape can serve as recreation to all visitors (local and tourist)?

How can the relevance and importance of the fossiliferous deposits discovered at Bolt's Farm be understood and valued by the local and visiting tourism community, as a unique series of discoveries, and in the context of the Cradle specifically?

How can the perception of tourism in the Cradle move away from a commodified heritage experience to a 'take-home' visitor experience?

A

B



▲
FIGURE 1.3
LEFT LATERAL VIEW (A) & PALATAL VIEW (B)
OF THE CRANIUM OF *DINOFELIS BARLOWI*
(Cooke 1991:13)

1.4 DISSERTATION QUESTIONS

How can architecture assist the way in which the impact of human-beings in a landscape is perceived, by moving away from a disruptive impact on the living systems of the landscape towards a positive one?

What role can architecture play in the building of connections between the three layers of the landscape, namely the historical, economic, and social layers, as well as the relationships and connections between the current and future users and visitors to Bolt's Farm?

How can architecture create a physical interaction between the visitors and the landscape, including the living networks found in the landscape, without negatively disrupting the landscape, to be conductive to the formation of new memories and relationships, and so forming a take-home visitor experience?

In what way can spaces be created through architecture to allow for the co-evolution of humankind together with other living beings, to create spaces which are not only beneficial for the dominant user of the space, but which are mutually beneficial for all components hosted in the habitat?

1.5 DISSERTATION INTENTIONS

The intention of this dissertation is to reconsider the current discourse in architecture in dealing with the landscape, proposing an alternative method in which humankind actively engages with, and accepts its role as a component of nature. The dissertation aims to establish a precedent for the tourism industry of the Cradle of Humankind, as well as a precedent for future developments in a karst region. It aims to introduce a new programme to Bolt's Farm, building on the existing tourism networks of the Cradle, to align the three layers of the landscape, increase the sense of ownership of the karst system, and to increase the biodiversity and ecological health of the site. The project aspires to develop an architecture which allows for co-evolution, creating spaces which allow for all users to not only co-exist, but to thrive in the habitat created.

1.6 RESEARCH METHODOLOGY

The research methodologies utilised in this dissertation aim to address the general and dissertation-specific questions, as well as support the development of an appropriate architectural response.

Archived and historical data, including archaeological reports, copies of original photographs, and maps, where collected so as to gain an understanding of the development of the site, both from an archaeological stance, as well as from the development of the site since the advent of humankind in the area.

Desktop studies, including content analysis, secondary data analysis, and comparative analysis, together with participant observation, were utilised as a method to map the various layers of the landscape of Bolt's Farm. Together with the quantitative data gathered through desktop studies, the participant observation method allows for the collection of qualitative data.

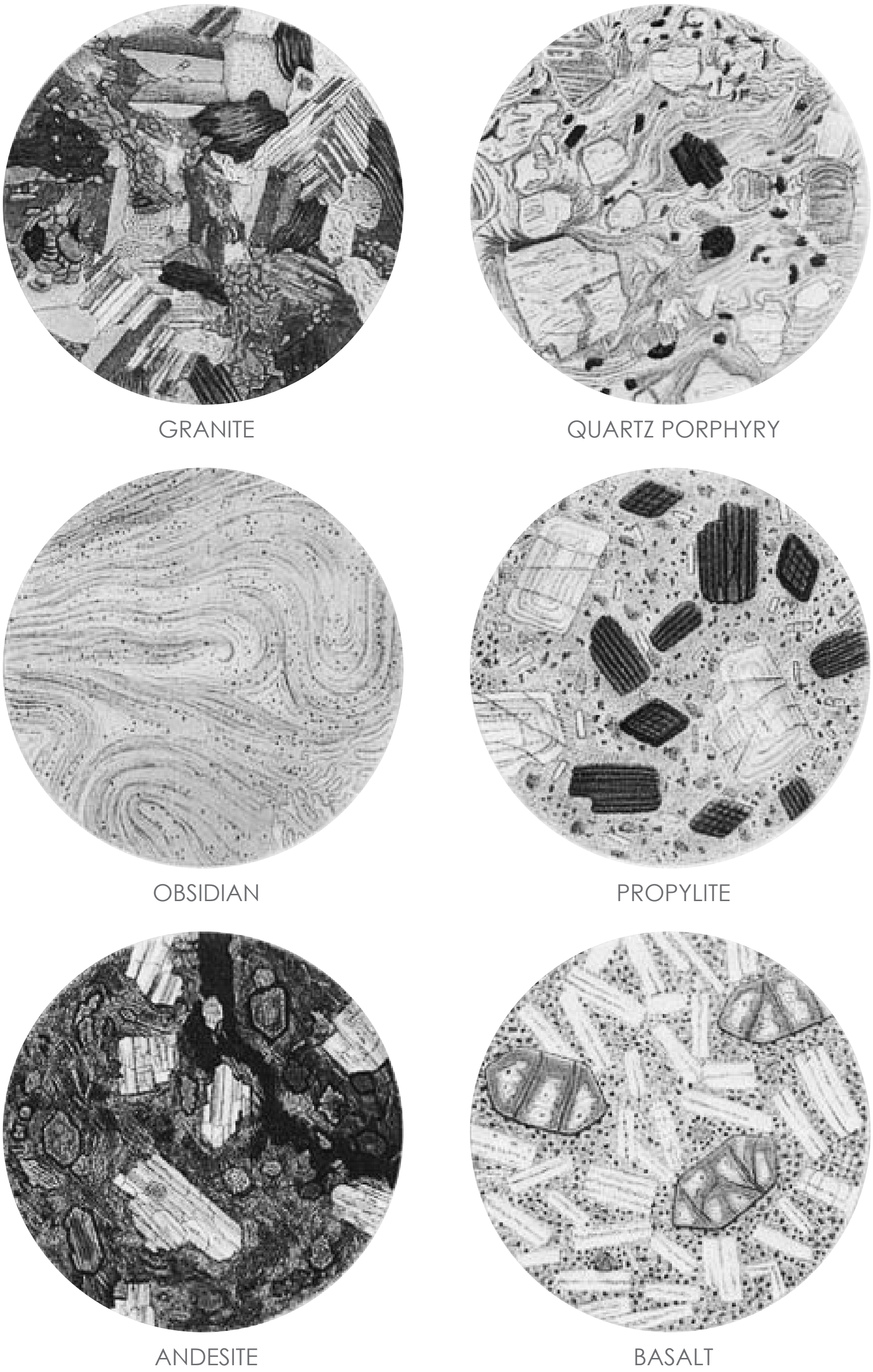


FIGURE 1.4
CHROMOLITHOGRAPH OF ROCKS
UNDER A MICROSCOPE
(Carambas Vintage, 1923)

A review of literature, together with the investigation of critical theories, contributed to the understanding and development of a theoretical response to the conditions of the context and specific site, in turn guiding the development of programme and design. The programme was further developed through case studies and interdisciplinary research, allowing for an understanding of the workings of various components of the chosen programme.

A conceptual design approach was developed as a response to the geology of the landscape, which was refined into a tectonic concept, and iterated through a critical review process.

1.7 DELIMITATIONS

The statement of significance of the Bolt's Farm as Natural and Cultural World Heritage Site as accepted as inscribed by The United Nations Educational, Scientific and Cultural Organization (UNESCO).

The urban framework for the development of tourism facilities does not aim to redesign existing tourism facilities, but serves as a guideline for further tourism development.
The dissertation will not attempt to develop an alternative method for the treatment of acid mine drainage (AMD), but rather, suggests the implementation of existing passive treatment solutions for AMD as part of the larger framework.

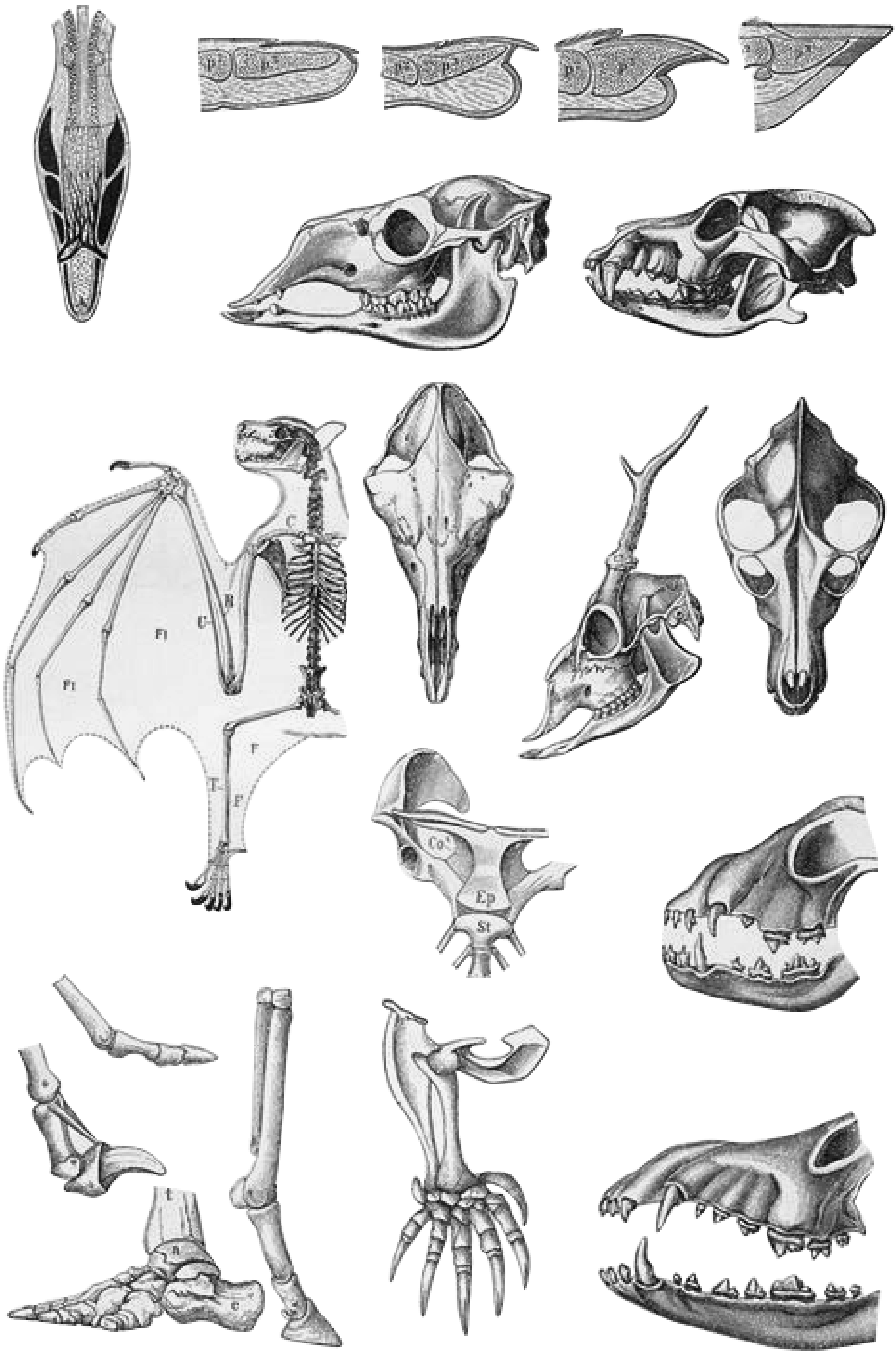
The dissertation will not attempt to develop a remediation strategy for the deteriorated structure of the karst system, but will focus on the development of strategies to reduce further destruction of the karst system, as well as strategies to remediate the lost habitat of the karst system.

1.7 ASSUMPTIONS

Although initial measures have been undertaken to improve the mine water treatment plant, the measures have proven to be ineffective during the wet summer rainfall seasons. The assumption is made that the State through the Inter Ministerial-Committee (IMC) on AMD and the Inter-Governmental Task Team (IGTT) will continue to develop the second phase of the Western Basin works for the significant mitigation and treatment of the raw mine water threat and sewage affluent, as stated in the State of Conservation Report for the Fossil Hominid Sites of South Africa World Heritage Sites (CSIR 2014:4).

The Sterkfontein stone aggregate quarry will obtain a decommissioning certificate within the next ten years.

Ongoing archaeological digs in the region of Bolt's Farm will remain active for a minimum period of 80 years.



▲
FIGURE 1.5
ANTIQUE ZOOLOGIST LITHOGRAPH PRINT OF BAT SKELETON, SKULL, BRAIN, & INTERNAL ORGANS
(Bibliographisches, 1908)

1.8 GLOSSARY

Acid Mine Drainage (AMD)
(noun)

Acid mine drainage is defined as effluent containing sulphuric acid created by oxidation of pyrites in the rock, combined with water during mining operations. This contaminated water may be highly acidic, and therefore may have the ability to dissolve the dolomite, creating sinkholes, and destroying the karst formations (The South African Karst Working Group 2010:17)

Aquifer
(noun)

A water-bearing geological unit or set of units that yields a significant amount of water to wells or springs of a high enough quality to be economically usable (The South African Karst Working Group 2010:13)

Biome
(noun)

A homogeneous ecological formation that exists in a geographical region, such as bushveld or grassland (Krige and Van Wyk 2005:135).

Breccia
(noun)

Sedimentary rocks as a conglomeration of sand, mud and silt washed in from the surface of the landscape and containing fossil fragments (Cooke 1993).

Karst System
(noun)

A karst system is characterised by the relief caused by the dissolution of the, predominately carbonate rich, underlying rock, by the groundwater flow. Caves, sinkholes and aquifers are typical of a karst landscape, with distinctive soils, micro-climates, flora and fauna indicating the specific patterns of the karst hydrology.

Karst Ecology
(noun)

The interaction between the organism, and between the organism and the physical and chemical surroundings both within and on the exterior of the karst system.

Ecotone
(noun)

The narrow transitional zone between two distinct biomes (Krige and van Wyk 2005:136)

Chiroptera
(noun)

An order of flying mammals comprises the bats as they are they only mammals capable of true and sustained flight through use of webbed wings formed by their forelimbs (Jagnow 1998:34).

CONTEXT

PRESSURES & POTENTIALS OF
BOLT'S FARM

FIGURE 2.1
BOLT'S FARM LOCATION
(Author , 2016)

-2-

PRESSURES & POTENTIALS

OF BOLT'S FARM

The site is located in the North-eastern quadrant of what is referred to in historical literature as Bolt's Farm. It is located towards the Krugersdorp border of the Cradle, and comprises more than 30 fossiliferous loci of different ages, ranging in age from between 1.5 and 4.5 million years old ago (Gommery and Potze 2013:2). Bolt's Farm contains the oldest fossils discovered in the Cradle so far. Today Bolt's Farm is divided into three properties, namely Klinkert's, Greensleeves and the Main Quarry (Gommery and Potze 2013:2). With each new epoch, the landscape is altered, with some alterations such as the quarry being more evident, and leaving scars in the landscape.

The fossiliferous findings and the impact of the quarry on Bolt's Farm are, however, only two of the potentials and pressures of the site, with the historical, economic, and social landscapes of the site all contributing to the current and future state of the landscape of Bolt's Farm.

2.1
HISTORICAL LANDSCAPE

The fossiliferous deposits at Bolt's Farm represent the longest chronological sequence within the region of the Cradle, illustrating the impact of climatic changes over the course of this period (Gommery and Potze 2013:2). Although no hominid remains, with the exception of one tooth, have been discovered at Bolt's Farm, the vast span in age of the numerous fossiliferous sites within this area allows palaeontologists to study the adaption of hominids to this habitat, as well as their relationship to fauna in the changing environment brought about by climatic change (Gommery et al. 2010:10).

Since the first collection of fossils at Bolt's Farm in 1936 by Dr. Robert Broom, five major phases of fieldwork have taken place (Fig. 1). The current fieldwork on Bolt's Farm is focused on a few active digs, including Aves Cave, located south-west of the quarry. Breccia's, sedimentary rocks containing fossil fragments collected during previous years at Cobra Cave are prepared by scientists from the Ditsong Museum. This cave is one of only two sites where Chiroptera fossils were discovered (Gommery and Potze 2013:6). Although the quarry yielded many original fossils, including some collected by Broom, it is not included as part of the National or World Heritage Site, due to the destruction of the habitat brought about by mining (Gauteng Provincial Government n.d.).

If one visits the site today, the collection of caves and sinkholes of Bolt's Farm bears little significance to the everyday tourist, and is a site where the archaeological and palaeontological significance of the landscape is only apparent to those who have emerged themselves in the research thereof (Gauteng Provincial Government n.d.:15).

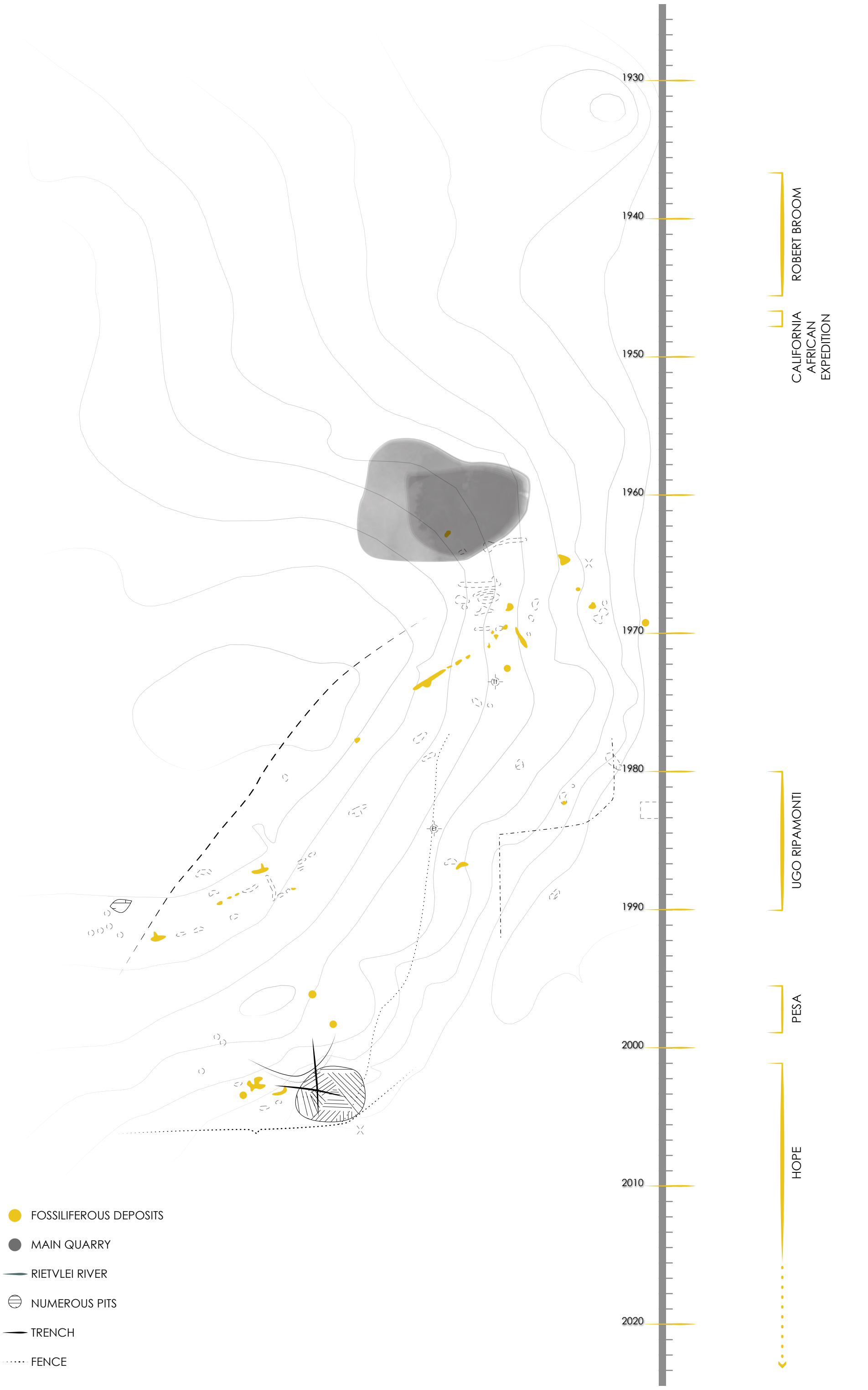


FIGURE 2.2
FIELDWORK PHASES
AT BOLT'S FARM
(Author , 2016)

2.2 ECONOMIC LANDSCAPE

2.2.1 HYDRO-VULNERABILITY

Bolt's Farm is located above the Zwartkrans Aquifer Compartment, and lies immediately north of the Riet Spruit, a river which has been severely contaminated by acid mine drainage from the mines of the West Rand, as well as municipal wastewater from Rand Sewage Works. All the caves located on Bolt's Farm either intersect the water table, or are located immediately above it (Hobbs 2011:189). Upstream from Bolt's Farm, the Riet Spruit loses as much as 32ML/d of contaminated water to the karst system. This not only contaminates the groundwater, but also has led to a 4m rise of the water table. Caves which extend below the groundwater elevation (~1450 m above mean sea level), display a very high vulnerability to water quality as well as quantity brought about by groundwater level fluctuations. The fossiliferous discoveries of Bolt's Farm located in the caves extending below the water table elevation are thus under threat (World Heritage Committee 2013:101); this includes Aladdin's Cave, which has been exposed by quarry mining activities (Hobbs 2011:189).

The treatment of the point sources of contamination is the most effective means of limiting further damage to the site. However, the responsibility for remediation lies with government authorities and mining officials, who have shown little interest in dealing with the destruction caused downstream to date (Witthüser 2016). Mitigation measures can, however, be put in place upstream from Bolt's Farm, to lessen the impacts of the deteriorated water quality on the sensitive karst landscape (Hobbs 2011:189). These measures include the containment and treatment of mine water at the decant at Tweelopie Spruit, the placement of limestone in the channels of the Tweelopie and Riet Spruits to lower the pH of the mine water in passage, and the planting of an acid mine treatment wetland along the Riet Spruit (Witthüser 2016).

2.2.2 MINING ACTIVITY

Apart from the impact that mining activities on the West Rand have had on the Cradle of Humankind, mining activity occurs within the Cradle itself. This includes the Sterkfontein Quarry located on Bolt's Farm (Hobbs 2011:184). The stone aggregate quarry, although not decommissioned, has been inactive since 1992, due to unstable geological conditions at the base of the quarry. The quarry is visible from the main route between the Sterkfontein caves and Maropeng, and creates a scar in this otherwise seemingly pristine landscape. Mining operations at the quarry have severely damaged or destroyed many caves exacerbated by the quarry pit, which pierced the water table, and thus altered the hydraulic recharge rate of the Zwartkrans aquifer (The South African Karst Working Group 2010:206).

Although the presence of the quarry is seen as a major threat to the Cradle (Annexure B), the quarry has unlocked educational potential in the landscape, displaying the resistance of the geological features to vibrations and blasting, as well as the impact of the oxidation rate to exposed caves. Both students and researchers from the geological and palaeontological departments of the University of the Witwatersrand regularly visit the quarry site as part of their educational programmes (The South African Karst Working Group 2010:206).

2.3.1 AGRICULTURE & (PERI)-URBANISATION

Poor farming practices and urbanisation are two of the biggest threats to the ecology of the karst system of the Cradle (Annexure B). This is firstly due to the impact on the water quality and quantity. With the increased use of groundwater for irrigation purposes, the water table drops, not only altering the humidity level in the caves on which bats are dependant, but also affecting the structural stability of the caves (The South African Karst Working Group 2010:359). The water quality is in turn affected by pesticides, which not only poison the borehole water consumed by the local community, but also destroy the karst-ecosystem, by exterminating aquatic life, in turn poisoning or starving other cave-dwelling creatures.

Informal settlements near Bolt's Farm also impact the water quality, with sinkholes and caves being used as garbage dumps, and pit latrines being placed over these openings, due to ease of drainage (Witthüser 2016). These settlements also threaten the population dynamics and foraging patterns of cave-dwelling bat populations in the Cradle, such as *Rhinolophus clivosus, Miniopterus schreibersii, Myotis tricolor, and Nycteris thebaica* (The South African Karst Working Group 2010:360). The existence of the bats in the area however, has a positive, often unrealised agricultural impact, by serving as natural pest control, as they forage for the insects within the agricultural land (The South African Karst Working Group 2010:359).

2.3 SOCIAL LANDSCAPE

2.3.1 CHIROPTERA OF THE CRADLE OF HUMANKIND

Bats are classified under the Chiroptera family, a term meaning 'flying mammal'. Bats are the only true flying mammal, and although there are no endemic bat species in South Africa, many of the caves, sinkholes, and abandoned mines in the Cradle serve as ideal roosting spaces for bats, contributing to the biodiversity of the region (The South African Karst Working Group 2010:16). The insectivorous cave dwelling *Nycteris thebaica* (common slit-faced bat), *Myotis tricolor* (Temminck's hairy bat), *Miniopterus schreibersii natalensis* (Schreiber's long-fingered bat), *Rhinolophus blasii* (peaksaddle horseshoe bat) and *Rhinolophus clivosus* (Geoffroy's horseshoe bat) have all been reported in the vicinity of the Cradle.

Various researchers have conducted or are still conducting research on the Chiroptera of the Cradle, and these parties include J.F. Durand from the Zoology Department at the University of Johannesburg, who conducted research on karst ecology, aquatic health and geo-tourism; M. van der Merwe from the Department of Zoology at the University of Pretoria, focusing on bat reproduction, migration, roosting and feeding habitats; D. Peinke from the Department of Agriculture, Conservation and Environment (GDACE), focusing on the identification and protection of sensitive roosting environments; and the various researchers from the Transvaal Museum of the Northern Flagship Institute (NFI), collecting cave-dwelling bat specimens (The South African Karst Working Group 2010:98).

With the abandonment of the caves by hominids and mammalian predators, bats have become the most important, present day active importers of organic matter into caves, serving as a crucial link between photosynthetic processes on the surface of the landscape, and the troglobitic end-consumers residing within the caves. As

▶
FIGURE 2.3
STONES FROM QUARRY
(Author , 2016)

FIGURE 2.4
ENTRANCE TO
ALLADIN'S CAVE
(Author , 2016)

▲
FIGURE 2.5
KARST NETWORK
(Krige, G , 2016)

a result of the variety of habitats within the Cradle, roosting and feeding ranges of multiple bat species is possible in the Cradle, leading to the result of overlapping roosting sites, as well as bats being active throughout the entire night (The South African Karst Working Group 2010:360).

The Cradle is home to one bat species of particular importance, namely Schreiber's long-fingered bat. The bat species is listed as a Red Data listed species, which migrates to the Cradle annually. The habitat of Schreiber's long-fingered bat is under threat, as this species is susceptible to temperature and humidity change, both aspects being affected by various components within the Cradle (Durand 2007).

2.3.2 THE ECOLOGY OF THE KARST SYSTEM

The northern Bushveld and southern Grassland Biomes that constitute the Cradle support a diverse variety of habitats, including hills, grasslands, water streams, and vleilands, which in turn support a rich diversity of fauna, including the insects on which the bat species feed (The South African Karst Working Group 2010:16). The insects in turn support a larger food web within the caves, including micro-organisms, fungi, and crustaceans, that depend on organic matter imported by the bat populations.

The karst ecosystem not only provides the ideal habitat for bat roosting and hibernation, but also supports and provides shelter for a variety of fauna and flora, both on the surface, and in the subterranean layers of the landscape. Some cave openings provide the ideal conditions for moss and fern species to flourish and provide shelter, shade and cooling air during the extreme heat during the Bushveld summers, to both antelope and baboons (The South African Karst Working Group 2010:330). These cave openings are, however, also ideal habitats for invasive alien species, such as the Pyracantha, commonly known as the fire-thorn, decreasing the biodiversity and causing the deterioration of breccias over time.

On the surface of Bolt's Farm one finds a relatively unspoilt grassland, dotted with remarkable geophytes and edible plant species, such as Hypoxis, which are collected by the local informal and farming communities (Gauteng Provincial Government n.d:17).

2.3.3 CHIROPTERA CONSERVATION THROUGH WILDLIFE TOURISM

Tourism is one of the greatest income generators annually in the world, as well as in South Africa. The social and environmental impacts of mass tourism, however threaten the sustainability of tourism in most countries. The new emerging market of eco- and wildlife tourism is one of the fastest growing sectors in the tourism industry, and is seen as a sustainable alternative to mass tourism. Wildlife tourism includes three dimensions, namely: consumptive wildlife tourism, including hunting and fishing; low consumptive wildlife tourism, where wildlife is kept in captivity; and non-consumptive wildlife tourism, where wildlife is viewed and experienced in a habitat (Pennisi et al. 2004:198).

Wildlife tourism and the conservation of wildlife through tourism depend on promoting environmental awareness and providing environmental protection (Pennisi et al. 2004:195). Wildlife tourism has been successfully implemented to conserve endangered species, such as the Mountain gorillas in Uganda, while providing economic benefits to the local community (Pennisi et al. 2004:196).

▲
FIGURE 2.6
CHIROPTERA
(Author , 2016)

FIGURE 2.7
WILDFLOWERS ON
BOLT'S FARM
(Author , 2016)

For non-consumptive wildlife tourism to be viable, viewing areas are often centred around locations where predictable aspects of the focal animal's behaviour occurs. These locations can be natural or artificial, such as a watering hole or salt licks (Pennisi et al. 2004:201). The concept of bat tourism becomes feasible when one takes into consideration the predictability of time in the evening when bats emerge from their roosting sites, as while as the specific location of bat roosting sites, be these natural, such as a cave, or artificial in the case of roosting boxes or bridges.

The gathering of wildlife watchers around predictable sighting areas might, however, negatively effect on the focal animal, if these gatherings are not managed correctly. This has been seen in California, where bird watching, a non-consumptive wildlife experience, has altered the nesting patterns of birds and endangered hatchlings (Pennisi et al. 2004:201).

Commercial show caves in the Cradle, although not focused on wildlife, or more specifically bat tourism, have been negatively affected by the tourism industry. The first impact can be observed at the entrance of the commercial caves, where the structure of the caves is altered to accommodate the movement of visitors (The South African Karst Working Group 2010:299). This continues throughout the cave with the construction of pathways, access routes and stairways. The structural changes to the cave alter ventilation, which in turn alter both the temperature and humidity in the cave, two aspects on which Schreiber's long-fingered bat relies. Bat watching, as with all wildlife recreation, must thus be implemented in such a way as to not disturb the bat colonies, or the environment in which they reside. One measure to preserve the cave habitats of the bats is to prevent cave intrusion. In Yucatan, Mexico, this strategy was implemented by placing metal bars at cave entrances (Pennisi et al. 2004:201). Another strategy is the provision of artificial roosting areas, where access and the internal climate of the roosting area can be controlled, without impacting on a larger ecosystem.

THEORY

REGENERATIVE THINKING

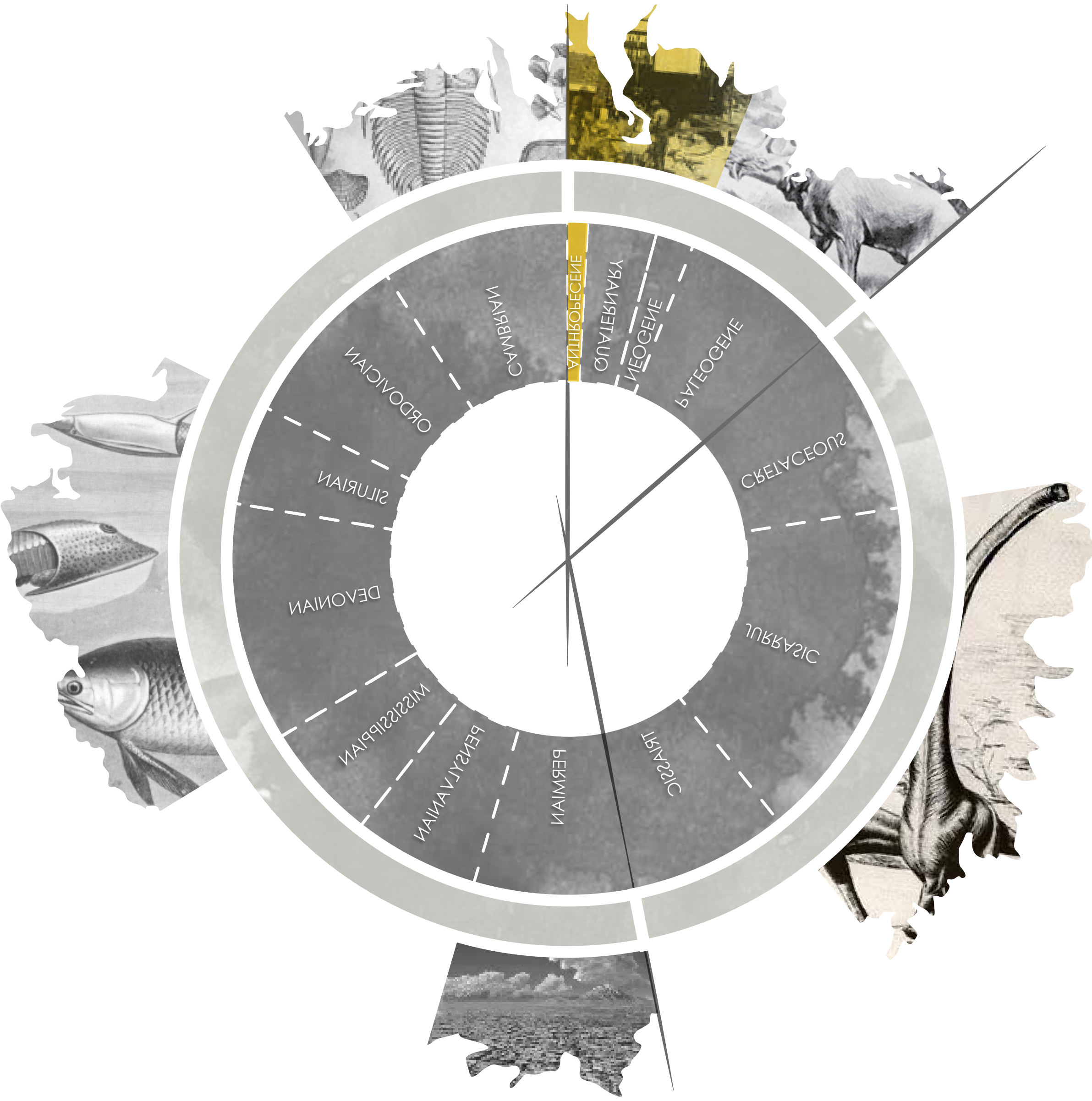


FIGURE 3.1
GEOLOGICAL
EPOCHS
(Author , 2016)

-3-

REGENERATIVE

THINKING

The landscape of Bolt's Farm, as part of the Cradle of Humankind, has seen the impact of the modern human, altering the landscape from a pristine historical landscape to a scared landscape in the form of a quarry, and a karst system in disrepair.

In an attempt to understand the current state of the site, which can be described as a scarred fragment in what is now a social landscape; the site was approached through a regenerative lens. This theoretical departure serves as a basis for understanding the networks of the site, some of which are hidden, to serve as informants in the regeneration of the site.

3.1 PLACE DEFINING THE STORY OF PLACE

The unique and complex nature of the networks formed in a specific geographic region is what differentiates one place from another. The multi-faceted nature of these networks is a result of the interactions between ecological systems, and socio-cultural systems through time. Place is thus created as a relationship between humankind and nature, and it is within this relationship that the intimacy and responsibility towards the living world is fostered, and humankind's role is nature comes about (Mang and Reed 2012:28).

History has seen the influence of ecological systems on socio-cultural relationships in the rise and fall of civilizations due to climatic change, and the wars between nations to gain power over natural resources, transforming both the physical context of a place and the society associated to that place (Cole et al. 2013:244). The relationship between humankind and nature (figure 3.2) has likewise seen a paradigm shift from pre-agrarian societies, where humankind relied on nature, and had little permanent impact on their surroundings, to the rise of modernity, where humankind and nature were clearly defined as separate entities. Within the modern era nature was seen through two contrasting lenses; the one seeing nature as a resource, the other seeing nature in a romantic sense, as a place outside of the city, where man could feed his soul. Although the latter seemed to conserve nature, both these attitudes towards nature separate "human place" from "natural place".

With the modernisation and globalisation of the world, both the cultural and biological diversity of places have begun to become increasingly homogenised (Mang 2007:2). Large green spaces are often cleared for either housing developments or monoculture farming practices, such as LVG Plants, a cut-flower farm located on the eastern boundary of Bolt's Farm. The farm, like many other farms, truck service stations, and housing developments in the area, has not only cleared large parts of the veld which supported indigenous fauna and flora, but also further diminishes ecosystems through the contamination of water sources (Witthüser 2016).

Mang (2007) has asked the question of how we, like our indigenous ancestors, could come to see the places in which we live as sacred and vital to our lives, where places are not disregarded and pillaged of their resources, but are rather cherished, cared for and celebrated.

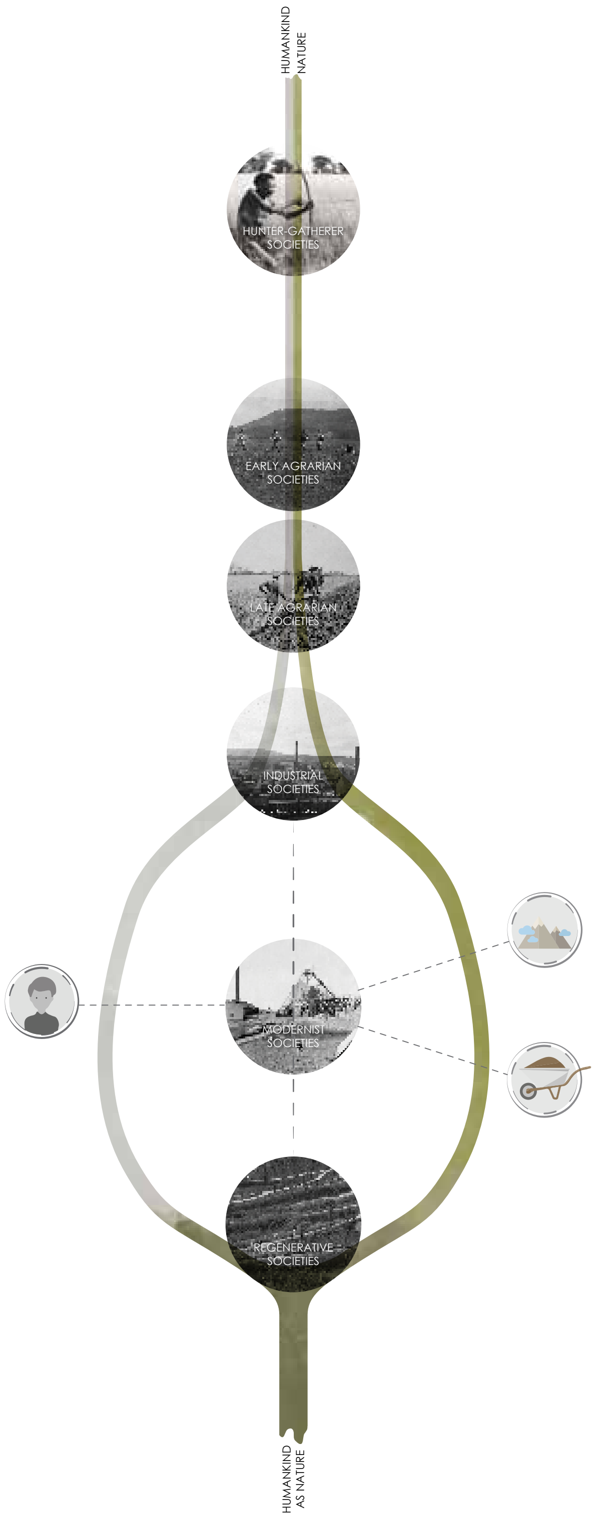


FIGURE 3.2
THE RELATIONSHIP BETWEEN HUMANKIND AND NATURE
(Author , 2016)

The 'story of place' starts to guide humankind in the understanding of the information, relationships, and connections to create a holistic picture of what place is and how to act in accordance with it. Human memory is based on narratives, not merely data, rendering stories as a crucial part of how humankind learns and organises information. Narratives are not only part of the past in the form of memory, but facilitate the understanding and sharing of a collective image of the future, serving as a vision or framework which guides humankind in the co-evolution with their environment (Mang and Reed 2012:29).

3.2 BOUNDARIES, PATTERNS & SYSTEMS THINKING

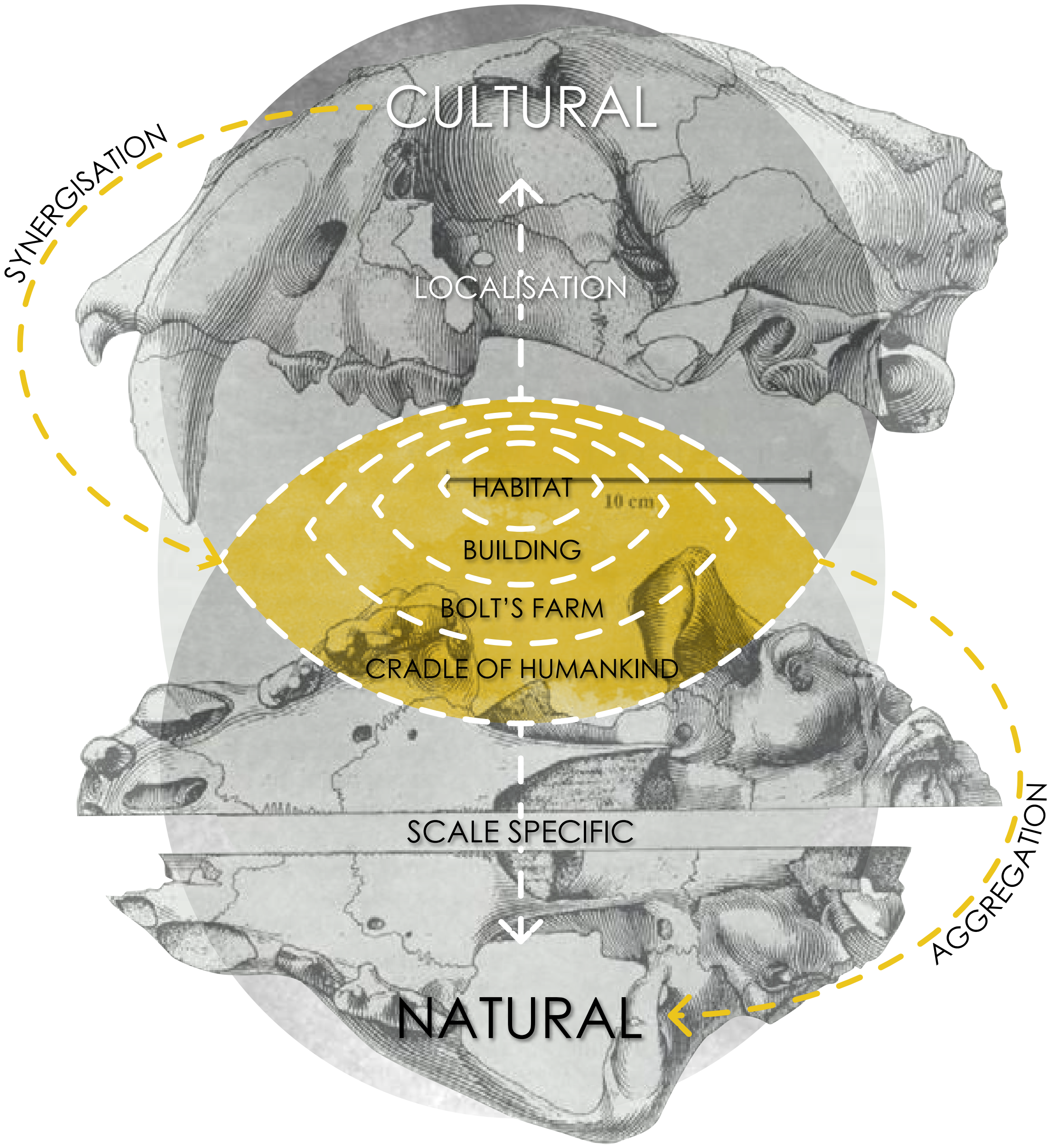
Places are defined by boundaries, shaping the identity of what a place holds and what not (Mang 2007:9). Through the unique biogeographical setting of the silver-leafed plant communities of the Cradle, the potential of boundaries to create and support life spaces can be seen. The silver-leafed plant species are located within an ecotone, the narrow transitional zone between the bushveld and grassland biomes of the Cradle. The evolutionary pressures on the fauna and flora in such regions is very high, as they have to adapt to both regions, resulting in more resilient species (Krige and Van Wyk 2005:135). Thus, the boundaries of place do not limit the expansion of place, but create the opportunity for connections, which result in more resilient systems and places.

Places, such as neighbourhoods, exist within a series of nested systems, consisting of connections on both macro and micro scales, from cities to individual households. Systems thinking requires one to look at the various elements of a place, such as the roads, water systems, and vegetation, not as a series of things, but as a system of energies or life processes (Mang and Reed 2012:31). All living systems, independent of scale, are either moving towards or away from their inherent potential. According to Mang and Reed (2012), the web or larger contexts of reciprocal relationships in which a system is nested, reveals the potential that the specific system is attempting to manifest.

Socio-ecological systems attempt to understand the relationship between humankind and nature through the lens of both the ecological and social sciences. Fischer-Kowalski and Haberle, as cited in Cole et al. (2013), defines this cross-disciplinary interaction as the "particular form in which societies establish and maintain their material input and output to nature and how it changes over time". Socio-ecological systems encompass the connections between the biophysical, social and human elements at various scales and within nested systems (Cole et al. 2013:242).

The built environment is a complex socio-ecological system, with the socio-cultural and ecological connections between the larger context of the neighbourhood, and the building in which it exists, having the possibility of benefitting from the energy and social synergies of the neighbourhood. This would not be possible if the building was designed in isolation. Gestalt theory, a principle in design, suggests that the whole is greater than the sum of its parts. This theory can be applied to the built environment (Figure 2.3) where the balance between the localisation and synergisation of socio-cultural systems impact and react to natural systems, resulting in an efficient, diverse built environment (Cole et al. 2013:242).

In contrast to conventional sustainable building practices, regenerative design does not aim to create closed loop


CULTURAL
SYNERGISATION
LOCALISATION
HABITAT
10 cm
BUILDING
BOLT'S FARM
CRADLE OF HUMANKIND
SCALE SPECIFIC
AGGREGATION
NATURAL

systems with a net-zero environmental footprint. Regenerative design also does not aim to merely reverse the damages caused by source-to-sink one-way flows, narrowing the scope of the potential of a place to specific disciplines. Regenerative design includes the various aims and disciplines as part of an integrated system, including community engagements, which leads to stewardship (Mang and Reed 2012:28). It implies an adaptive approach to architecture, allowing for the technical and human systems of a building to adapt to both time and the environment in which it sits, leading to the co-evolution of humankind together with nature (Cole et al. 2013:238).

3.3 CO-EVOLUTION

Co-evolution is one of the key principles of regenerative design, as it promotes a partnered relationship between socio-cultural and ecological systems, rather than a managerial one (Cole et al. 2013:238). This co-evolutionary relationship attempts to amplify social and natural resources, generation a system, which includes the building, its inhabitants, and the larger social and environmental context, to provide a catalyst for an upward cycle of change, strengthening the uniqueness of a sense of place (Cole et al. 2013:238).

Mang and Reed (2012) define regenerative development and design as "the reconnection of human aspirations and activities with the evolution of natural systems, shifting human communities and economic activities back into alignment with life processes". Regenerative development is thus not to be understood as the protection or restoration of an ecosystem, but the continuous evolution of the socio-cultural together with ecological systems, placing humankind and nature side-by-side, to create and sustain greater health for both (Mang and Reed 2012:26).

◄
FIGURE 3.3
SYNERGISATION AND LOCALISATION
(Author, 2016, adapted from Cole et al. 2013)

SITE ANALYSIS

BOLT'S FARM

Fig 1.1
Eucomis autumnalis

Fig 1.4
Gladeolus permeabilis

Fig 1.2
Eucomis autumnalis

Fig 1.5
Brachystelma barberiae

Fig 1.3
Hibiscus microcarpus

Fig 1.6
Hermannia depressa

FIGURE 4.1
USEFUL FLORA OF BOLT'S FARM
(Author, 2016)

-4-

BOLT'S FARM

SITE ANALYSIS

The site is analysed as a series of networks, seeking out the boundaries and their overlaps in order to identify the uniqueness of place in the Cradle area. The site is analysed within the context of Bolt's Farm, taking into account the historical, economic, and social layers of the landscape. The bio-diverse and thriving habitats found on site are mapped, together with the existing activities, and threats to the landscape. These maps are then overlaid in order to identify the areas on site with the highest energy, thus seeking out the areas on site with the most potential to connect with and build upon.

4.1 HABITATS

Bolt's Farm and surrounding areas is home to a number of interesting plant species, including a large variety of orchids and bulbous geophytes. Together with these beautiful plants species, a large variety of useful plant species are found on site (Annexure C), and are collected by the local communities, as either edible or medicinal plants. These plant species include the Brachystelma barberiae, commonly known as the Platvoetaasblom (Krige 2016). The roots of this plant is known to be eaten when food is in short supply, and is used by traditional healers to treat headache, stomach ache and colds in children.

The flora of the site not only attracts human users, but also attracts many animal and insect species. Other than creating a biodiverse habitat for the surface dwelling and growing fauna and flora, the landscape also hosts a unique and hidden habitat found in the caves and openings of the karst system. These habitats, both on the surface and hidden in the landscape, were mapped through desktop studies, as well as observation, through a site visit, as indicated in green (Fig. 4.3).

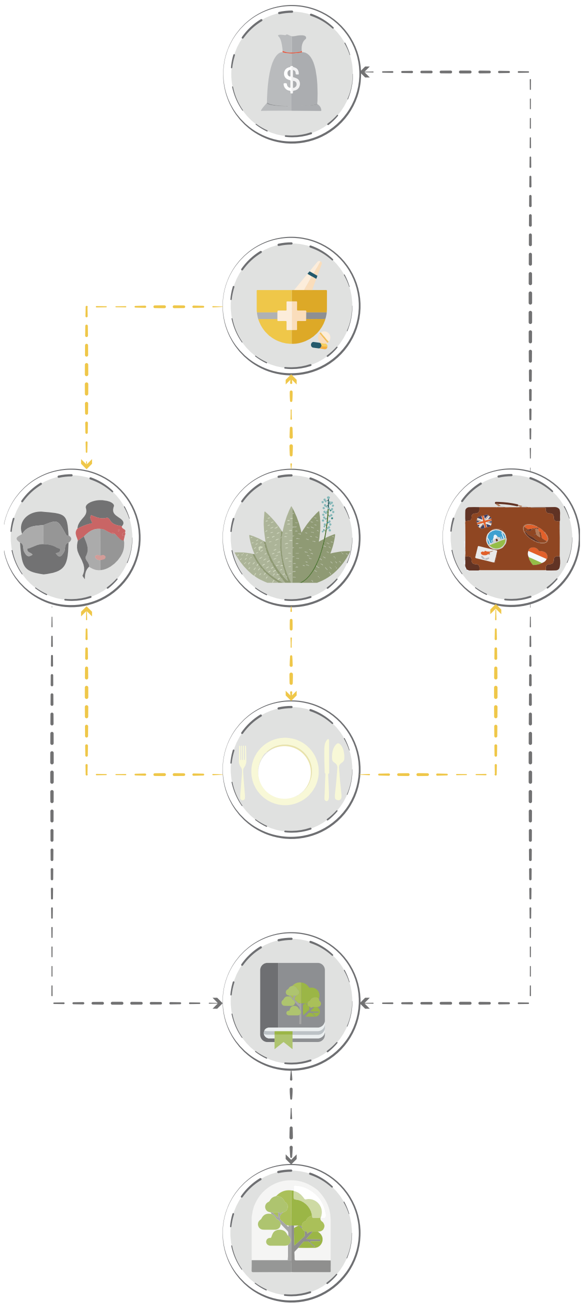
4.2 ACTIVITIES

At first glance, Bolt's Farm seems almost sedentary. Bolt's Farm, however, brings together a multitude of activities, each drawn from a different layer of the landscape. Bolt's Farm is most well-known for the fossiliferous discoveries located across the site, with a few active digs, located to the South of the site, continuing to this day. Other research and educational activities include geological research, with student training located in the Quarry, hydrological research along the Riet Spruit edge, and zoological research focused on the Chiroptera species.

Other activities on and around Bolt's Farm include dairy and cut flower farming, foraging for building materials and edible plants, and informal dwellings (Fig 4.5).

4.3 HYDROLOGICAL VULNERABILITY

The Hydrological Vulnerability of the site is determined through large scale research by Kai Witthüser (2016), together with on-site evaluation and speculation by the South African Karst Working Group (2010). The hydrological vulnerability of the site determines the areas on site which is fragile for development, as well as the areas on site needing protection (Fig 4.7).



▲
FIGURE 4.2
USES OF FLORA OF BOLT'S FARM
(Author, 2016)

▲
FIGURE 4.3
HABITATS
(Author , 2016)

FIGURE 4.4
STERKFONTEIN DIARY
(Author, 2016)

FIGURE 4.5
ACTIVITIES
(Author , 2016)

FIGURE 4.6
CAVE OPENINGS IN THE QUARRY WALL
(Author, 2016)

▲
FIGURE 4.7
HYDROLOGICAL VULNERABILITY
(Author , 2016)

FIGURE 4.8
SUCCULENTS IN QUARRY
(Author, 2016)

FIGURE 4.9
ENERGY
(Author , 2016)

PROGRAMME

EXPLORING THE ENERGY OF
BOLT'S FARM

FIGURE 5.1
REMEDIATION POTENTIAL
(Author , 2016)

FIGURE 5.2
EDUCATION POTENTIAL
(Author , 2016)

FIGURE 5.3
RECREATION POTENTIAL
(Author , 2016)

5
EXPLORING THE ENERGY
OF BOLT'S FARM

The proposed development of the Greensleeves portion of Bolt's Farm is based on a response to the inherent energy of the site brought about by the confluence of the historical, economic and social landscapes. The threat of the current state of the landscape on the Schreiber's long-fingered bat, served as the basis for future development, as the Chiroptera family has been part of the historical landscape, is threated by the economic activity of the larger landscape, and holds the potential to build on the social landscape of the Cradle of Humankind in the form of tourism.

The programme is centred around the areas on site with high energy, thus, areas where existing activities, bio-diverse habitats, and pressures of the site intersect. The heritage and tourism value of the Cradle, and more specifically, Bolt's Farm, also forms part of the larger system in which the programme is developed.

The programme further aims to consider what the area and surrounding community is lacking, such as the education on the diffuse threats to the karst system. The programme is divided into three fundamental categories, the first being the remediation of the karst system and landscape. A recreational programme is then introduced as a funding model to the remediation of the site, as well as a way to bring focus to the value of the landscape. The third part of programme is devised through the presence of new activity on site, serving as an educational programme. The educational programme connects to existing educational activities onsite i.e. archaeological and geological research, introducing the public to the historical, economic, and social layers of the landscape.

The areas on site with high energy are seen as areas where interventions would be most viable, demarcating spaces where architecture could be placed to further the remediation, promote education, and serve as recreational spaces. Where these spaces coincide, various parts of the programme will be developed.

5.1
VISITOR CENTRES

Visitor centres are defined as distinctive purpose-built tourism facilities, to serve as multi-functional infrastructure to use and manage tourist attraction resources. Visitor centres differ from museums, as the emphasis is not on the display of artefacts, but rather on the convening of information and enhancing of a travellers' experience of the region (Pearce 2004:8).

Visitor centres typically have one or more of four primary functions, undertaken to various degrees. The four primary functions are defined as the promotion and orientation of a tourism region, the convening of information and enhancement of the visitor's experience, the control and filtering into the region, and interpretation (Fallon and Kriwoken 2003:290).

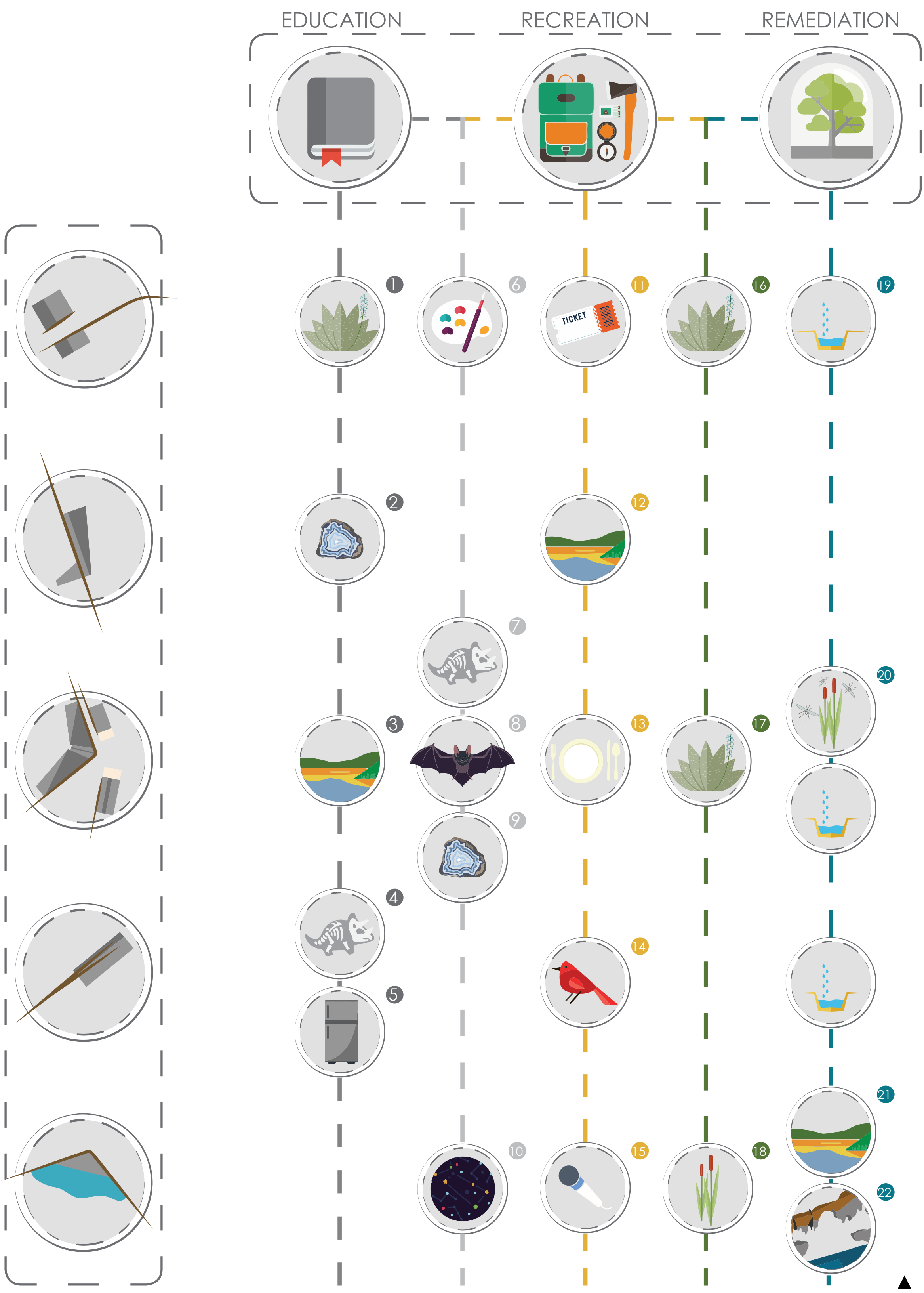


FIGURE 5.4
PROGRAMME
(Author , 2016)

FIGURE 5.5
PROGRAMME
POTENTIAL
(Author , 2016)

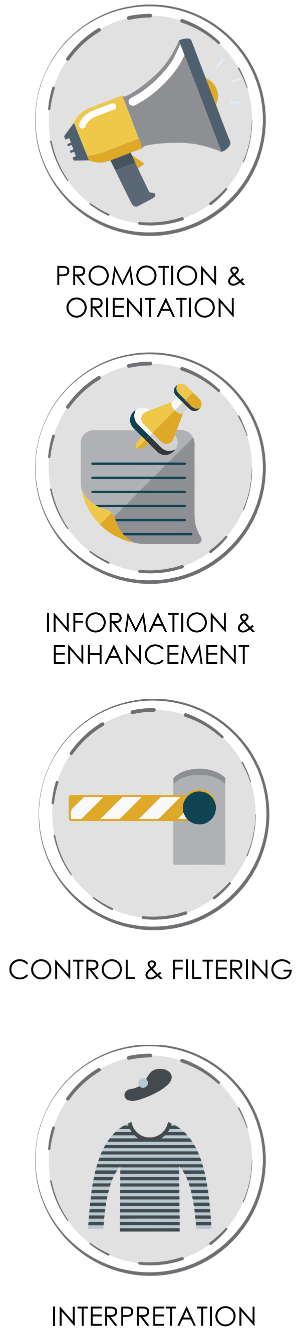


FIGURE 5.6
VISITOR CENTRE FUNCTIONALITY
(Author , 2016)

5.1.1 PROMOTION & ORIENTATION

The role of promotion is to stimulate the tourist demand within a region, where its aim is to increase visitor expenditure within the defined area (Pearce 2004:2009). This includes providing orientation and guiding the visitor what to do, suggesting attractions and activities within the tourism region (Fallon and Kriwoken 2003:290).

5.1.2 INFORMATION & ENHANCEMENT

The role of providing information places less emphasis on the economic gain associated with tourism activates, and more on the value of the attractions themselves. Information conveyed through visitor centres attempts to inform the general visitor about the region to promote responsible behaviour (Pearce 2004:10). The provision of information also aims to improve the quality of the visitor's experience, through creating an understanding of the value of the region (Fallon and Kriwoken 2003:290).

5.1.3 CONTROL & FILTERING

The control of flow of visitors into a region or area is put into place in order to reduce the pressure on resources and to limit destructive visitor behaviour. The location of a visitor centre has the possibility to concentrate a large group of visitors away from fragile sites and provide the needed understanding of the site, as well as to shape the visitors' attitude towards more responsible and sensitive behaviour (Pearce 2004:11).

5.1.4 INTERPRETATION

Interpretation centres partly serve as substitution for the attraction, but also serve as substantial attraction in its own right. Interpretation centres are often developed when the resources are fragile, sites are inaccessible, as in the case of marine or demanding terrestrial environments, or are scattered across a vast area, such as historical battle sites, or a series of fossiliferous discoveries (Fallon and Kriwoken 2003:291).

Apart from these four primary functions, visitor centres can encompass a multitude of programmes, to function beyond the realm of tourism. Visitor centres can, for example, function as community facilities to host local cultural and social events, or act as educational facilities to the community and visitors (Pearce 2004:11).

The functioning of visitor centres can be improved by providing a facility that can be easily and clearly read by the visitor, a facility which has a clear programme, catering to visitors, staff, and the community, and a facility which is designed for the future, able to adapt to its vicissitudes.

FIGURE 5.7
TWYFELFONTEIN VISITOR CENTRE
(Afritecture 2015)
(Esposito 2011)
(Grahl 2012)
(Lanting n.d.)

PRECEDENT STUDY: TWYFELFONTEIN VISITORS CENTRE

LOCATION Twyfelfontein, Namibia
ARCHITECT Nina Maritz
Dennis Mc Donald
CLIENT National Heritage Council of Namibia (NHC)
COMPLETION 2005

ATTRACTION Twyfelfontein, located in the Northwest region of Namibia, is home to one of the largest concentrations of petroglyphs, or rock engravings, in Africa. The barren valley in which the rock engravings are found is characterised by little rainfall, high temperatures, and poor soil, with red coloured sandstone cliffs surrounding the valley (Afritecture 2015). The engravings found against the sandstone cliffs include six painted elephants, ostriches and giraffes, as well as drawings of human and animal footprints, forming an extensive, high-quality record of the San rituals over more than 2 000 years (UNESCO World Heritage Centre 2007).

FUNCTION The visitor centre not only acts as tourism resource, but also as a tool to preserve the engraving and the walking routes, as well as fuelling income generation for the local community.

PROMOTION & ORIENTATION

The centre does not promote the area in a traditional sense, as there are few other tourist attractions in the immediate vicinity of the visitor centre, but rather focuses on the preparation of the visitor for the experience of the engravings along the route (Afritecture 2015).

INFORMATION & ENHANCEMENT

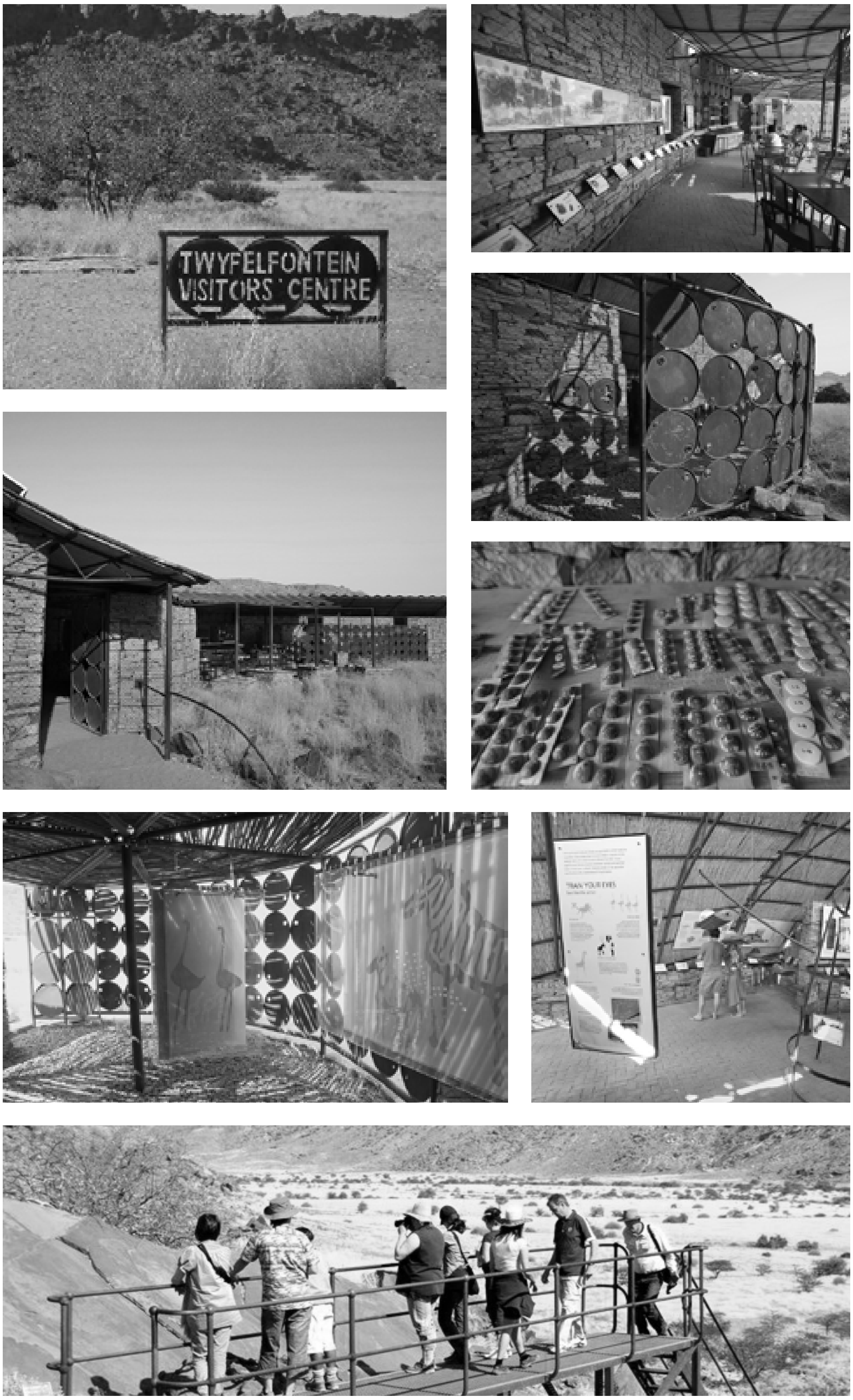
Other than the information of the engravings communicated through the interpretation programme, the architecture itself communicates the sensitivity of the site, through its environmentally sustainable approach (Afritecture 2015).

CONTROL & FILTERING

The entrance to the visitor centre is through a narrow slit, leading the visitor into the foyer and souvenir shop: visitors are then received by guides behind the reception counter, regulating the circulation by leading groups of ten or less people on walking routes. Visitors waiting their turn, reside in the dining area, which is served by a small kiosk (Afritecture 2015).

INTERPRETATION

As the visitors move through the building, they are prepared for engagement with the rock engravings. The series of spaces refer to the different stages of trance ritual associated with the indigenous San culture (Esposito 2011). The first stage of the ritual resembles the phases a person experiences during a malarial attack, where phosphenes appear to the shaman, these retinal images appear in the shapes of spirals, circles, and



◄
FIGURE 5.8
TWYFELFONTEIN
VISITOR CENTRE
(Afritecture 2015)
(Esposito 2011)
(Grahl 2012)
(Lanting n.d.)

parallel lines, creating abstract patterns.
This stage is then followed by the 'little death', where the shaman starts to shiver and sweat, resembling the symptoms displayed by a wounded animal as it is dying. This stage is characterised by a feeling of weightlessness and is followed by the third and final stage.

In the third stage, when the shaman reaches a stage off full trance, the shaman leaves his/her body to merge with the animal, to enchant the animal, either for hunting or to make it rain (Afritecture 2015).

CONTEXTUAL RESPONSE

The narrow vertical slits created by two large slabs and rocks, and the curved overhangs from shallow caves of the Twyfelfontein landscape, where influential elements in determining both the construction method and form of the visitor centre. The plan of the visitor centres is based on one of the San metaphors for the third stage of the trance ritual, and is reminiscent of an antelope curled up.

The armoured cladding reminds one of antelope spoor-shaped mopane tree leaves, insect carapaces, and animal skeletons, and was construction from recycled oil drums (Esposito 2011). Over 600 second-hand oil drums where sources from all over Namibia, each drum then sandblasted, to remove the paint and start the rusting process, before installation. The tiles for the roof cladding were constructed by quartering the oil drums, then overlaying and installing the tiles in a Roman tile fashion, where concave tiles are fixed to purlins, and convex tiles to the exterior to close the roof (Afritecture 2015).

The project also made use of gabion baskets filled with recycled rubble and loose stones gathered from the area to construct solid masonry walls. This labour-intensive process of filling each gabion basket brought much-needed employment to the area (Afritecture 2015). Thus, this project not only created economic opportunity for the local community in tourism-related labour, but also in the form of labour required for the construction of the visitor centre.

FIGURE 5.9
STONEHENGE VISITOR CENTRE
(ArchDaily 2013)
(Daily Mail 2013)
(Lovair 2015)
(Macarthur 2014)
(The Hub 2016)

PRECEDENT STUDY: STONEHENGE VISITORS CENTRE

LOCATION	Stonehenge, Amesbury, UK
ARCHITECT	Denton Corker Marshall
CLIENT	English Heritage
COMPLETION	2013

ATTRACTION

Stonehenge n Wiltshire is among the most famous groups of megaliths in the world. The sanctuary is arranged in circles of menhirs, in patterns that have astronomical significance. Stonehenge, together with Avebury, is seen as a holy place, harking back to prehistoric times (UNESCO World Heritage Centre 2008).

The Stonehenge visitor centre is located 1.5 miles west of the stone circle, falling within the World Heritage Site, but is invisible from the monument. The visitor centre is designed with a light touch on the landscape, consisting of three simple enclosures, sheltered by a perforated

FUNCTION

The three enclosures are all finished in different materials, the first and largest box is clad in chestnut timber, and houses the museum display of artefacts and interpretive audio-visual presentation. The second largest is made up of glass and contains the café, shop and classroom education centre. The smallest box sits between the two larger enclosures, and is clad in zinc. This box provides the ticketing and guiding facilities, and also leaves room for a view (Macarthur 2014).

PROMOTION & ORIENTATION

The visitor centre at Stonehenge has long been anticipated, and there have been many attempts and competitions to design a suitable visitor centre. The design of the centre was awarded to Denton Corker Marshall's architects, and was formally opened in December 2013. Although the visitor centre does serve to promote Stonehenge as well as the surrounding Neolithic settlement remains, the substantial hike in ticket prices to view Stonehenge has dampened visitor enthusiasm (Macarthur 2014).

CONTROL & FILTERING

The building provides external access and circulation to accommodate the varying amplitude of flow of visitors to the site. The arrival foyer and ticket queues are placed on the exterior of the building, and are covered by the undulating canopy (Macarthur 2014). All visitors to this World Heritage Site must pass through the visitor centre, before walking, or taking a ten-minute shuttle ride to Stonehenge. As visitors move towards to East, the henge slowly emerges, until the visitor centre disappears behind the visitor.

◀
FIGURE 5.10
STONEHENGE
VISITOR CENTRE
(ArchDaily 2013)
(Daily Mail 2013)
(Lovair 2015)
(Macarthur 2014)
(The Hub 2016)

INTERPRETATION

The design of the visitor centre aims to act as a prelude to Stonehenge, intending not to diminish the sense of timeless strength and powerful sculptural composition of the stones themselves. The visitor centre was designed to accommodate dedicated facilities on site for the education of the public and the interpretation of Stonehenge. Dr. Simon Thurley, the chief executive of English Heritage has said: "For too long, people's appreciation of Stonehenge is this mysterious, impressive but anonymous monument. The Neolithic period itself is pretty much a murky expanse of time, shrouded by many outdated notions. We want people to come here and take away a fresh view" (ArchDaily 2013).

Together with the interior museum and interpretation centre, an outdoor gallery space was introduced. The gallery includes three reconstructed early Neolithic houses, based on the forensic evidence recorded from the nearby surroundings (ArchDaily 2013). The reconstruction of the settlements, together with the insight provided by the visitor centre, provides visitors with a new understanding of the context in which Stonehenge was built.

CONTEXTUAL RESPONSE

With the site's close proximity to the stones, the placing of a discreet building, which does not detract from the monument, became a challenge. The architect, together with English Heritage proposed a principle of "reversibility", resulting in a building which has minimal foundations and excavations to minimally disrupt the site, which is of ongoing archaeological interest. The design of the building was based on two principles: where the stones are exposed and purposely positioned, the centre is sheltered, lightweight and informal; and where the stones are embedded in the earth, the centre is lightly placed on the surface of the landscape (Macarthur 2014).

Where possible, local, recycled and renewable materials where used, including locally grown sweet chestnut timber used for cladding, and Salisbury limestone (ArchDaily 2013). Two hundred and eleven slender columns are clustered in uneven intervals, and lean slightly in different directions, alluding to the trunks of forest trees. These columns support the roof in the form of an irregular aerofoil, which mimics the rolling, sheep-grazed hills of Salisbury. Macarthur has stated of it that "the centre does not seem jaunty and wilful, as it might easily have done, and there is a kind of calm and not overstretched homology of the roof and the landforms, the columns and trees and fence posts, that brings together the building and landscape" (2014).

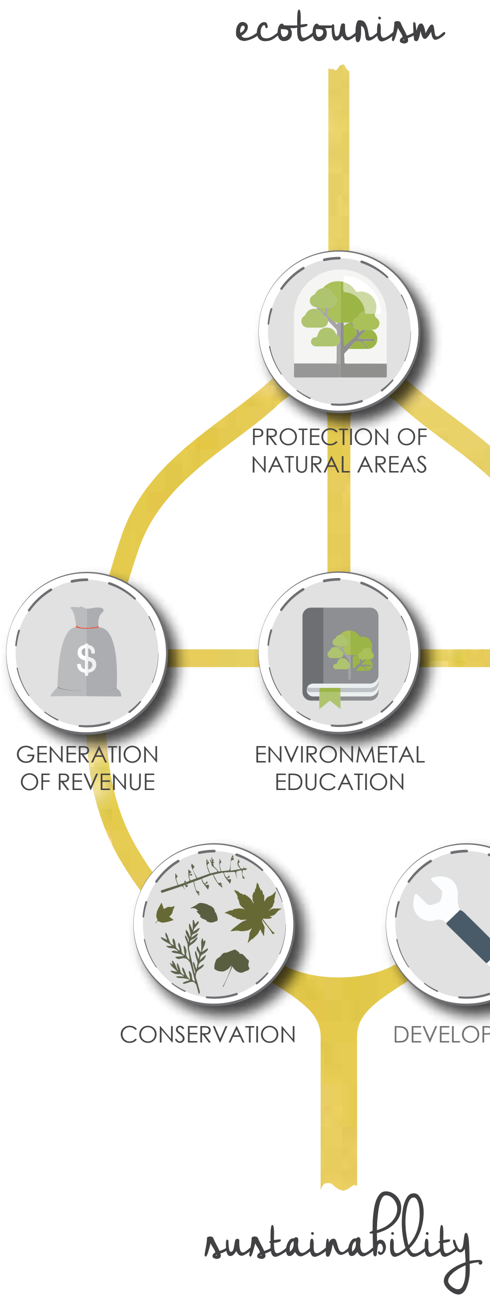


FIGURE 5.11
ECOTOURISM AS
SUSTAINABLE TOURISM
Image adapted from
(Ross and Wall 1999, p.124)

5.2 ECOTOURISM

Ecotourism is defined by the Ecotourism Society as "purposeful travel to natural areas to understand the culture and the natural history of the environment; taking care not to alter the integrity of the ecosystem; producing economic opportunities that make the conservation of the natural resources beneficial to local people". The World Conservation Union (IUCN) defines ecotourism in a similar way as "environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature and any accompanying cultural features, both past and present, that promotes conservation, has low visitor impact, and provides for beneficially active socio-economic involvement of local populations" (Ross and Wall 1999:124).

These definitions suggest that in ecotourism, the introduction of responsible tourism serves to create a symbiotic relationship between the ecological tourism resource and the local community. Through environmental education, the generation of income and the involvement of the local community, ecotourism is seen as a conservation tool to protect sensitive or undisturbed areas (Ross and Wall 1999:124).

The role of ecotourism is not only to provide an enjoyable visitor experience of nature, but to protect natural areas, generate income, serve as an educational tool, and build a relationship between local authorities and communities. The objectives of ecotourism are intertwined, as is the success or failure of one objective influences the success of another. When all of the objectives are met to a certain degree, ecotourism mediates the tension between resource exploitation and resource conservation, creating a sustainable tourism environment, which can be enjoyed by generations to come (Ross and Wall 1999:125).

5.3 TAKE-HOME VISITOR EXPERIENCE

In recent years, the expectation of the tourism industry to aid in the adoption of environmentally sustainable principles has increased. This is especially true in the niche market of nature and wildlife tourism, where visitors have the opportunity to directly interact with nature or wildlife, either in a natural habitat, or in captivity (Ballantyne et al. 2011:770). Nature and wildlife tourism can potentially impact visitors short- and long-term attitude of the environment, by developing their respect and appreciation for wildlife and nature, by raising awareness of environmental issues, by promoting environmentally sustainable attitudes and actions, and by building visitors capacity for longer term adoption of sustainable living practices (Ballantyne et al. 2011:770).

The stimulation of tourism in a given area can also have a positive impact on the environment, by generating income for the protection and sustainable management of wildlife and their habitat; it also encourages visitors to contribute to environmental causes, financially or otherwise, and influences the behaviour of visitors during the tourism experience. The educational aspects of the tourism experience not only contribute to the behaviour of the visitor during and after the visit, but also contributes to visitor satisfaction of the experience (Ballantyne et al. 2011:771).

Visitors to nature and wildlife-based tourist attractions typically respond to and recall their experience on four levels. These levels include:

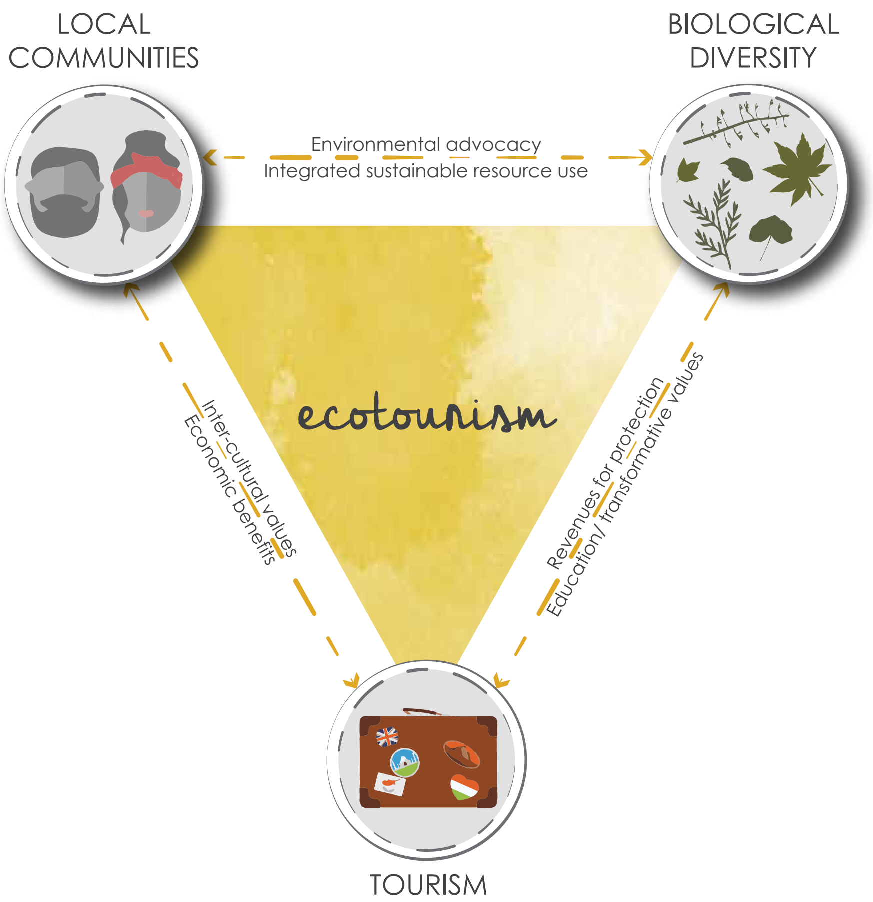


FIGURE 5.12
ECOTOURISM AS CONNECTOR
Image adapted from (Ross and Wall 1999, p.126)

- the visitor's sensory impression, recalling vivid visual, auditory, and olfactory memories of their experience;
- the emotional affinity visitors experience during the visit, including emotional responses to and forming an emotional connection with the animals;
- a reflective response to the experience, where the visitors gain new insight; and
- a behavioural response, where visitors alter their behaviour as a post-experience response.

5.3.1 SENSORY IMPRESSIONS

Visitors to nature and wildlife tourism attraction often recall the experience with vivid sensory impressions. These sensory impressions are not only of the animals themselves, but also include sensory impressions extended to the environment in which the animals are situated. Ballantyne et al. (2011) speculate that it might be the multi-sensory element of the "real-life" experience that these attractions provide, which is captured in the minds of the visitors long after the experience.

5.3.2 EMOTIONAL AFFINITY

Together with visitors' sensory impression, visitors also refer to emotional content when recalling a wildlife tourism experience, with these emotional events often being the visitors' strongest memory of the experience (Ballantyne et al. 2011:773). Visitors also convey a sense of empathy, when recalling the experience, identifying with the animals and forming an emotional connection, as the visitors start to become concerned with the viewed animals' well-being (Ballantyne et al. 2011:774).

5.3.3 REFLECTIVE RESPONSE

A reflective response from visitors is often not only based on the factual information received during the wildlife tourism experience, such as interpretive content talks or signage, but includes the sensory and emotive experiences, or discussions facilitated through social interaction (Ballantyne et al. 2011:774). The combination of the processing of factual information and the emotional affinity developed during the experience, leads to a greater concern and respect for the viewed species and their environment, thus making environmental issues more relevant to the individual visitors.

A greater awareness of the threats and dangers to the viewed species is also developed, as visitors recall the threats to "their" animals in greater detail than other information provided about the species, with many visitors becoming more aware of the impact they as individuals might be having on the environment (Ballantyne et al. 2011:774).

By providing opportunities for socialising, with companions, staff members or volunteer guides during the visitors experience, the visitors process and reflect on the experience, grounding the information received in their minds. The social interaction allow for the visitors to formulate and communicate their own thoughts and feelings, with the comments by others stimulating curiosity, and feelings of comradery and security within the group contributing to the positive emotions associated with the tourism experience (Ballantyne et al. 2011:775).

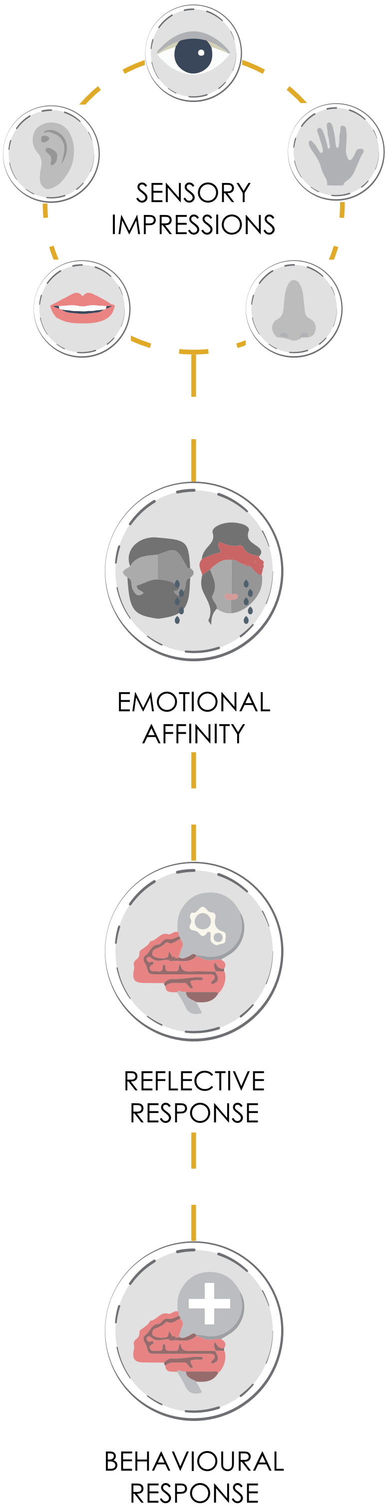


FIGURE 5.13
VISITOR RESPONSE TO
WILDLIFE TOURISM
(Author , 2016)

5.3.4 BEHAVIOURAL RESPONSE

Following on the reflective response of visitors, one of the key goals of nature and wildlife tourism attractions is a positive behavioural change by the visitors, taking home and altering their everyday behaviour (Ballantyne et al. 2011, :776). In this way, nature and wildlife tourism contributes to environmental conservation, by raising community awareness, with the hope that visitors not only take home and apply the message to their own lives, but further the adaption of environmentally conscious living within their own communities.

5.3.5 TOURISM FACILITY DESIGN & MANAGEMENT IMPLICATIONS

To instil the take-home message in the minds of visitors, the design and management of tourism facilities, act to facilitate the experience of the tourism facility by evoking responses from the visitor. The following are suggestions by Ballantyne et al. (2011) to consider when developing a wildlife tourism facility in order to evoke powerful memories, enhance the visitor experience, and encourage visitors to adapt environmentally responsible behaviours in response to their visit:

- designing interpretation installations with the five primary senses in mind, focusing on sight, sound, smell and touch;
- providing visitors with the opportunity to come in contact with the visitors, within reason and without compromising the animal's well-being;
- providing visitors with the opportunity to view and experience the animals and environment from a different perspective;
- the provision of information about the threat and dangers to the viewed animal;
- setting aside time and providing a space for visitors to reflect on the meaning of the experience;
- providing opportunities to socialise with peers, staff and guides; and
- providing resources that visitors can access post-visit.

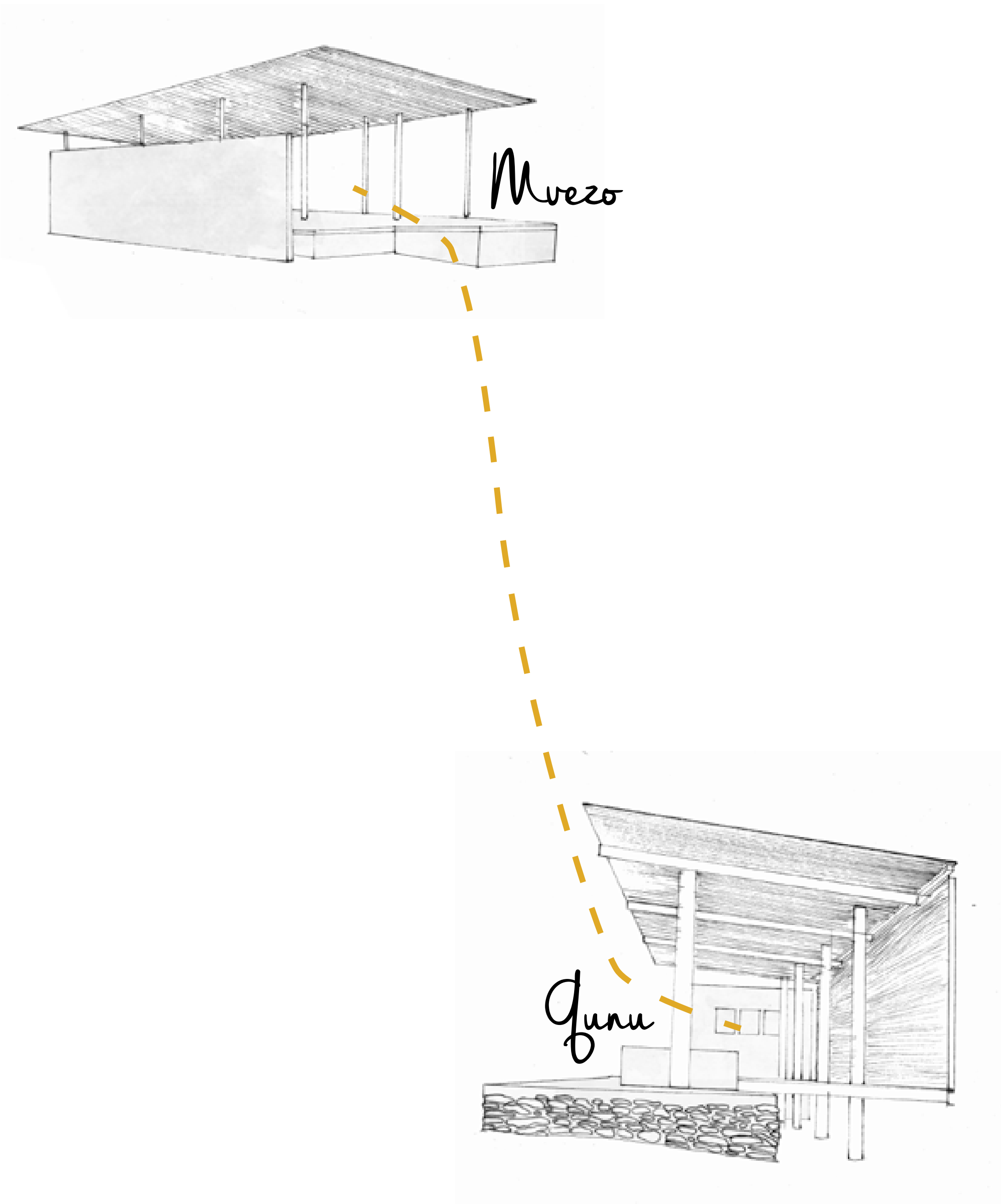


FIGURE 5.14
ROUTE BETWEEN
MVEZO & QUNU
(Author , 2016)

PRECEDENT STUDY: NELSON MANDELA MUSEUM PAVILIONS

LOCATION	Mvezo & Qunu, Eastern Cape, South Africa
ARCHITECT	Cohen & Judin Architects TCN Architects
CLIENT	Department of Public Works Department of Arts & Culture
COMPLETION	2000

The Nelson Mandela Museum Pavilions were commissioned by the Department of Arts & Culture to honour both the birthplace and the childhood of former President Nelson Mandela. The design of the pavilions challenged the idea of the museum, as the collecting and displaying of artefacts is not of African origin, commemorating and celebrating a place instead of an object.

ROUTE

The Nelson Mandela commemorative project creates a pilgrimage route between two places of equal importance: Mvezo, the birthplace of Mandela; and 30km further, Qunu, where he spent his childhood. The pilgrimage route continues to a third place of remembrance, Bhunga Building in Mthatha. Although this building connects to the pavilions through the photographic exhibition of Mandela's presidency, it is architecturally unrelated to the pavilions (Fraser 2009:386).

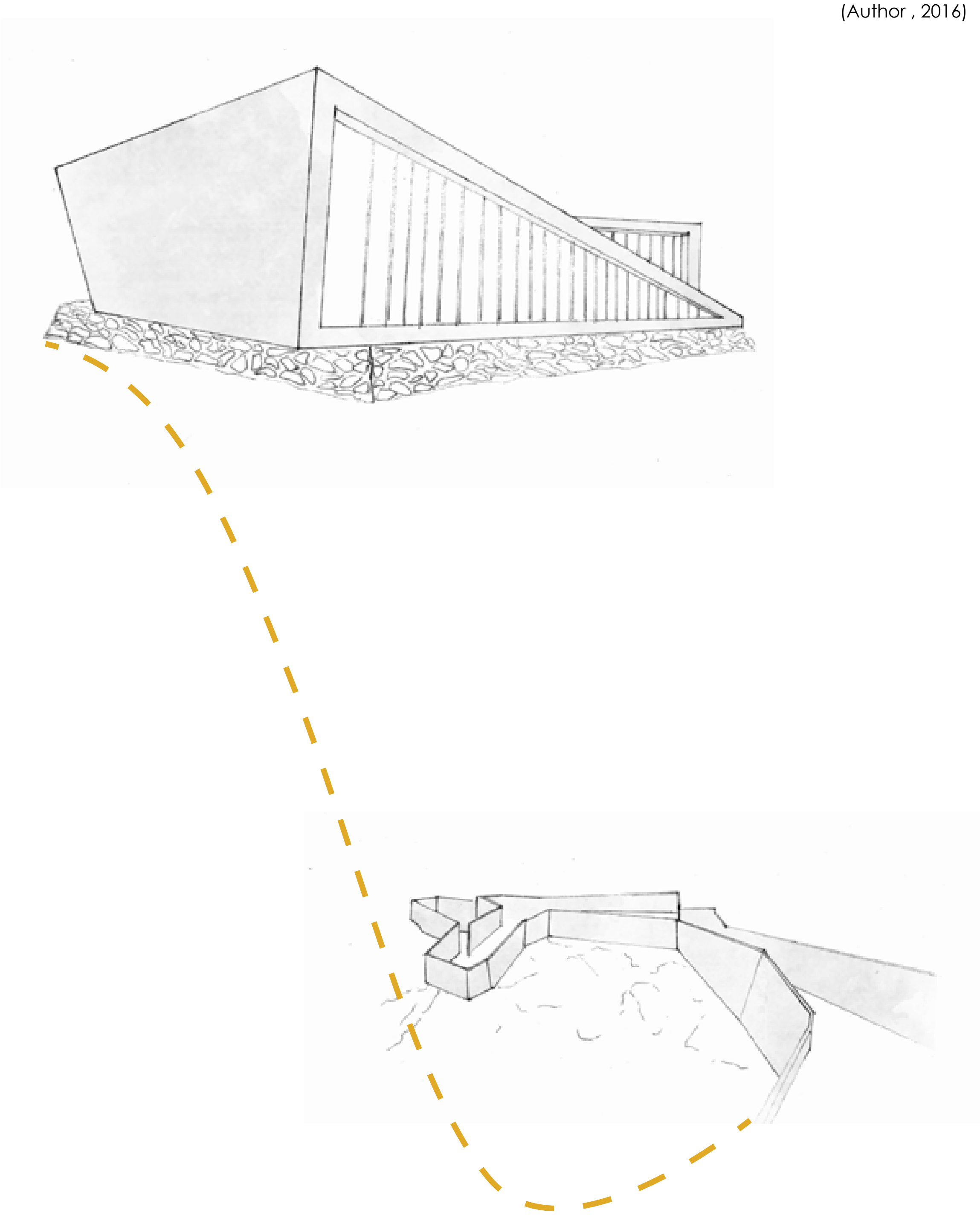
When approaching the design, the idea of creating a monumental structure to memorialise the former president did not seem appropriate to the context of this underdeveloped part of the country. Thus, the community was consulted to develop a programme which could contribute to addressing its most pressing needs. As part of the design strategy, the project took into consideration the procurement and enhancement of existing skills, creating a series of water points, which not only generated an income through tourism, but also provided the community with much needed infrastructure (Fraser 2009:386).

ATTRACTION

The pavilions at Qunu and Mveso are both humble in scale, and are designed to commemorate Mandela, while serving the current the community. The larger pavilion is located in Qunu, and serves as a community meeting space and a gateway to the area. An open-air gumpole, galvanised steel I-beams and sheet metal structure contains a large gathering space, with a masonry podium as the footprint of the structure.

The pavilion at Mveso is smaller in scale, and is covered by a similar structure. A lattice screen is used as an exhibition space for both Mandela and the landscape, by engaging with the visitors' auditory and visionary senses. The screen captures the sound of the wind, while creating a backdrop for the exhibition of photographs and extracts from Mandela's autobiography (Fraser 2009:386).

FIGURE 5.15
TROLLSTIGEN NATIONAL TOURSIT ROUTE
(Author , 2016)



PRECEDENT STUDY: TROLLSTIGEN NATIONAL TOURSIT ROUTE PROJECT

LOCATION Romsdalen, Rauma, Norway
ARCHITECT Reiulf Ramstad Architects
CLIENT Norwegian public roads administration
COMPLETION 2010

The Trollstigen National Toursit route is located on Norway's west coast. The panoramic site sits within a dramatic pass between the deep slivers of ocean formed by the fjords that characterise the landscape (Frearson 2012). As a result of the severe winter weather of the region, the route can only be constructed and visited during the summer. The project aims to enhance the visitors' experience of the landscape, drawing attention to the nature and the location on the plateau (Reiulf Ramstad Architects 2012).

ROUTE

The route is designed to connect the various, otherwise inaccessible, tourism based programmes of Trollstigen, forming a pathway between a mountain lodge with restaurant and gallery, flood barriers, water cascades, bridges, pavilions and platforms with a view of the breath-taking scenery (Frearson 2012).

The various architectural interventions are sculpted from the landscape, with a thin thread guiding the visitor from one overlook to another. The route not only gives the visitor a view of the landscape, but aims to submerge the visitor into their environment (Frearson 2012).

ATTRACTION

The intention of the architect was to develop a clear architectural language, emphasising the transition between the planned zones and the natural landscape. The collection of tourism facilities is functional, in response to the site character, and serve to augment the visitors' view of the landscape. At a conceptual level, tension was created between water as a dynamic element, and rock as a static element, manifesting in the form of a series of spaces magnifying the spatiality of the landscape (Reiulf Ramstad Architects 2012).

5.4
HABITAT
5.4.1
THE VIVARIUM

The vivarium, a constructed artificial habitat for the study of animals, is a specialised building typology, which accommodates the control of small scale environments for the care and maintenance of animals under research (Stark et al. n.d.). Vivaria are related to but are distinct from other research laboratories, and aim to support research programmes that promote the health and well-being of the animals under study, as well as the researchers that occupy the vivaria (Hessler and Lehner 2009:98).

Vivaria has become an essential extension of the laboratory of animal research facilities, moving from merely a support structure to an integral part of the research programme (Hessler and Lehner 2009:109). Vivaria can be embedded within the laboratory building, accommodated by a separate structure connected to the laboratory or in a free standing structure, depending on the size of the reached animals and their habitat requirements (Stark et al. n.d.).

Vivaria are among the most functionally driven typologies within the scientific research field, with the complexity and cost of designing and constructing for the technical requirements often overshadowing the aesthetic of the space (Hessler and Lehner 2009:109).

5.4.2
HABITAT FOR CHIROPTERA

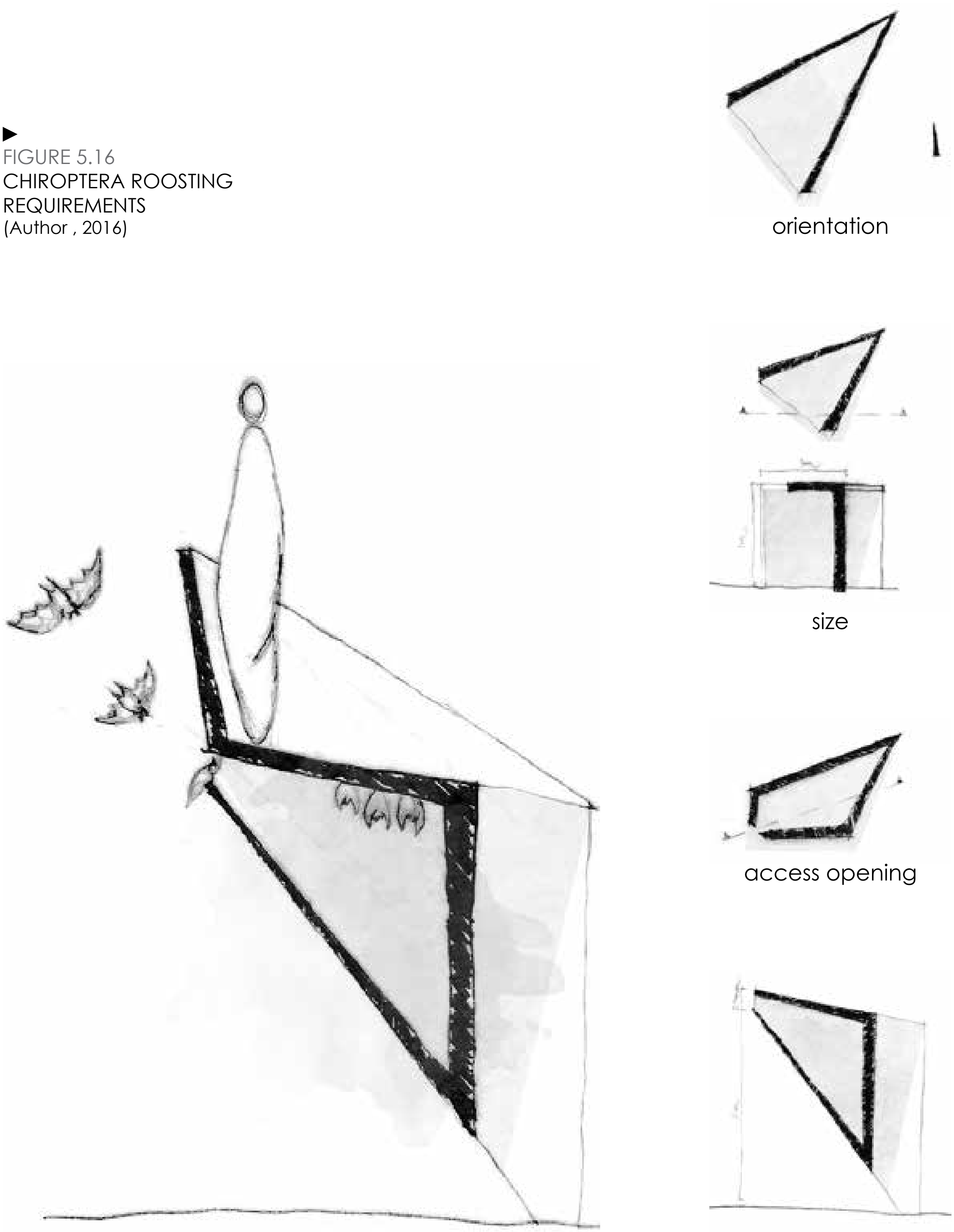
When designing an artificial habitat or roost for bats, a number of factors come into play in order to create the ideal habitat for the bats throughout the seasons. The control of the internal temperature and humidity of a roost are two of the key factors in designing a successful artificial roost (Bat Conservation Trust n.d.). Bats generally roost at temperatures between 30-40°C, taking into consideration that the heat generated by the body mass of the bats increases the internal temperature.

Larger, warm roosts are preferred by bats during the nursing season, and roosts with a consistent, warm microclimate are preferred during the winter months for hibernation (IUCN 2008). To optimise solar gain, the orientation of the opening of the roosts vary according to the season, with a north- facing opening being ideal in winter, and a south or west-facing opening in summer.

The Schreibers' long-fingered bat requires unobstructed flight space, occupying an interior space of no less than 1 meter squared. In roosting sites, the Schreibers' long-fingered bat establishes its colony in a bell-shaped hollow within the roof of the cave, trapping the heat of the bats to raise the internal temperature of the cave (IUCN 2008). Unlike horseshoe bats, Schreibers' long-fingered bat crawls, and does not fly, into roosts through small crevices. The openings range from 15-20mm high, and 20-50mm wide, and should ideally be located at a height of around 2 meters and upwards.

By locating roosts near vegetation and flight lines, bats emerge from the roosts much earlier, leading to a longer foraging time (Bat Conservation Trust n.d.). The vegetation also allows the bats to emerge directly into cover, so as to protect them from predators. Bats are known to use linear features in the landscape, such as hedgerows, tree lines and waterways as

▶
FIGURE 5.16
CHIROPTERA ROOSTING REQUIREMENTS
(Author , 2016)



commuting pathways between their roosts and the area in which the forage. The structure that these linear elements provide also assist the bats in acoustic orientation and navigation.

Natural and man-made shelters allow for the gathering of insects, increasing bat foraging. Good foraging areas are seen as the areas with a high density of insects, and more specifically, a high density of nocturnal insects. The Schreibers' long-fingered bat feeds on nocturnal flying insects, including moths, small beetles and the occasional fly (Bat Conservation Trust n.d.). The bat catches the insects by using echolocation, at heights ranging between 10-20 meters, often over large pools of water (IUCN 2008). Other habitats which feature a high density of flying, nocturnal insects are rivers, grassland and areas with endemic vegetation.

The endemic flora of Bolt's farm, not only offers the visitors to the site a picturesque view, but also host a variety of insects, on which the Schreiber's long-fingered bat feeds. Some of the most beautiful flora of the site includes the *Eulophia ovalis, Eulophia hians*, and *Eulophia inaequali* orchids. These orchids, along with the other endemic flora support insect life, including the *Phiala constipuncta*, and *Heliothis scutuligera* moths, on which the Schreibers' long-fingered bat feeds, as both the moth and the bat emerge at dusk.

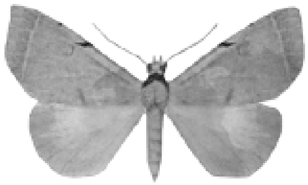
▶
FIGURE 5.17
THE MOTH &
THE ORCHID
(Author , 2016)

Heliothis scutuligera

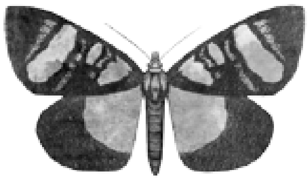
Pardoxia graellsi

Loxostege venustalls

Phiala constipuncta



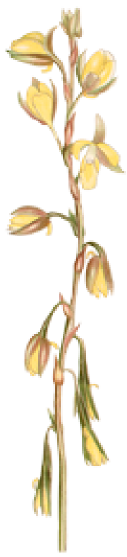
Ctenusa varians



Achaea catocaloides

Eulophia ovalis

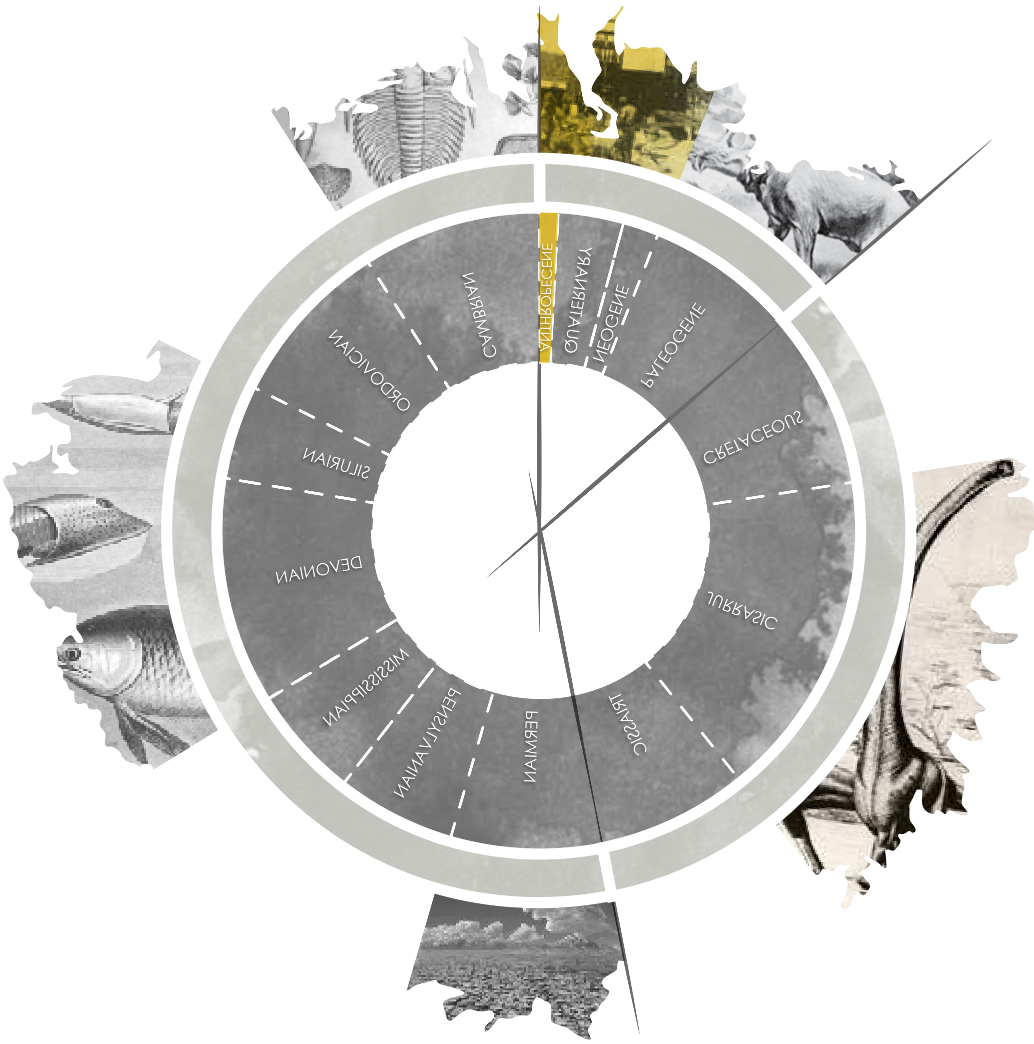
Eulophia hians



Eulophia inaequali

CONCEPT

THE ANTHROPOCENE
GEOLOGY AS INFORMANT



▲
FIGURE 6.1
GEOLOGICAL EPOCHS
(Author, 2016)

-6-

THE ANTHROPOCENE

GEOLOGY AS INFORMANT

We, as human beings, are currently finding ourselves in the Anthropocene, a new geological epoch where the impact of humans on the shaping of the Earth has become visible. Human beings are capable of geomorphic force, shaping the landscape together with other "natural" catastrophes (Yusoff 2013, :779). In a response to this, the dissertation reflects on the current position and impact humankind has on the geological make-up of the earth, exploring the way in which built form can alter the geology to benefit the landscape.

Learning from three concepts of the geology of the Cradle, namely the formation of geology, the creation of the karst ecosystem, and the mountain & the grotto, the dissertations investigates the way built form can serve to protect a landscape, while growing to support a habitat for the co-evolution of human beings together with other natural systems, and through this, brings focus to the role humankind has to play in the workings of ecological systems.

6.1 THE GEOLOGY OF CATASTROPHE

6.1.1 THE FORMATION OF GEOLOGY

From the outlook of French catastrophism, violence is at the heart of nature's creative act. This can be seen in the formation of geology, where geology is formed through geomorphic forces, and the resistance to these forces (Abalos et al. n.d.). Bolt's Farm has become a prime example of the impact of the forces of humankind, and the resistance thereof. Although the mining and blasting activities of the quarry on Bolt's Farm has rendered the site sensitive, it has become a platform in understanding the resistance the various layers of the geological make-up has to the shocks and vibrations of blasting (The South African Karst Working Group 2010:206).

The location of Bolt's farm, between the polluted Rietvlei River and abandoned aggregate quarry, places pressure on the networks found in-between. It is between these two forces, and the resistance thereof, that the architecture is created.

6.1.2 PROTECTING

In a response to the distressed state of the landscape, the primary intention of the placement of built structures in the landscape is to mitigate the current threats and past destruction of the landscape.

6.2 THE KARST LANDSCAPE

6.2.1 THE CREATION OF HABITAT

The unique geology of the Cradle landscape has not only preserved remnants of the historical landscape, but created favourable conditions for those living in the landscape, both past and present.

FIGURE 6.2
ANTIQUE ROCK MINERAL GEOLOGICAL GERMAN LITHOGRAPH PRINT
(Antique Print Gallery,1888)

The karst system is created through the presence of water, with water seeping into and flowing over the dolomitic formations, dissolving the dolomite at a slow rate. It is, however, the presence of the polluted water that is threatening the existence of this karst landscape.

The karst system also hosts a rich ecosystem, supporting life both in and on the surface of the landscape. The habitat, formed by the landscape, is home to a number of rare and endangered species, both fauna and flora, accommodating and supporting human and non-human life in the Cradle.

6.2.2
ACCOMMODATING HABITAT

In response to the complex habitats hosted by the karst geology, the structures placed in the landscape to mitigate the threats to the landscape, also serve to accommodate habitat. Although each structure favourers a dominant user, each habitat formed between the structures, accommodates a multitude of users, including human, animal and plant species.

The intention of these structures is to improve the current state of the site, thus altering the landscape for the sake of the landscape. The structures manifest in the form of stereotomic walls, constructed from materials inherent to the site, including earth and stone.

6.3
THE MOUNTAIN & THE GROTTO
6.3.1
SUBMERGENCE & EMERGENCE

The presence of the caves in the landscape, and the koppies on which they are found are reminiscent of the 'Mountain and the Grotto', where the emergence of the Mountain Sublime in the late 18th century explored the idea of surveying and display (Abalos et al. n.d.). In the Cradle of Humankind, tourism entities, such as Sterkfontein Caves and Maropeng, are based on the display or interpretation of objects found in the landscape.

Unlike traditional tourism entities, where the object displayed is removed from the context in which it is found (Naidu 2008, :191), the Chiroptera Visitor Centre, aims to showcase the objects, i.e. the bat, in the context or habitat in which they are found, allowing for a greater understanding of the landscape of Bolt's Farm.

The idea of the grotto, as seen in 19th century park follies and the unbuilt building of La Sainte-Baume Basilica by Le Corbusier, relates to the idea of submergence and intimacy. The caves of the Cradle are a literal translation of the grotto, where hominid species found refuse and where preserved until the percent day.

6.3.2
ACCOMMODATING

The idea of the mountain and the grotto translates into the secondary programmes connected to the habitats. These functions include tourism and research facilities, two functions which connect to the emergence from and submergence into the landscape. Where the tourism functions, such as the quarry pavilion, star-gazing platform and bird hide, place the landscape on display, the research facilities aim to engage with the hidden layers and workings of the landscape.

FIGURE 6.3
CONCEPT DIAGRAM
THE GEOLOGY OF CATASTROPHE
(Author , 2016)
▼

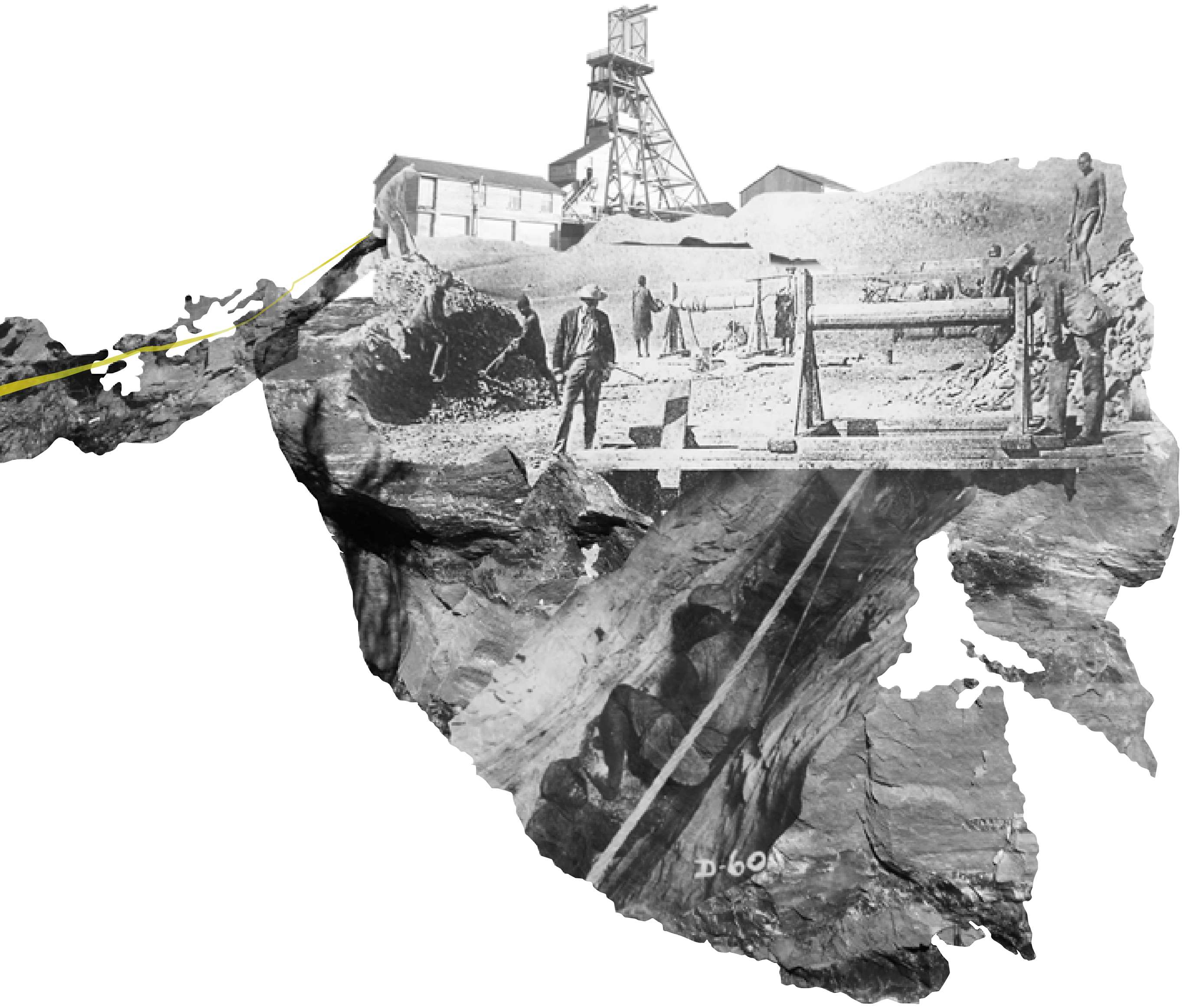

D-60

FIGURE 6.4
CONCEPT DIAGRAM
THE KARST SYSTEM
(Author , 2016)

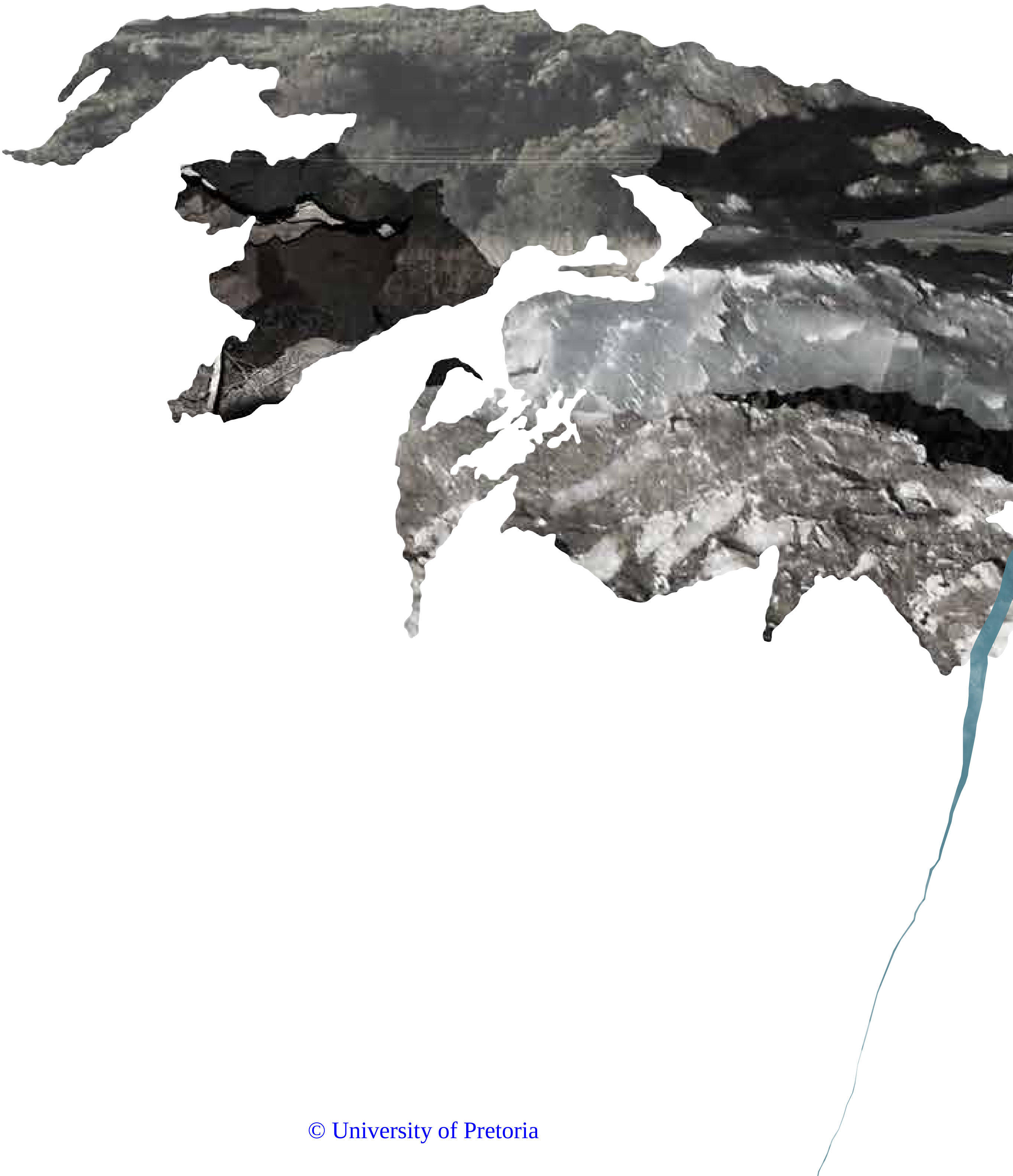
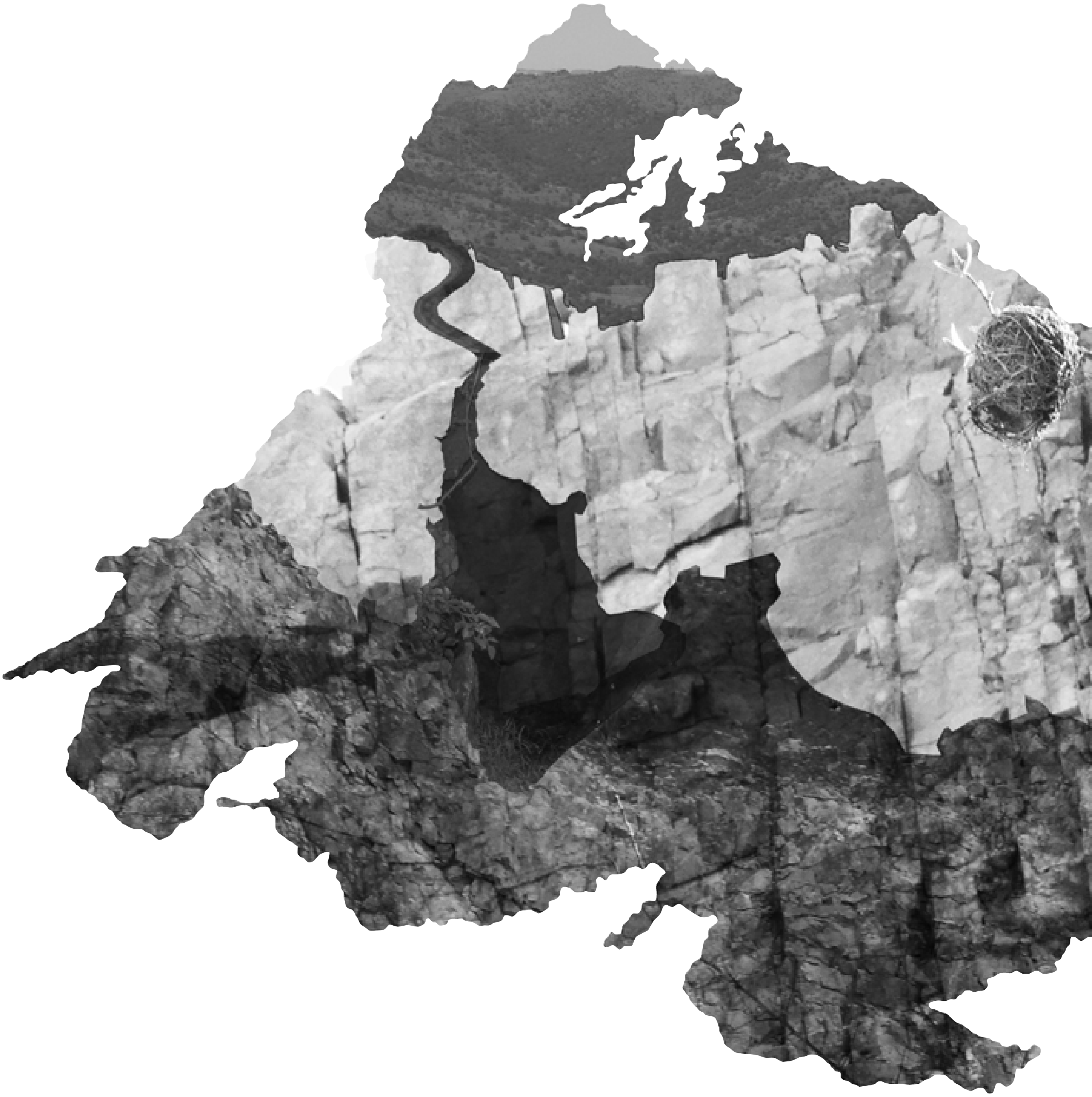


FIGURE 6.5
CONCEPT DIAGRAM
THE MOUNTAIN & THE GROTTO
(Author , 2016)



DESIGN DEVELOPMENT

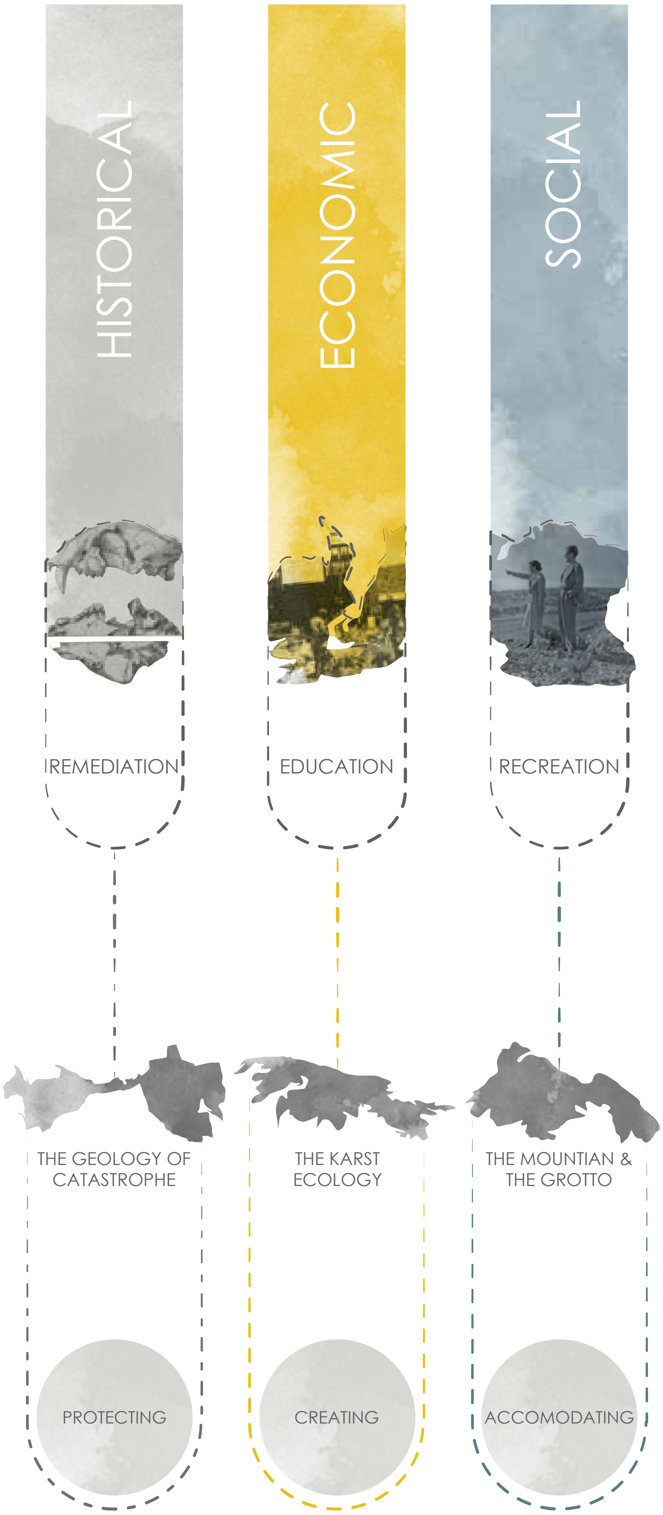


FIGURE 7.1
DESIGN FRAMEWORK
(Author , 2016)

-7-

DESIGN

DEVELOPMENT

The design strategy for the dissertation is developed as a response to the three layers of the landscape, namely the historical, economic and social landscapes. The design framework is manifest in the form of structures that are developed to protect the historical landscape. This is followed by the development of new and lost habitat as a response to the threats of the economic landscape. Lastly, the strategy focuses on developing structures that accommodate the programmes which enable and are enabled by the existence of the habitats in the form of tourism and research building on the social landscape (Fig. 7.1).

The development of the design is based on the objective of creating architecture which accepts the impact of humankind on the geology and ecological systems, investigating how this impact could improve, instead of leading to the demise of the landscape, its' networks, and the living systems to which it plays host.

The approach to the development of site and the individual interventions is based on five architectural intentions. The connecting of the three landscapes and its' networks, and the revealing of the hidden layers of the landscape are the two over-arching intentions, and are applied throughout the design, from site to detail level. The further three intentions structure the development of built form, and are applied to individual parts, building on one another. These three intentions are the protection of the landscape, the creation of opportunities for habitats, and the accommodation of spaces for programmes, which build on the habitats.

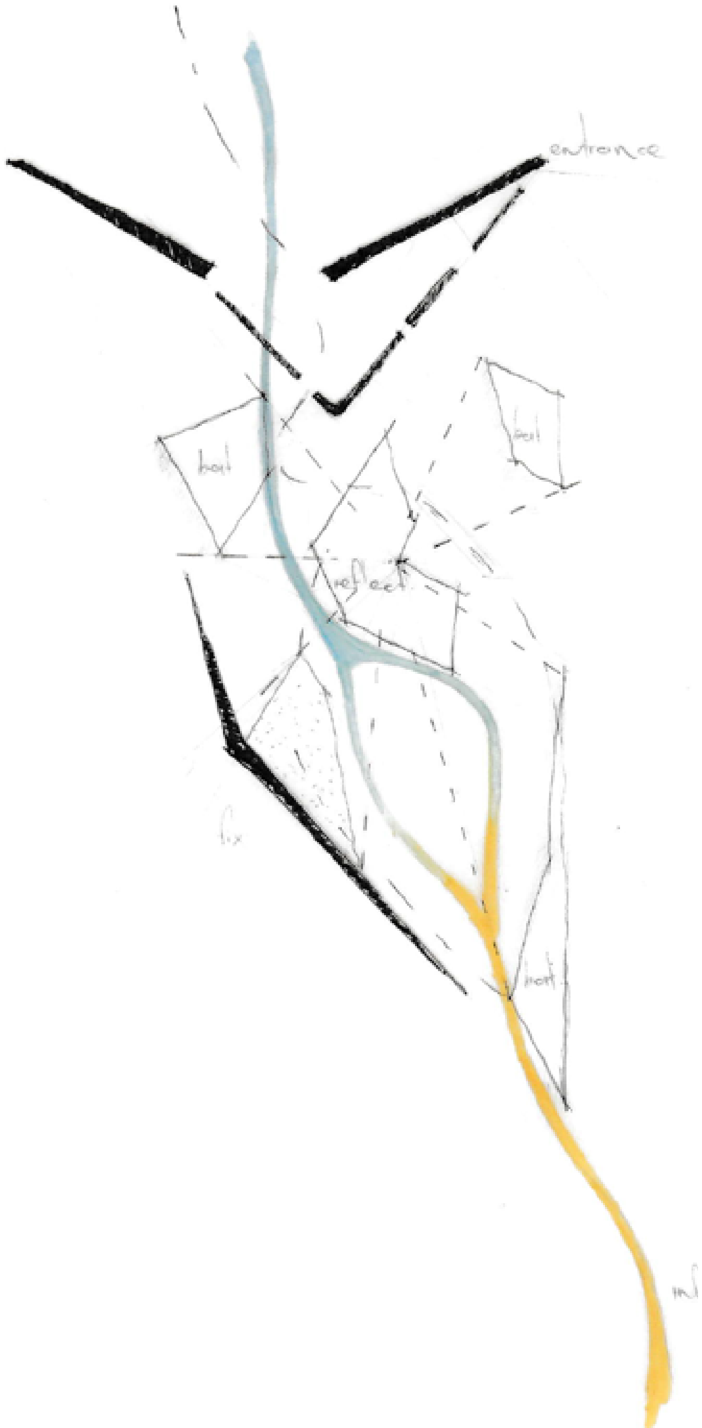
7.1 CONNECTING

7.1.1 ROUTE DEVELOPMENT

The development of the route is based on both a physical and physiological journey through Bolt's Farm. The route serves to connect the points of energy, thus the points of intervention, onsite, guiding visitors, researchers and staff from one point to another. The route also serves to guide visitors through the site to enhance the take-home visitors experience (Fig. 7.2), allowing the visitors to view the landscape from another perspective.

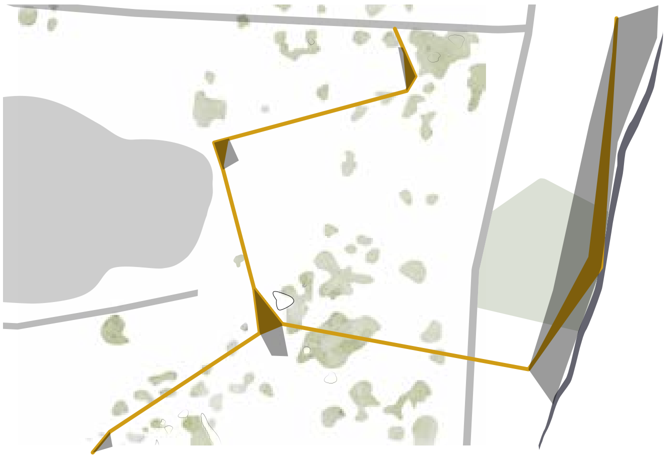
As the slope of the site is steep, specifically the connection between the Ticket Office and Quarry Pavilion, the route meanders up to the quarry, leading visitors through a large clump of trees, instead of directly connecting these two spaces (Fig. 7.5).

Other than guiding the users of the site from one space to another, the route serves to protect the site. The route not only reduces erosion and the trampling of endemic flora, but also channels storm water and acts as fire break to protect the landscape.



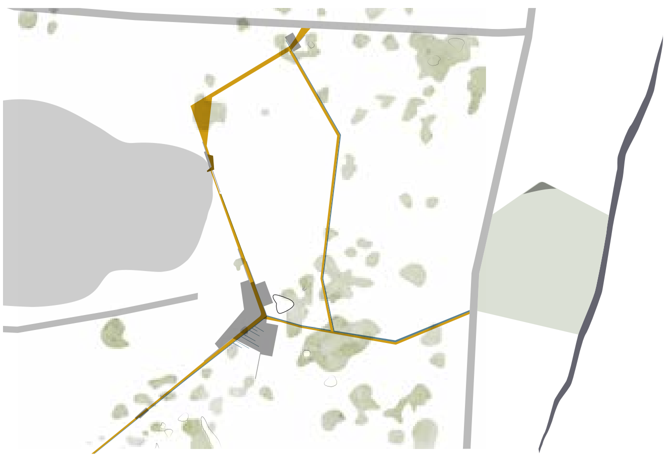
▲
FIGURE 7.2
ROUTE CONCEPT
-APRIL-
(Author , 2016)

▶
FIGURE 7.3
ROUTE DIAGRAM
-APRIL-
(Author , 2016)



▶
FIGURE 7.4
ROUTE DIAGRAM
-JUNE-
(Author , 2016)

▶
FIGURE 7.5
ROUTE DIAGRAM
-AUGUST-
(Author , 2016)



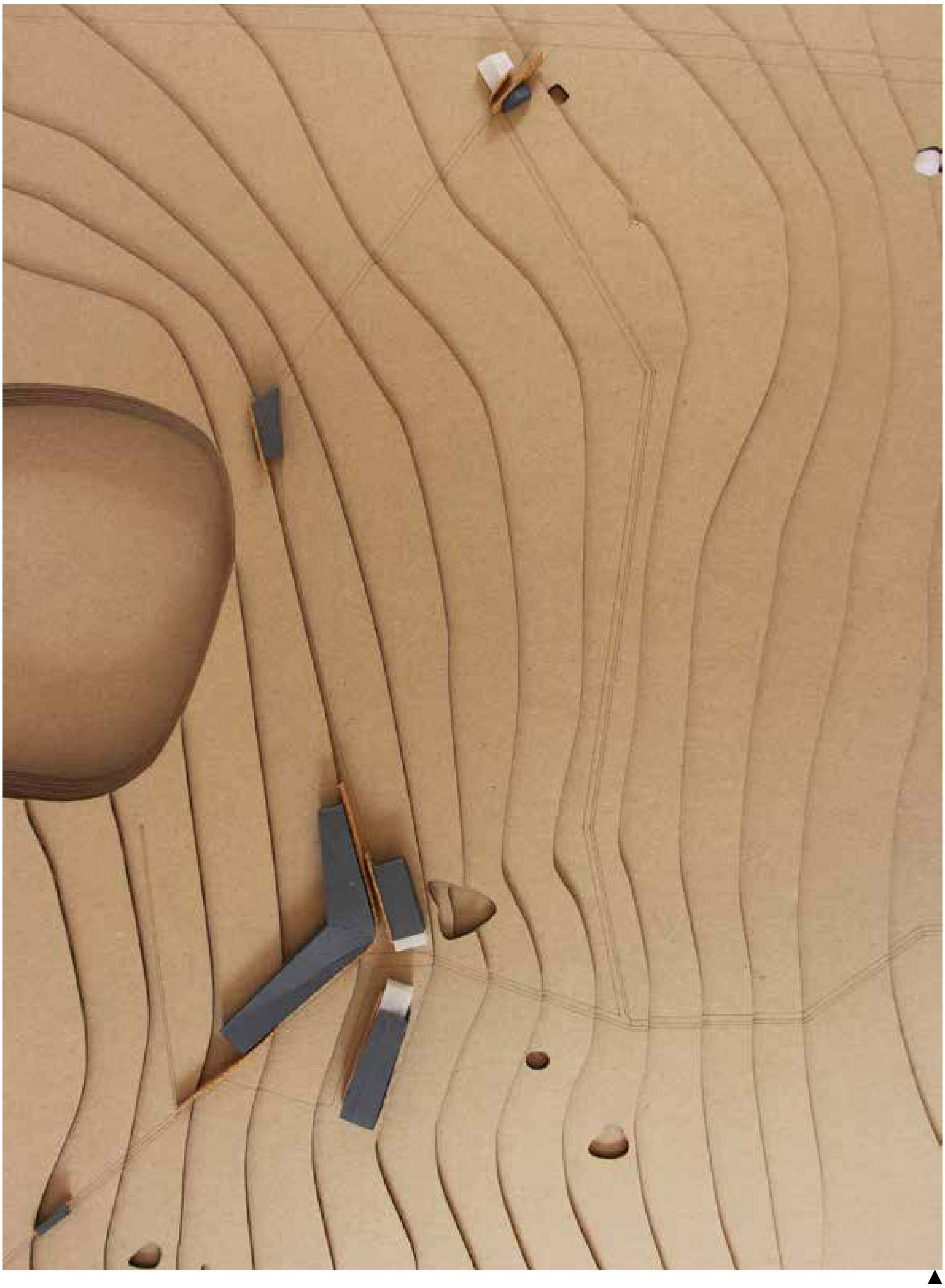
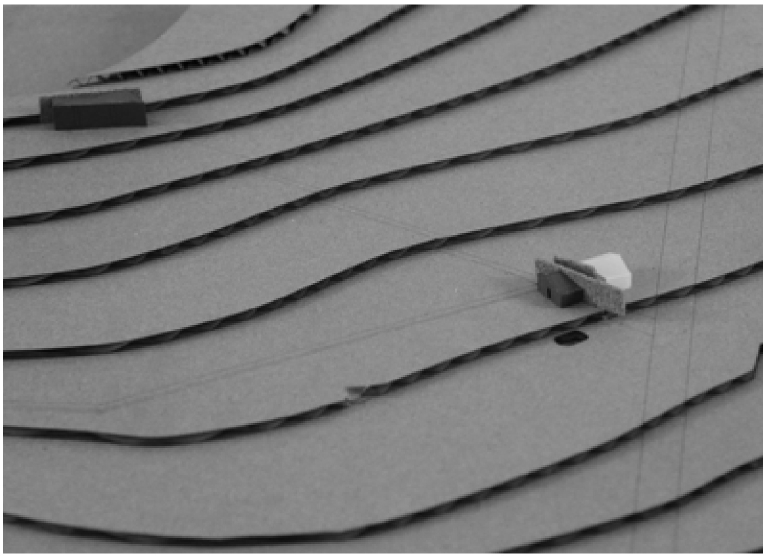
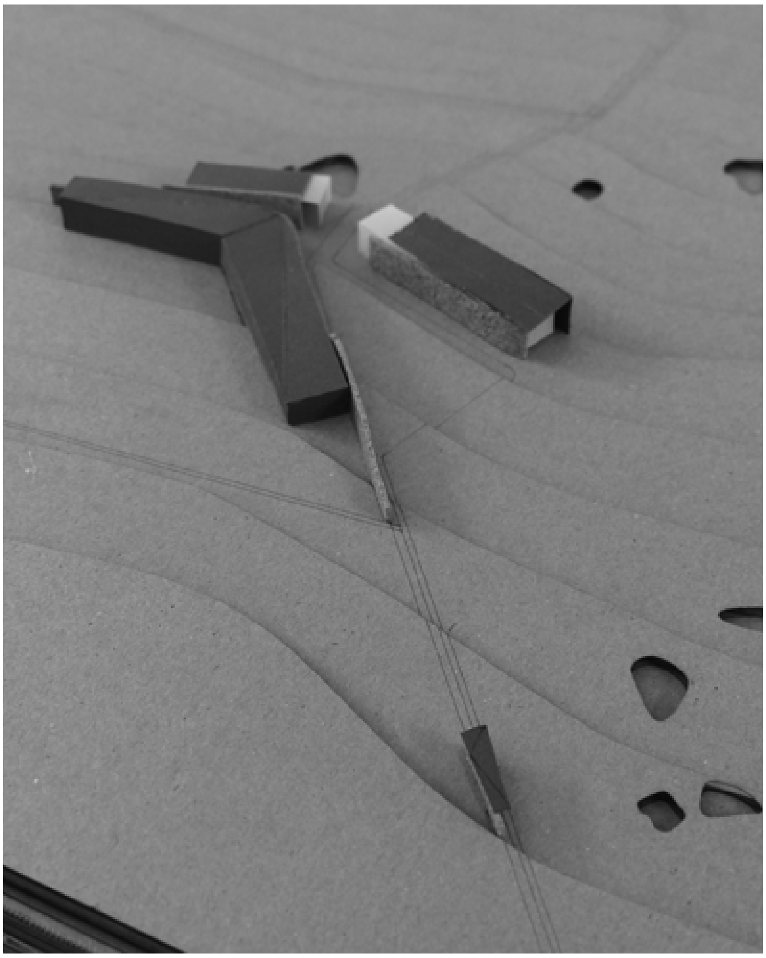


FIGURE 7.6
SITE MODEL
-JUNE-
(Author , 2016)



▶
FIGURE 7.7
ROUTE BETWEEN TICKET OFFICE & QAURRY PAVILION
-JUNE-
(Author , 2016)



▶
FIGURE 7.8
ROUTE BETWEEN VIVARIUM & FIELDWORK STATION
-JUNE-
(Author , 2016)

7.2
REVEALING
7.2.1
SCREENING & REVEALING

Along with the direction of the route, physical elements placed in the site direct the visitor's view. Throughout the site, the visitor's perception of the landscape is altered by screening and revealing the landscape.

7.2.1.1
THE QUARRY PAVILION

The Quarry Pavilion introduces visitors to the threats to the seemingly pristine landscape. The aim of the pavilion is thus to shock, for rhetorical effect. As one approaches the pavilion, the quarry is not visible as seen in both the major design iterations. With the May iteration, the visitor is lead through the pavilion to the side of the quarry (Fig. 7.9). The design was developed further, to become narrower as one moves through the buildings, becoming more claustrophobic, introducing tinted light reminiscent of the colour of acid mine drainage, and turning the route at a sharp angle, forcing the visitor onto a viewing platform over the edge of the quarry (Fig. 7.10).

7.2.1.2
THE FIELDWORK STATION

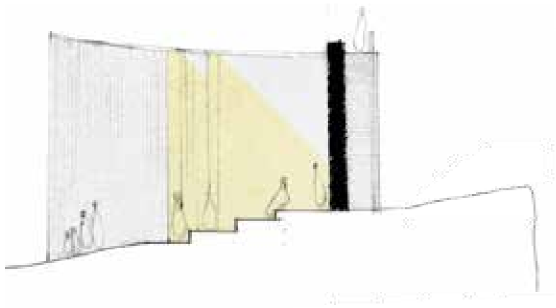
The screening element of the Fieldwork Station is applied for utilitarian purposes, amongst others. The initial design of the Fieldwork Station catered only for the use of archaeologists (Fig. 7.11), with the addition of functions, such as a bird hide, a screening elements is placed as a barrier between the visitors and viewed birds (Fig. 7.12). The screen allows archaeologists and visitors to move freely behind the screen, without disrupting the birdlife.

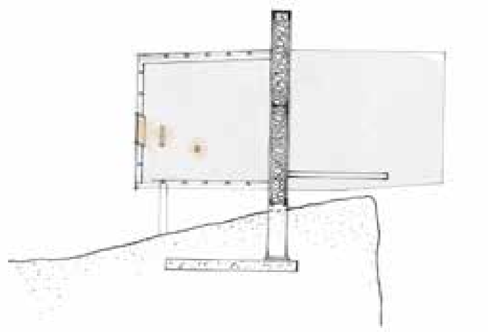
▶
FIGURE 7.9
QUARRY PAVILION SECTION
-MAY-
(Author , 2016)

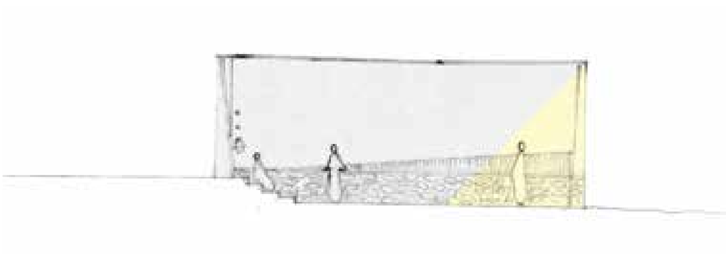
▶
FIGURE 7.10
QUARRY PAVILION SECTION
-AUGUST-
(Author , 2016)

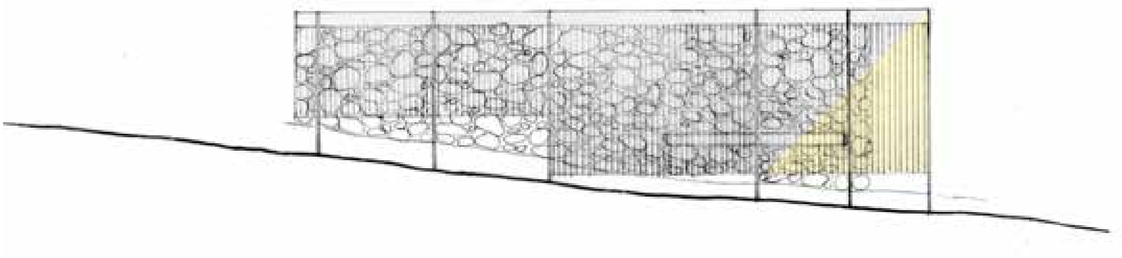
▶
FIGURE 7.11
FIELDWORK STATION ELEVATION
-MAY-
(Author , 2016)

▶
FIGURE 7.12
QUARRY PAVILION SECTION
-AUGUST-
(Author , 2016)









◄
FIGURE 7.13
VIVARIUM MODEL EAST ELEVATION
-APRIL-
(Author , 2016)

◄
FIGURE 7.14
VIVARIUM MODEL EAST ELEVATION
-JUNE-
(Author , 2016)

◄
FIGURE 7.15
VIVARIUM MODEL EAST ELEVATION
-SEPTEMBER-
(Author , 2016)

7.2.1.3 THE VIVARIUM

The Vivarium is located in close proximity to Cobra Cave, one of only a few caves in the area where Chiroptera fossils where discovered. The restaurant building is placed on the edge of the cave opening, allowing visitors to view the direct link to the karst system. The initial design allowed a large open view across the site (Fig. 7.13), the restaurant building was further developed to create a contrast between interior and exterior space, with a large glazed opening revealing the karst opening (Fig. 7.14). The design iteration, as developed by September (Fig. 7.15), moved away from revealing the karst opening in an abrupt manner, such as done by the Quarry Pavilion, and made use of a screening element, opening up to the karst opening as the visitor progresses through the restaurant building.

7.2.2 LAYERS OF THE BUILDING

7.2.2.1 STEREOTOMIC

Each building one encounters along the route makes use of large walls, seeming to protrude from the earth, protecting the site, guiding the visitor and, over time, creating habitat. These walls are constructed from materials of the site, such as earth and stone.

The initial design saw all of the walls being constructed out of rammed earth. With further development, each building was developed to respond to the typology relating to the circumstances of the site it is influenced by, for example the Quarry Pavilion. The Pavilion is influenced by the industrial typology of the mining industry, moving away from a rammed earth wall (fig 7.16) to a welded mesh wall, made up of large steel channels, and filled with loose stones, found in the quarry itself (Fig. 7.17).

The Ticket Office (Fig. 7.18), located at the entrance to the site, is based on a barn typology, relating to the past and present farming activities of the surrounding area. With the development of the design, the construction material of the walls moved away from rammed earth to a patterned brick screen. The screen is constructed from reclaimed brick, found across the road in a kraal ruin.

As the design of the Vivarium progressed, the main construction material remained earth, due to its thermal and moisture control properties. The construction method, however, moved from rammed earth construction, to lime stabilised earth construction, supported on a stone wall of the same width.

The construction material of the final building on the route, the Fieldwork Station (Fig. 7.19), also changed as the design developed. The station makes use of a cavity wall with a passive evaporative cooling system, to act as a low-tech fridge. Rammed earth was thus seen as an unsuitable construction material, as it weathers at a faster tempo than does stone, when exposed to constant dripping water.

7.2.2.1 TECTONIC

The structures developed around the habitat created by the large walls are formed through light-weight structures, resting above the landscape. The structures are clad with an internal and external skin, regulating the internal environmental conditions. With further development of the design, the different parts of which the structure is constituted are revealed. The external skin pulls away from the structure, to allow for light to penetrate the internal spaces, while exposing the structure (Fig. 7.20).

7.3 PROTECTION

7.3.1 WATER

Water channels are proposed along the routes, running along the contours of the site to minimise the amount of water running down the slope to the openings and caves. The channels lead to one larger channel, running down the slope, leading the water to a retention pond. The water management strategy is to better control the quality and quantity of surface water infiltrating the karst system.

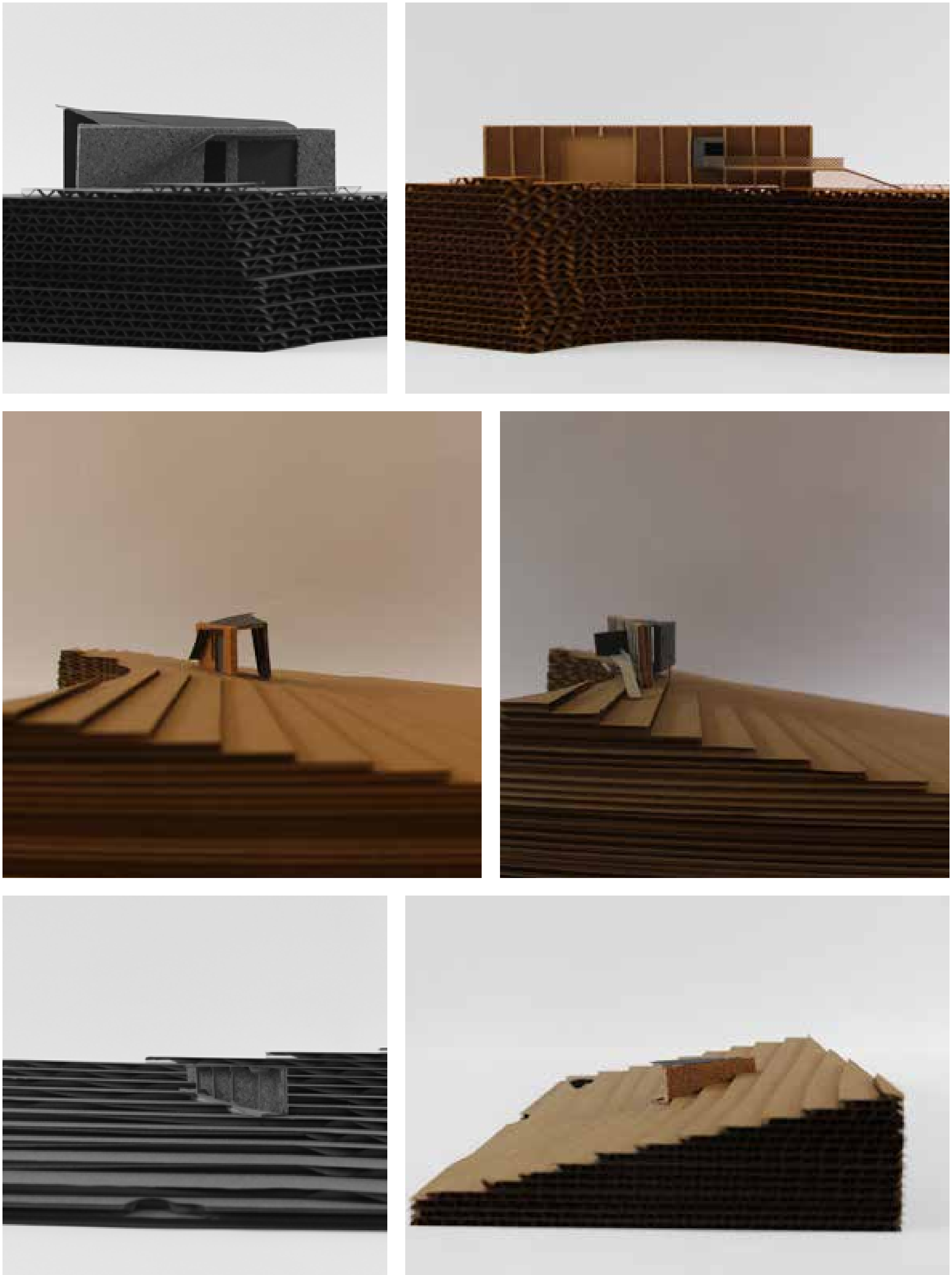
7.3.2 FIRE

Veld-fires in the grassland biome in which the Cradle of Humankind is situated are inevitable. The proposed routes that connect the various buildings on Bolt's Farm are also utilised to serve as fire breaks. These routes not only serve the human visitors to the site, protecting the buildings, but create open pathways the veld animals use to navigate to safety. With further development of the Vivarium, a temporary habitat is created, hosting the species which flee from the fires, until the animals can safely retreat back into the veld.

7.4 CREATING HABITATS FOR CO-EVOLUTION

7.4.1 CHIROPTERA HOUSE

The immediate environment of an animal directly and indirectly affects the animals biological and behavioural responses (The National Institutes of Health 2008, :192). The noise, light, vibrations, and thermal comfort of a vivarium not only affect the well-being of the animal, but also the quality of research. Together with the animals hosted, a vivarium is also a workplace for employees (The National Institutes of Health 2008:193). The development of the habitat for the Schreibers' long-fingered bat habitat takes these two types of



▲
FIGURE 7.16 & 7.17
QUARRY PAVILION & FIELDWORK
STATION MODEL DEVELOPMENT
(Author , 2016)

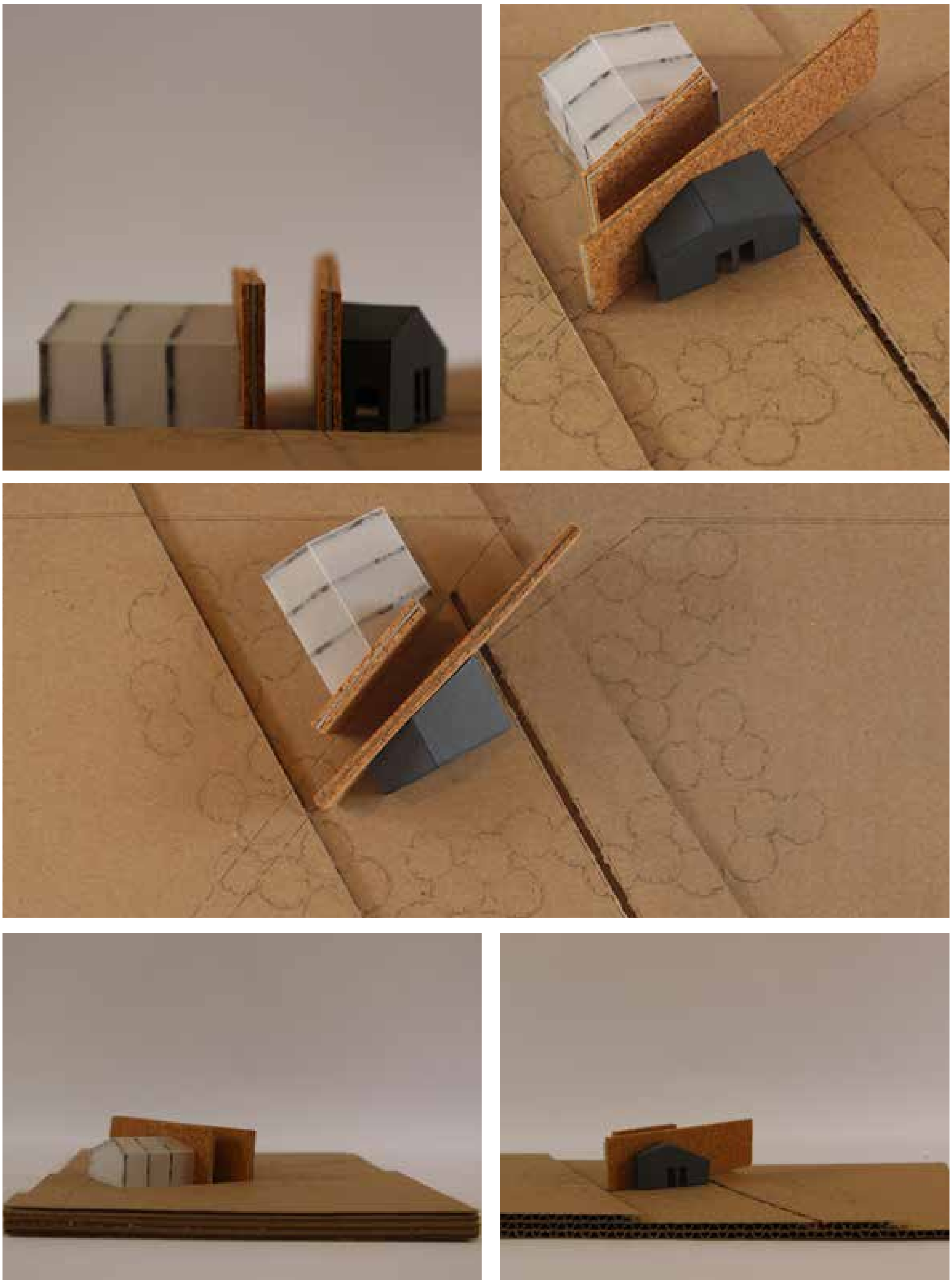
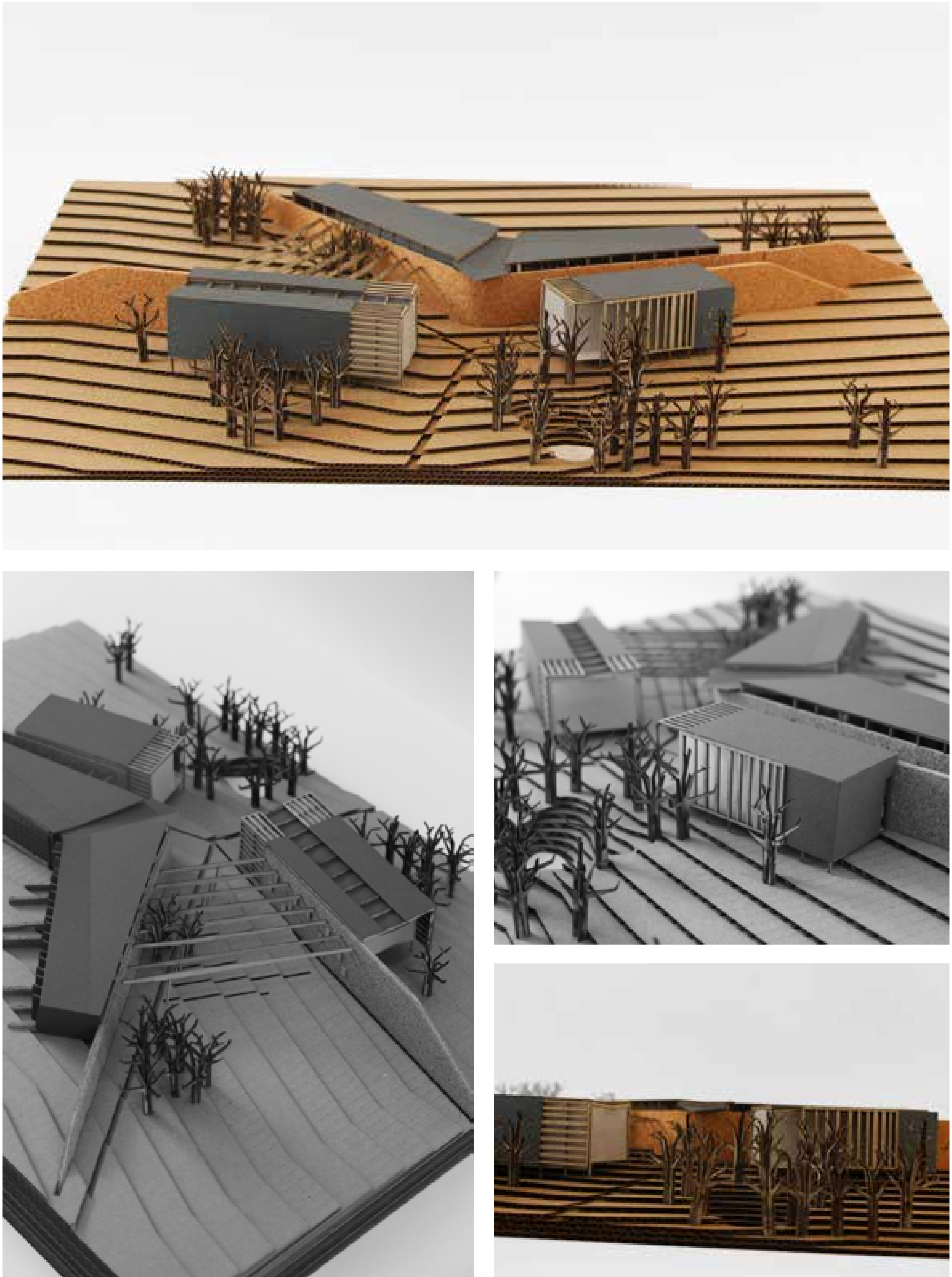


FIGURE 7.18
TICKET OFFICE MODEL
-JUNE-
(Author , 2016)



▲
FIGURE 7.19
VIVARIUM MODEL
-SEPTEMBER-
(Author , 2016)

users, namely the animals (bats) and the employees (chiroptera zoologists) into account, adding a third user, namely the (wildlife) tourist.

The design of the vivarium aims to create a favourable habitat to attract the Schreiber's long-fingered bat. The design of the vivarium not only strives to provide the ideal conditions for the bat colonies to thrive, but also to support a healthy social environment for the animals, mimicking the animal's natural environment (The National Institutes of Health 2008:193).

The Chiroptera House, as developed by April, (Fig. 7.21) is shown as one large internal space, allowing the wildlife tourists to walk underneath the opening and view the bats as they emerge and hang from the structure. With further research the internal space of the bat house is proven to be too large for the Schreiber's long-fingered bat species, as this species of bat prefers an internal space of 1-2 metre squared.

With the further development of the Chiroptera House, the internal space was reduced in order for the bat species to be able to heat up the space during the winter months with their radiating body heat. The design development by May (Fig. 7.22) did, however, not take into consideration the entirety of the eco-system in which the Schreibers' long-fingered bat species thrived, and did not offer the Chiroptera zoologists the opportunity to access the bats with ease.

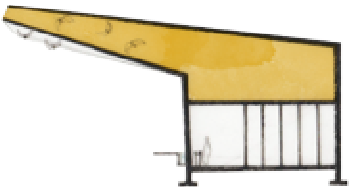
A series of Chiroptera Houses are further developed, along with a micro-habitat, including a green wall hosting Eulophia ovalis, Eulophia hians, and Eulophia inaequali orchids, in turn hosting various nocturnal flying insects. A series of water retention channels are also found in the foraging space at the openings of the Chiroptera Houses to host mosquitos, improving the biodiversity and foraging opportunities for the Schreiber's long-fingered bat (Fig. 7.24).

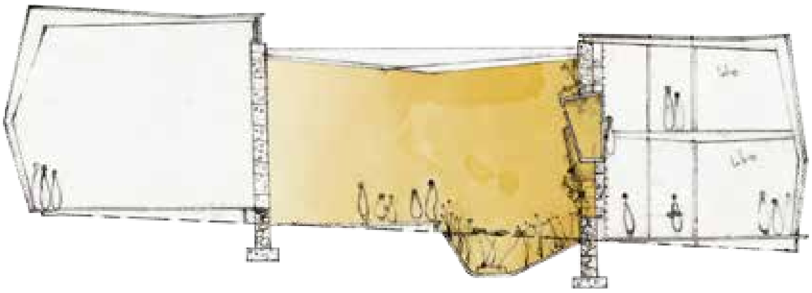
▶
FIGURE 7.20
CHIROPTERA HOUSE
-APRIL-
(Author , 2016)

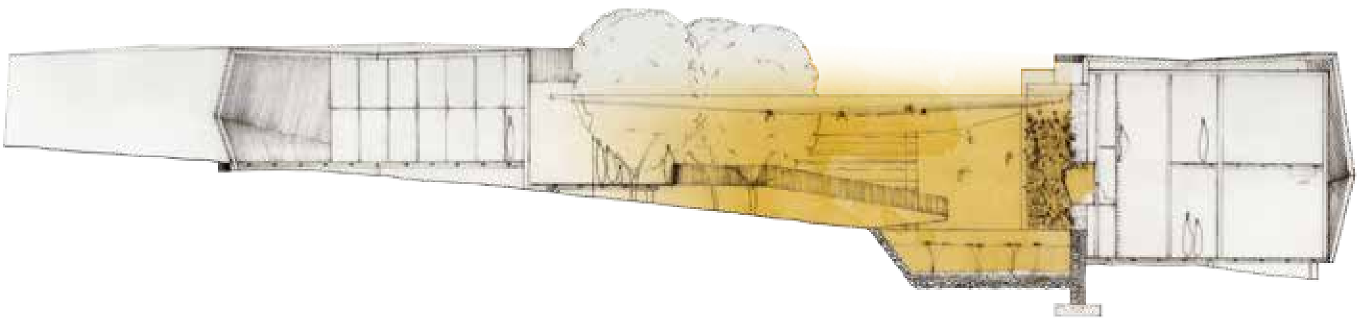
▶
FIGURE 7.21
CHIROPTERA HOUSE
-MAY-
(Author , 2016)

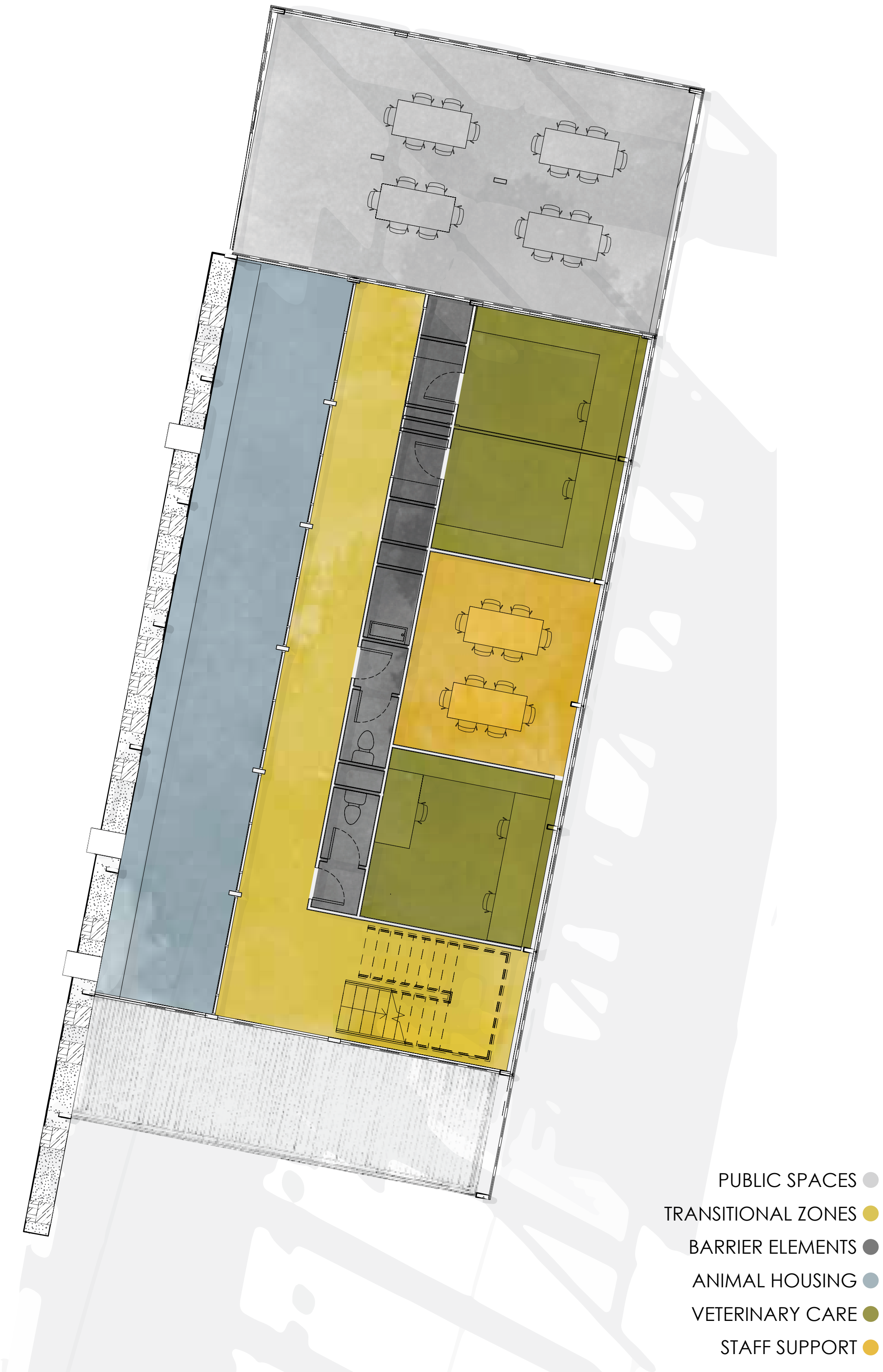
▶
FIGURE 7.22
CHIROPTERA HOUSE
-JUNE-
(Author , 2016)

▶
FIGURE 7.23
CHIROPTERA HOUSE
-JULY-
(Author , 2016)








PUBLIC SPACES
TRANSITIONAL ZONES
BARRIER ELEMENTS
ANIMAL HOUSING
VETERINARY CARE
STAFF SUPPORT

◄
FIGURE 7.24
CLASSIFICATION OF VIVARIUM LABORATORY SPACES
(Author , 2016)

7.5 ACCOMODATING

7.5.1 VIVARIUM LABORATORY

When designing for the employees, the occupational health and safety of the personnel become key considerations (The National Institutes of Health 2008:193). This includes factors such as sufficient air supply, adequate and hygienic work space and amenities like break-out spaces, training rooms, and staff offices.

Although natural light is favourable in some areas, including break out-spaces, controlled light is recommended for animal & laboratory spaces. The lighting requirements were taken into consideration, as seen in the June iteration, with the external skin controlling the lighting conditions of natural light. The external cladding is perforated in certain areas, to allow for the space to be lit up by both artificial and natural light.

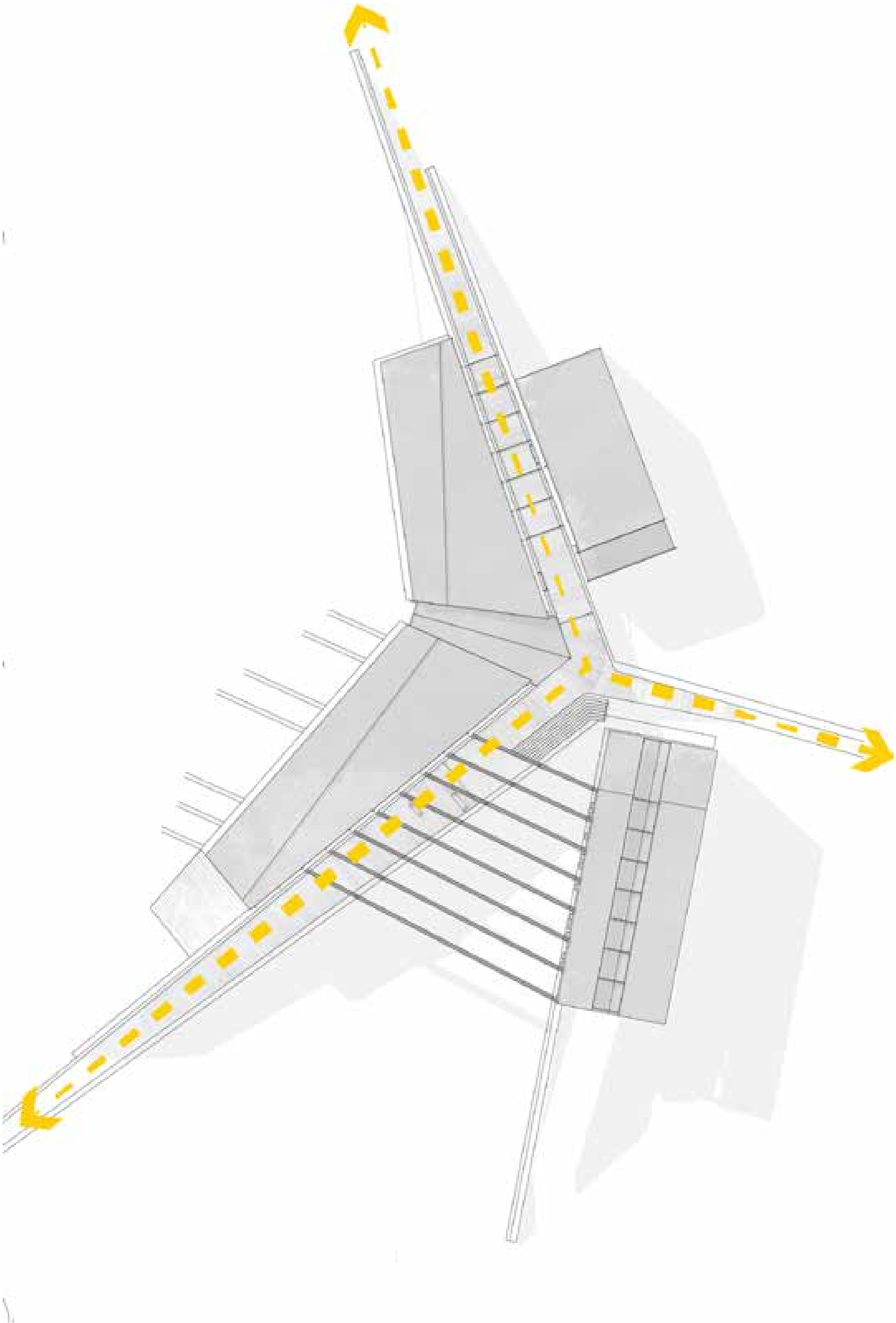
Traditional animal research facilities require support spaces, such as feed storage and quarantine areas for incoming animals. As the vivarium design creates a micro-habitat for the bats, these support spaces become redundant, and are not included within the laboratory spaces.

Hygiene is, however, a major priority when it comes to the design of the vivarium and laboratory spaces. The laboratory and supporting spaces are classified into the following zones:

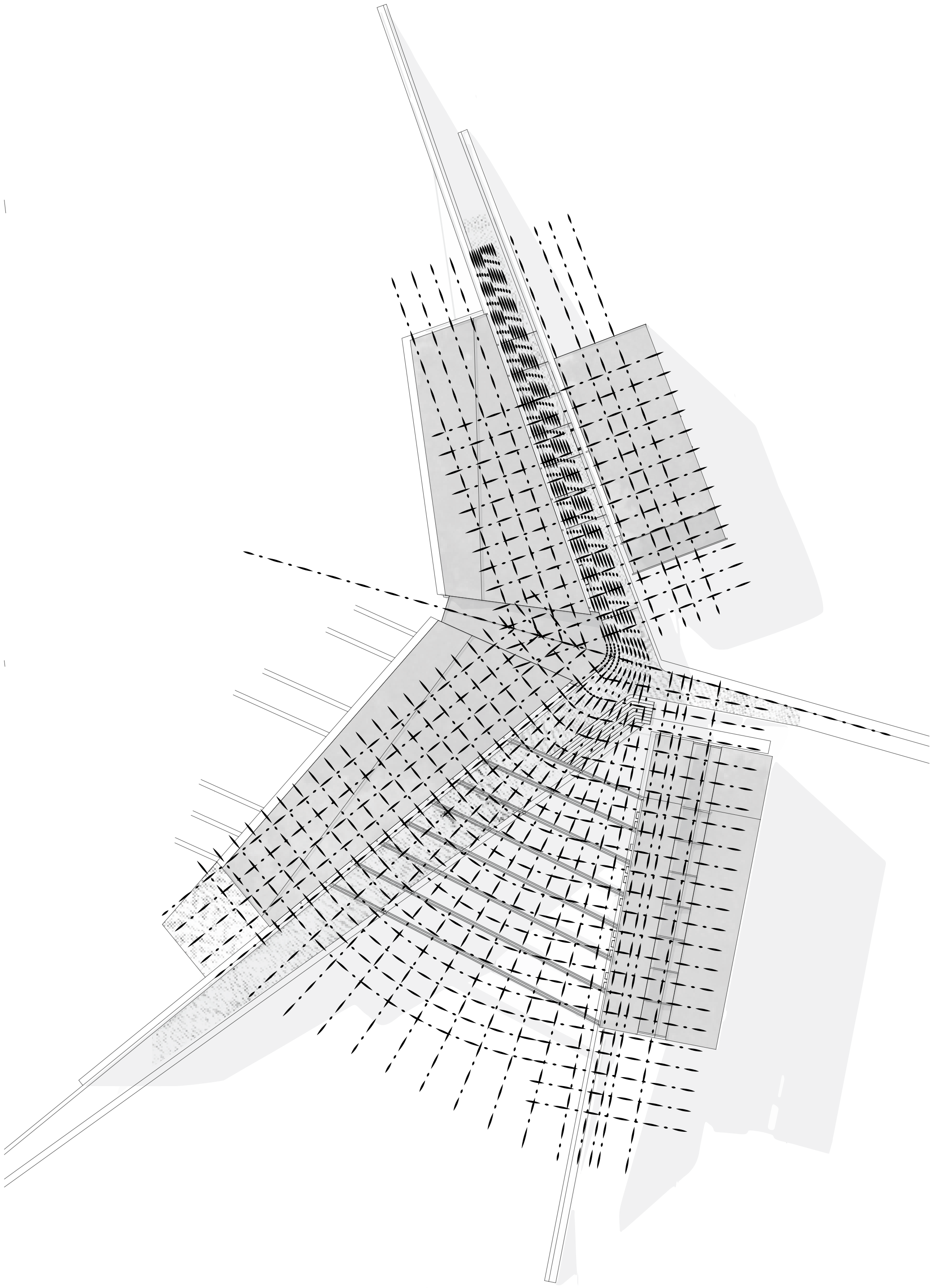
- Public spaces, including public corridors, training rooms and area where staff wear street clothing;
- Transitional zones, defined as areas of movement between the public areas and the areas the animals are housed;
- Barrier elements, including spaces such as airlocks and gowning areas;
- Veterinary care, including laboratories, clinical chemistry and histology rooms,
- Staff support areas; and
- Mechanical/ electrical equipment spaces (Stark et al. n.d.).

7.6 DESIGN RESPONSE SUMMARY

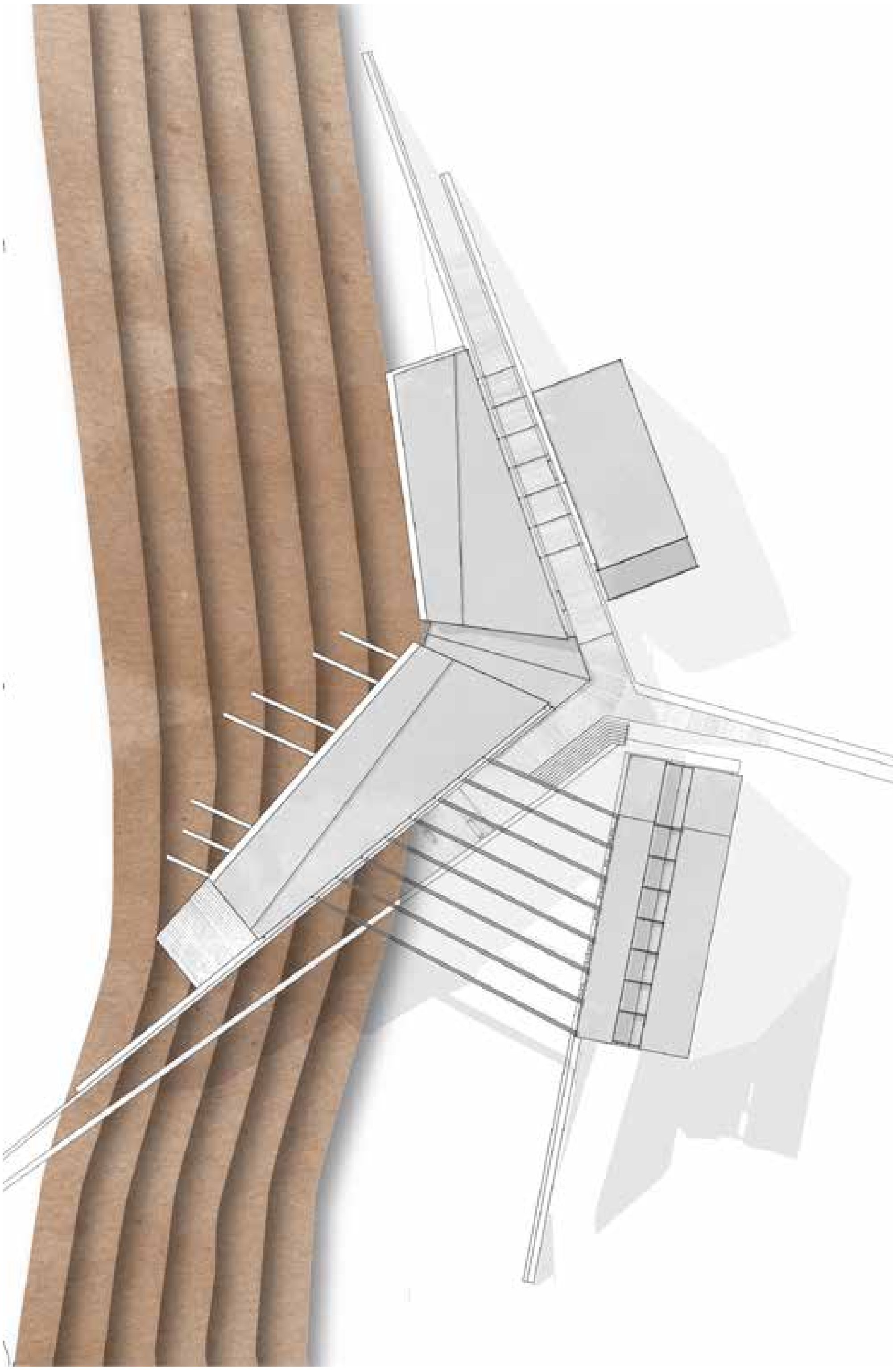
Together with the core intentions of protecting the landscape, creating habitat, and accommodation programme, the design of the Ticket Office, Quarry Pavilion, Vivarium, Fieldwork Station, and Amphitheatre is influenced by, and responds to various aspects of the landscapes, programmatic requirements, and the intended experiences of spaces. These influences include the relationship with the route running through Bolt's Farm, the geomorphology, including the slope of the landscape, and the openings to the karst system, the location of existing trees, and the views from specific vantage points in each building. The response to each aspect is illustrated through a series of diagrams based on the Vivarium.



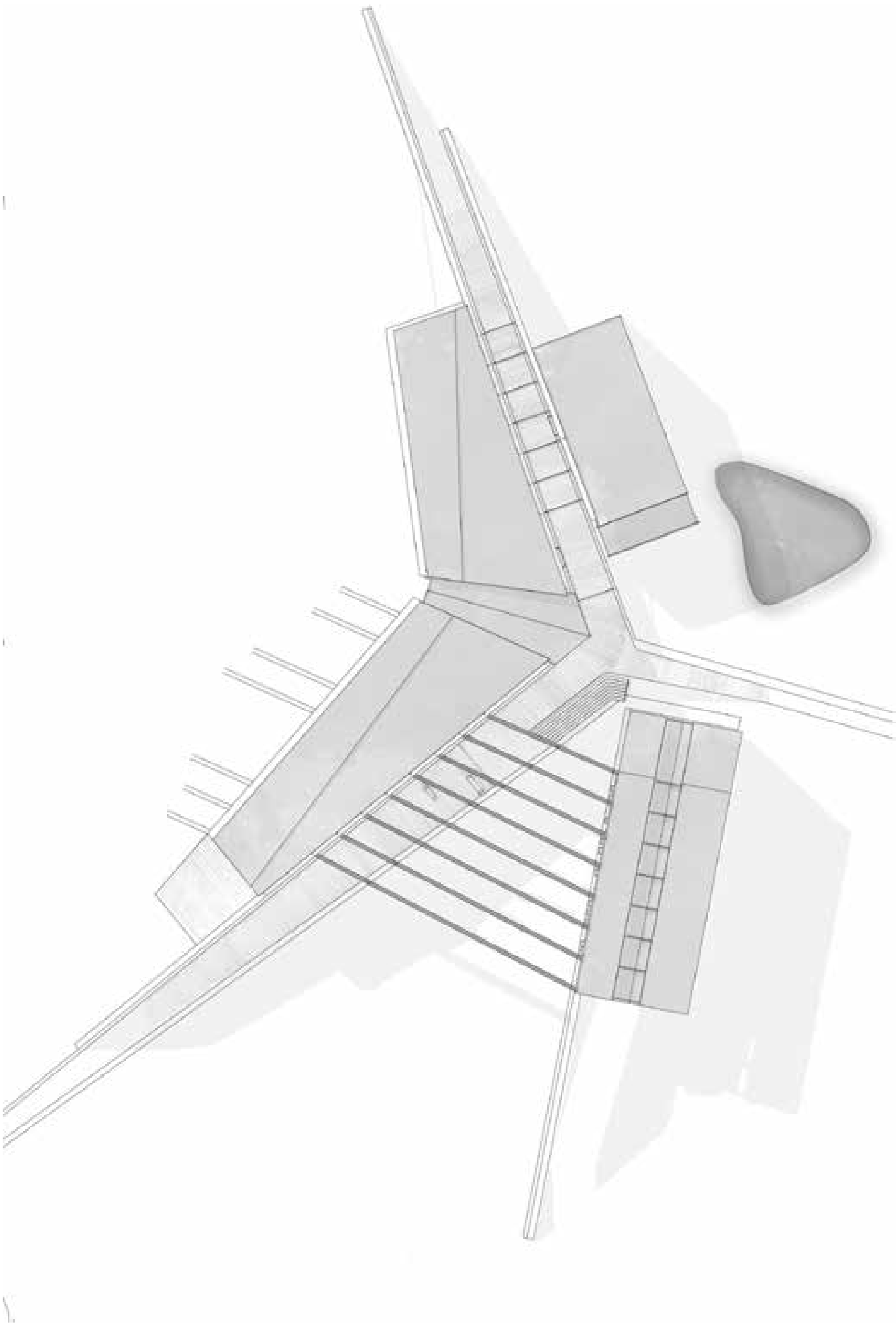
▲
FIGURE 7.25
RESPONSE TO ROUTE
(Author , 2016)



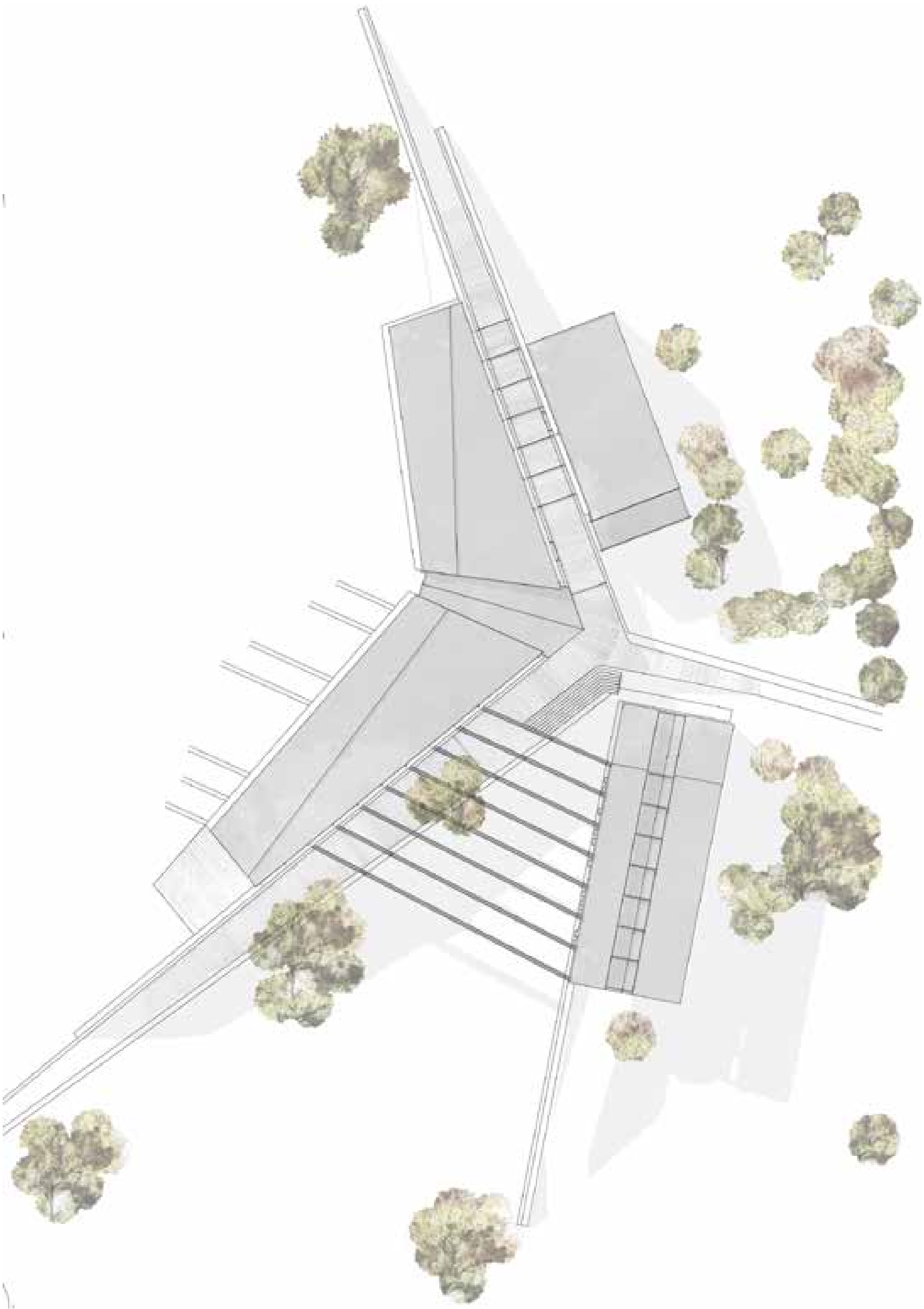
▲
FIGURE 7.26
RESPONSE TO
STRUCTURAL SYSTEM
(Author , 2016)



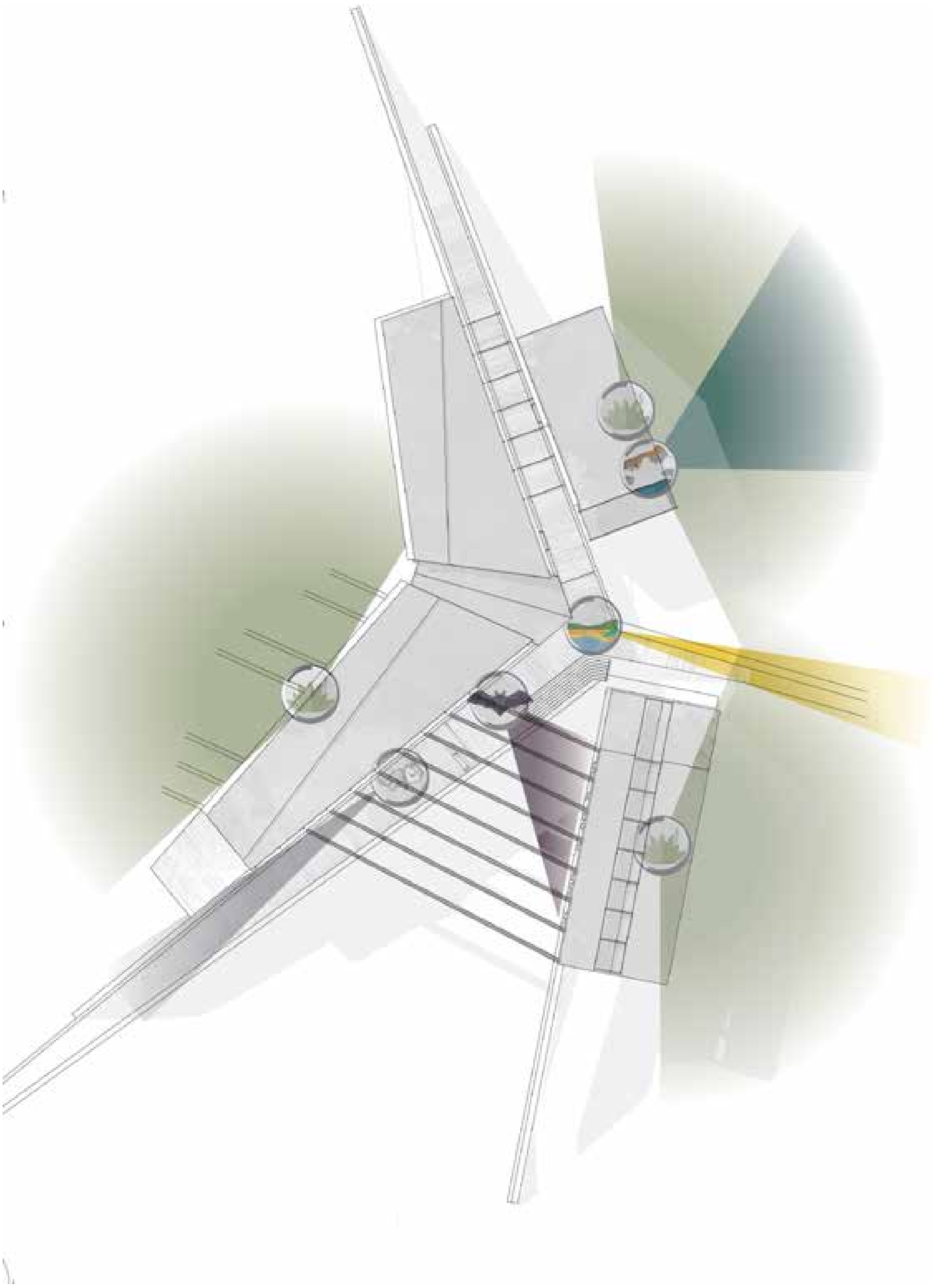
▲
FIGURE 7.27
RESPONSE TO CONTOURS
(Author , 2016)



▲
FIGURE 7.28
RESPONSE TO
CAVES & SINKHOLES
(Author , 2016)

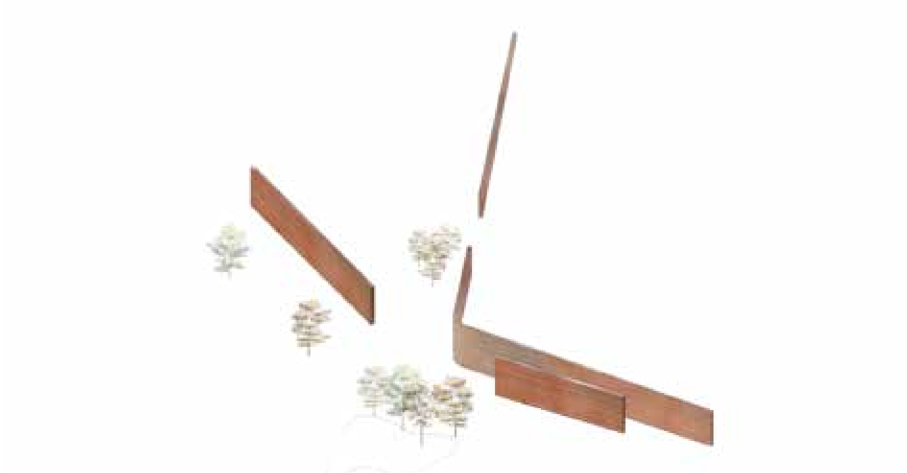


▲
FIGURE 7.29
RESPONSE TO
VEGETATION & TREES
(Author , 2016)

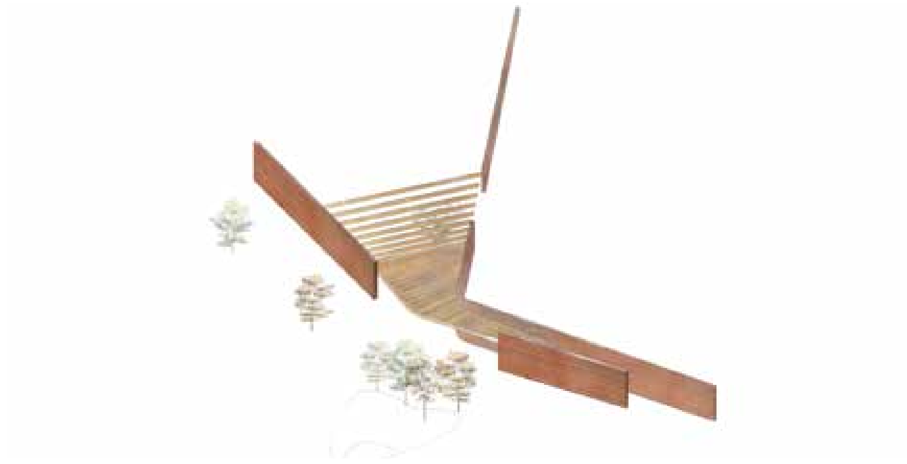


▲
FIGURE 7.30
RESPONSE TO VIEWS
(Author , 2016)

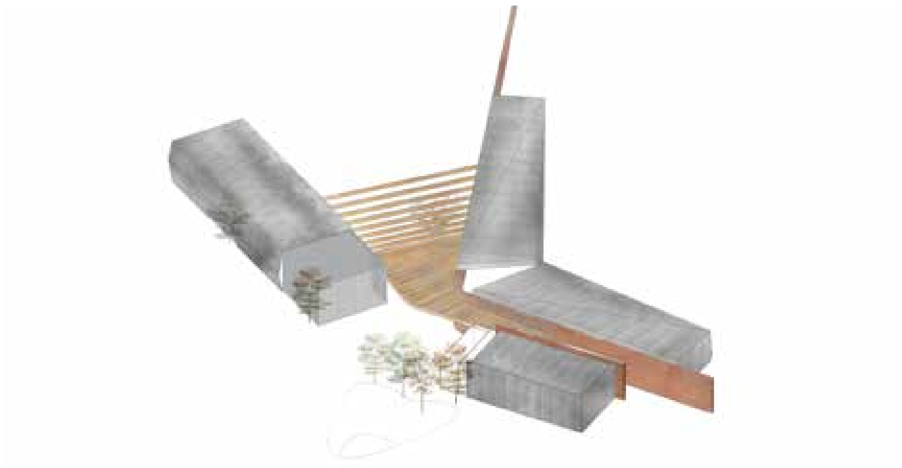
TECHNICAL INVESTIGATION



PROTECTING



CREATING



ACCOMMODATING

-8-

TECHNICAL

INVESTIGATION

◄
FIGURE 8.1
TECTONIC CONCEPT
(Author , 2016)

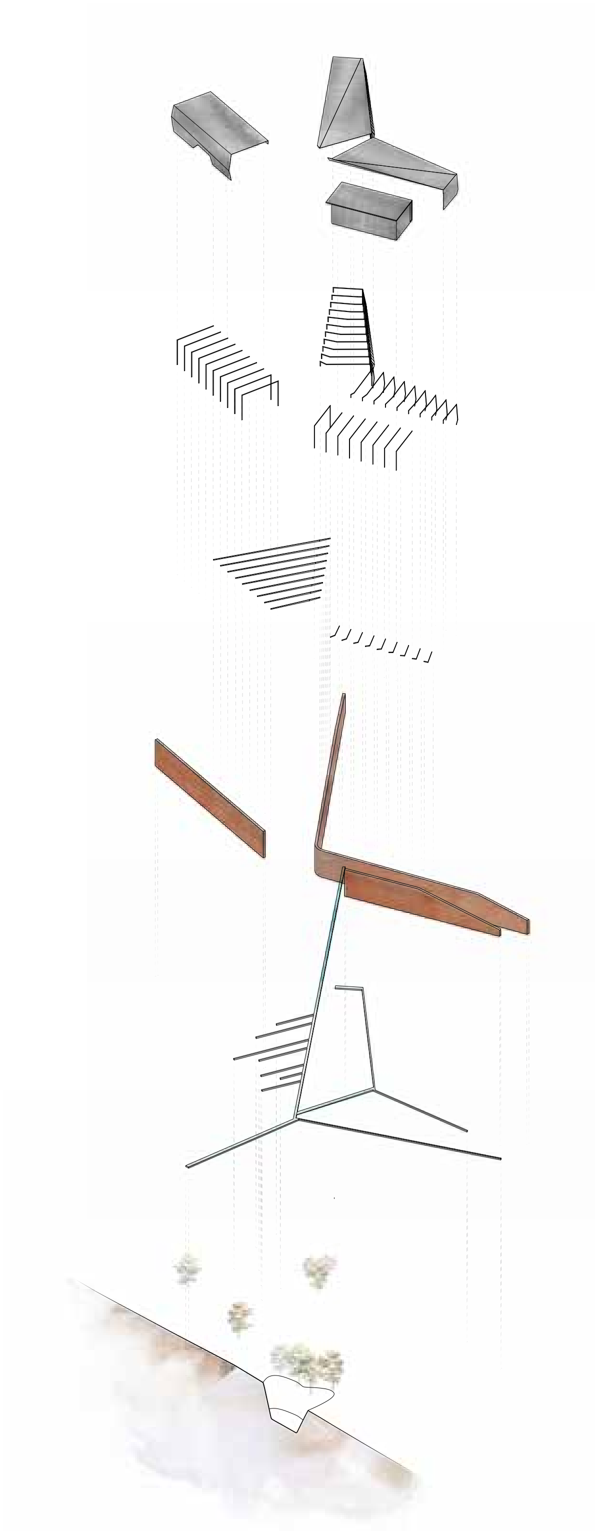
8.1 TECTONIC CONCEPT & STRUCTURE

The technical investigation explores two structural concepts developed as a response to the geology of the landscape. The technical premise of the dissertation brings the hidden and forgotten layers of the landscape of the Cradle of Humankind to the forefront. The investigation considers the way in which the layers of a building are exhibited, revealing the layers the building is made up of through both programme and structure.

The second structural concept is a response to the karst system found within the landscape of the Cradle. All structures placed on site intend to protect the landscape, to create habitat, and to accommodate the functions sprouting from the artificial habitats.

The primary intention of the placement of structures in the landscape is to mitigate the current threats and past destruction of the landscape. The proposed channels and furrows are submerged in the landscape, allowing surface water to move through the landscape.

The structures then serve to accommodate habitat, with each habitat favouring the dominant user, while allowing for co-evolution. The various walls forming the habitats are constructed from materials inherent to the site, including stone and earth. Together with the furrows and channels, these solid structures belong to geology of the landscape. The composition of the



structures relate to Kenneth Frampton's theories of architectural composition, where structures are divided into the stereotomic and tectonic. The solidity and mass of the stereotomic is seen to be of the "earth", with the dematerialisation of the tectonic compared to the sky (Van Eeden, 2013:98).

The tectonic structures accommodate the programmes connecting to the habitats, as seen through the tourism and research facilities. Unlike the water channels on site and the walls forming the habitats, these spaces do not add to the current and future functioning of the landscape, and so do not alter the landscape. The tectonic structure sits above the landscape, and is constructed as a laminated timber frame, clad in rheinzink.

8.2 BUILDING ASSEMBLY

The building construction relies on a hands-on approach, this allows for the method and craft of the assembly process being visible in the completed buildings. This is true for both low-and high-tech materials, including the construction of the stabilised earth walls and the rheinzink external cladding.

The Vivarium building is assembled by firstly erecting the laminated timber portal frames. The bearer beams on which the floors rest and the beams above the Chiroptera habitat are fixed to either side of the portal frames, allowing for thinner members. The dry packed stone walls, mortared stone walls, and stabilised earth walls are constructed simultaneously between the timber portal frames as infill, extending past the timber frames to the exterior of the building. The exposed timber portal frames are then clad in rheinzink, revealing the internal skin of glazing at points in the building.

◀
FIGURE 8.2
STRUCTURE
(Author , 2016)

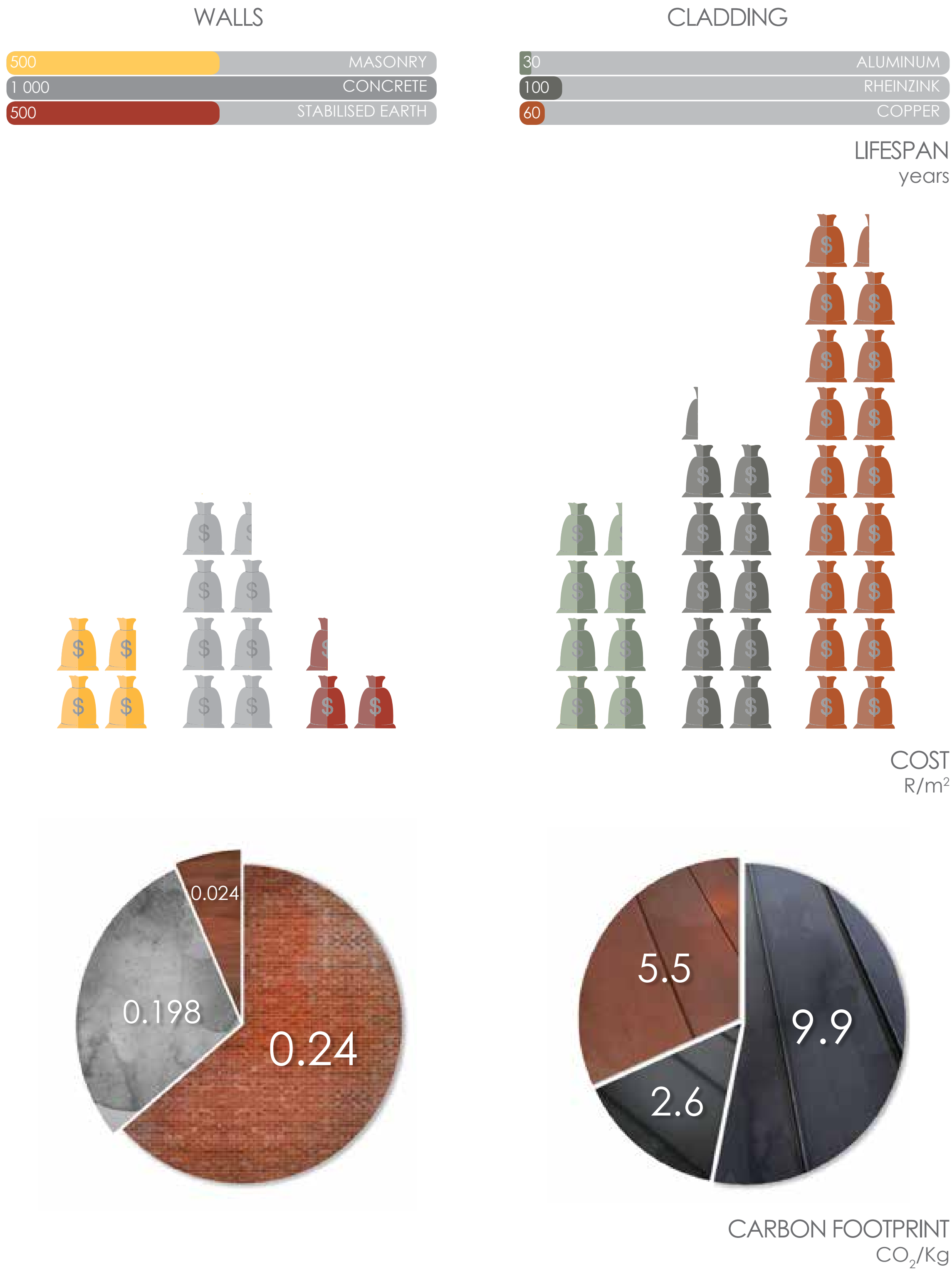


FIGURE 8.3
COMPARISON OF WALL & CLADDING MATERIALS
(Author , 2016)

8.3
MATERIALITY

All materials selected for the construction of the proposed buildings fall into one of two categories; materials from the landscape, and new materials to the landscape. In either case, a series of material options where compared with each other, in terms of lifespan, cost, and the carbon footprint of manufacturing the materials, in order to establish the most suitable material to be used in the context of Bolt's Farm and the Cradle.

For the construction of the walls protecting and creating habitats, the following materials where compared; masonry bricks, concrete, and stabilised earth. The study found stabilised earth to be most suitable, as it has the same expected lifespan as masonry bricks, while being lower in cost and carbon footprint (Fig. 8.3).

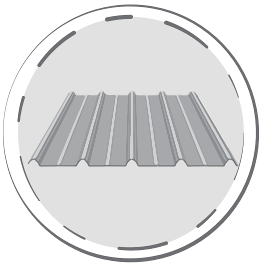
For the external cladding of the Vivarium, rheinzink, aluminum, and copper cladding where compared. Although rheinzink has a greater initial cost, the lifespan of the material outweighed both aluminum and copper cladding, has a lower carbon footprint, and is far less of a liability in terms of theft, when compared to copper cladding.

MATERIALS OF THE LANDSCAPE

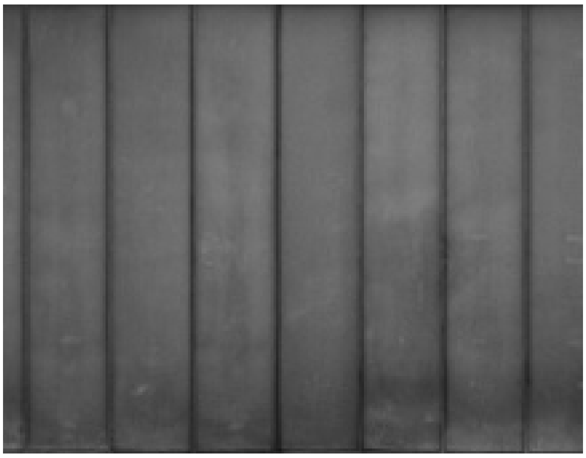
RECLAIMED BRICK SCREEN

WIRE MESH WITH STONE INFILL

NEW MATERIALS TO THE LANDSCAPE

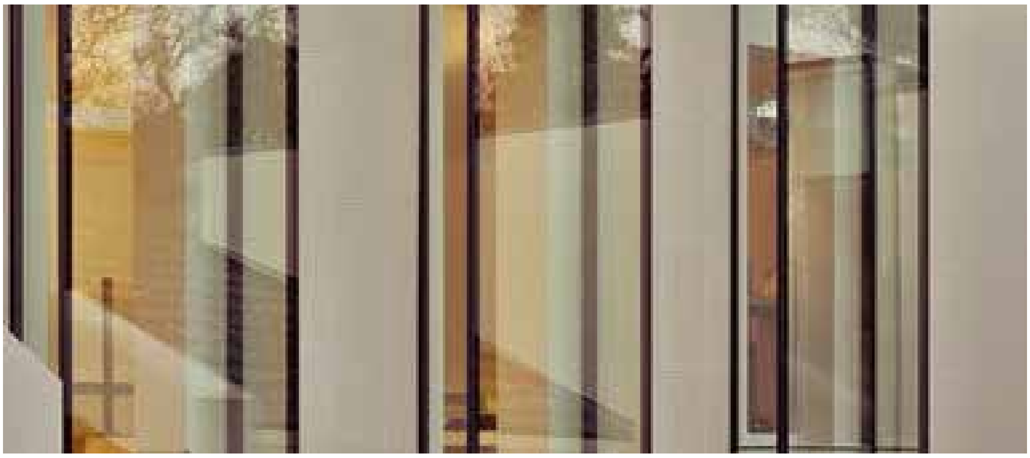


EXPANDED MESH

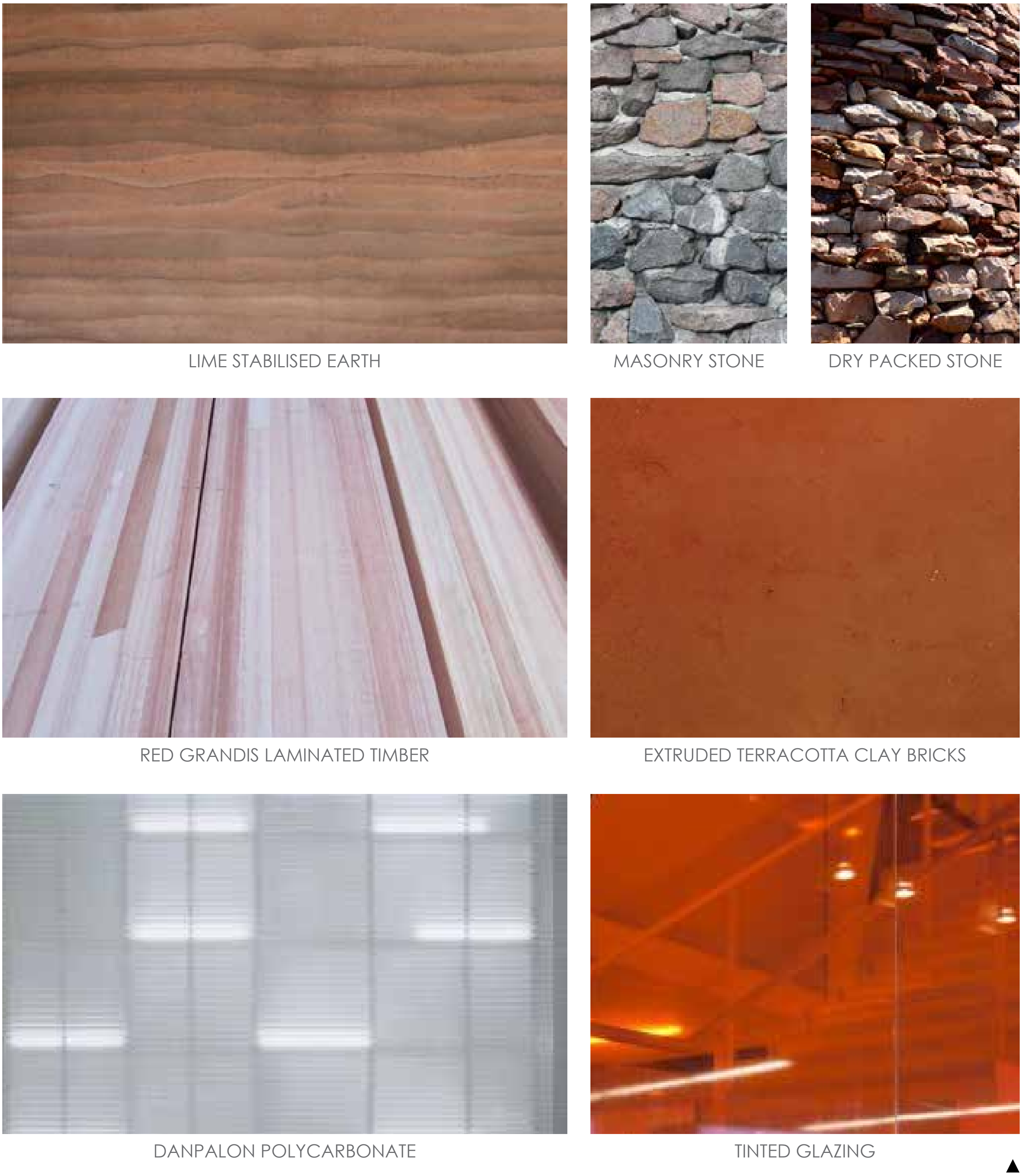


GRAPHITE GREY RHEINZINK

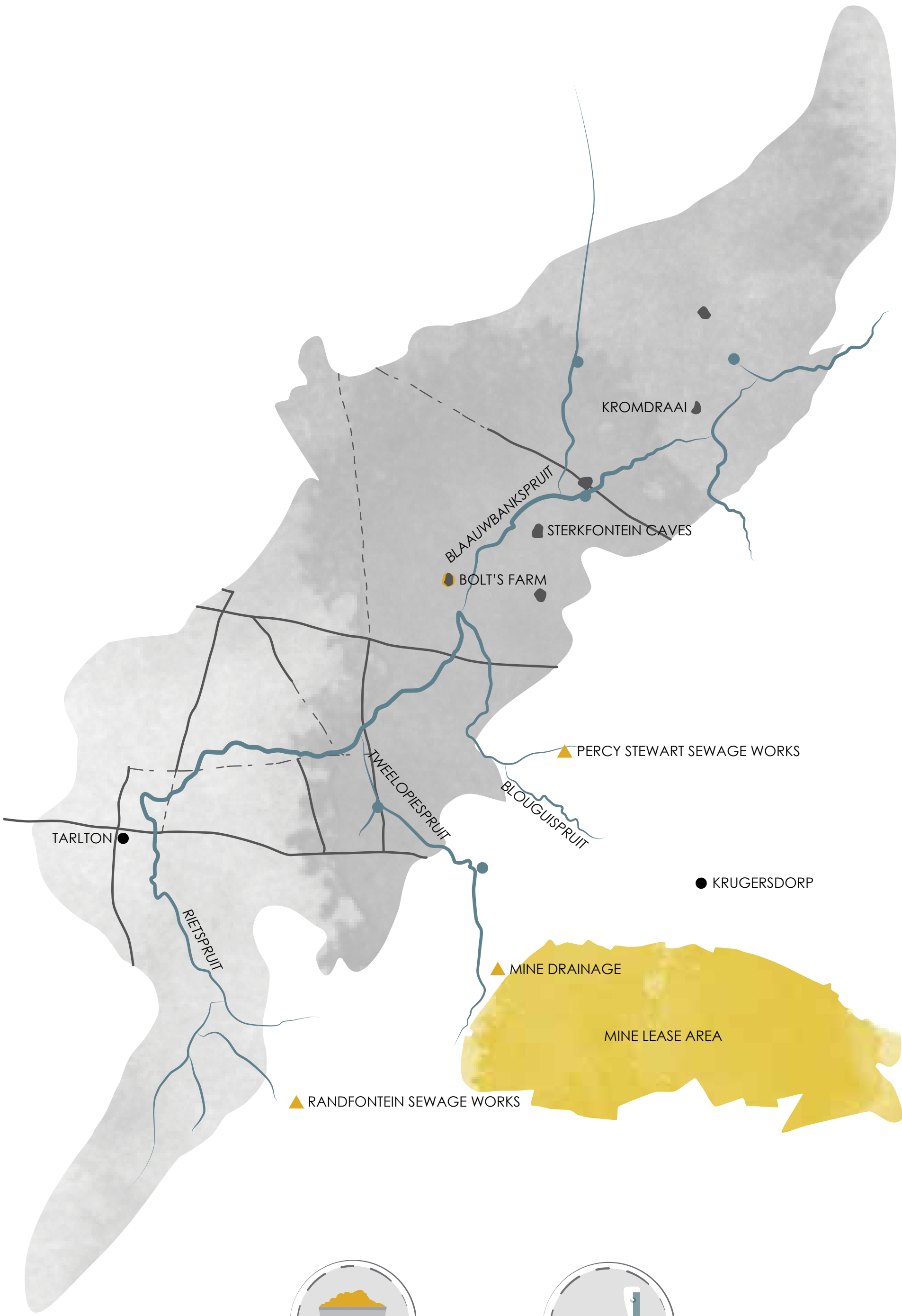
VIEWING THE LANDSCAPE



DOUBLE GLAZING



▲
FIGURE 8.4
MATERIAL PALETTE
(Author , 2016)



ACID MINE
DRAINAGE

SEWAGE
WORKS

8.4
TECHNOLOGY & ENVIRONMENTAL STRATEGY

The current state of the landscape is seen as a fragile, fragmented landscape, thus each structure placed in the landscape not only has to sustain itself, but also serves to remediate the landscape. The approach to servicing the habitats and secondary structures is thus to implement active and passive systems within it, with low maintenance and running energy requirements.

8.4.1
WATER
8.4.1.1
THREATS TO THE KARST SYSTEM

The structural and ecological stability of the karst system of the Cradle of Humankind relies on ground water of a high quality, as well a constant water level in the subterranean layers of the system (Witthüser 2016). Activities which influence these two factors, the water quality and quantity, are threats to the underground water system, and can be either diffused threats, such as poor farming practices, or point sources, such as the mining affluent and sewage running into the river system (Fig. 8.x).

◀
FIGURE 8.5
THREATS TO THE KARST SYSTEM
(Author , 2016)

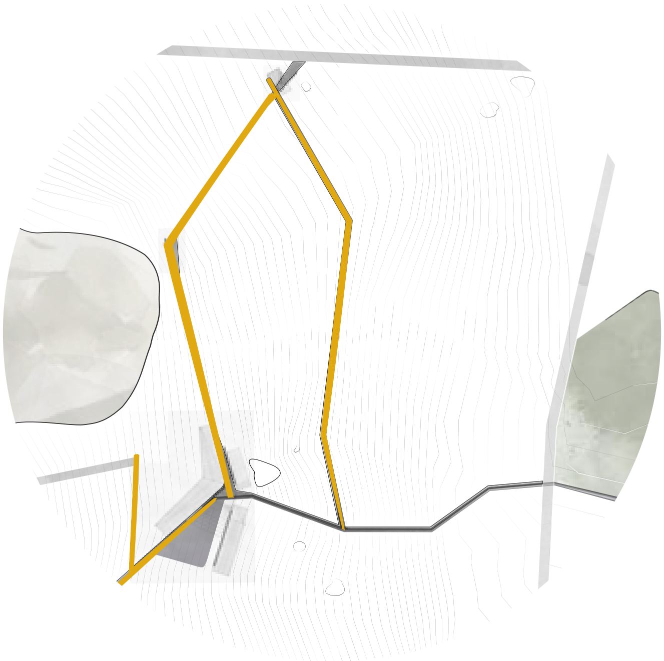
8.4.1.2
WATER STRATEGY

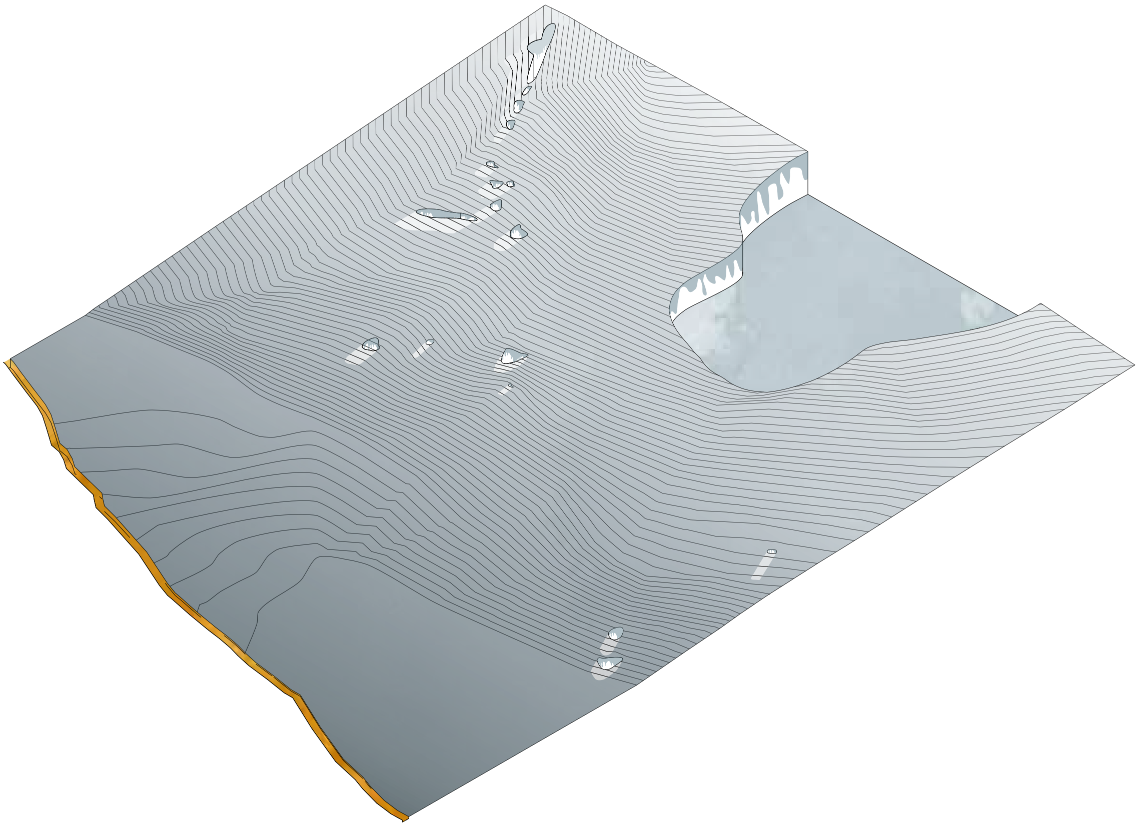
8.4.1.2.1
SITE

The water strategy of the larger site focuses on stabilising the water quality and quantity infiltrating the sections of the karst system, which can be controlled. Channels are constructed above the major openings and caves, running along the contours, to reduce the direct water flow into the karst system. The surface water is then channelled down the slope to a water retention pond, located above the Riet Spruit. The retention pond is placed in an area where the karst system is less sensitive, as previously indicated (Witthüser 2016), allowing the surface water to infiltrate the karst system at a slower rate, as well as filtering the surface water as it seeps through.

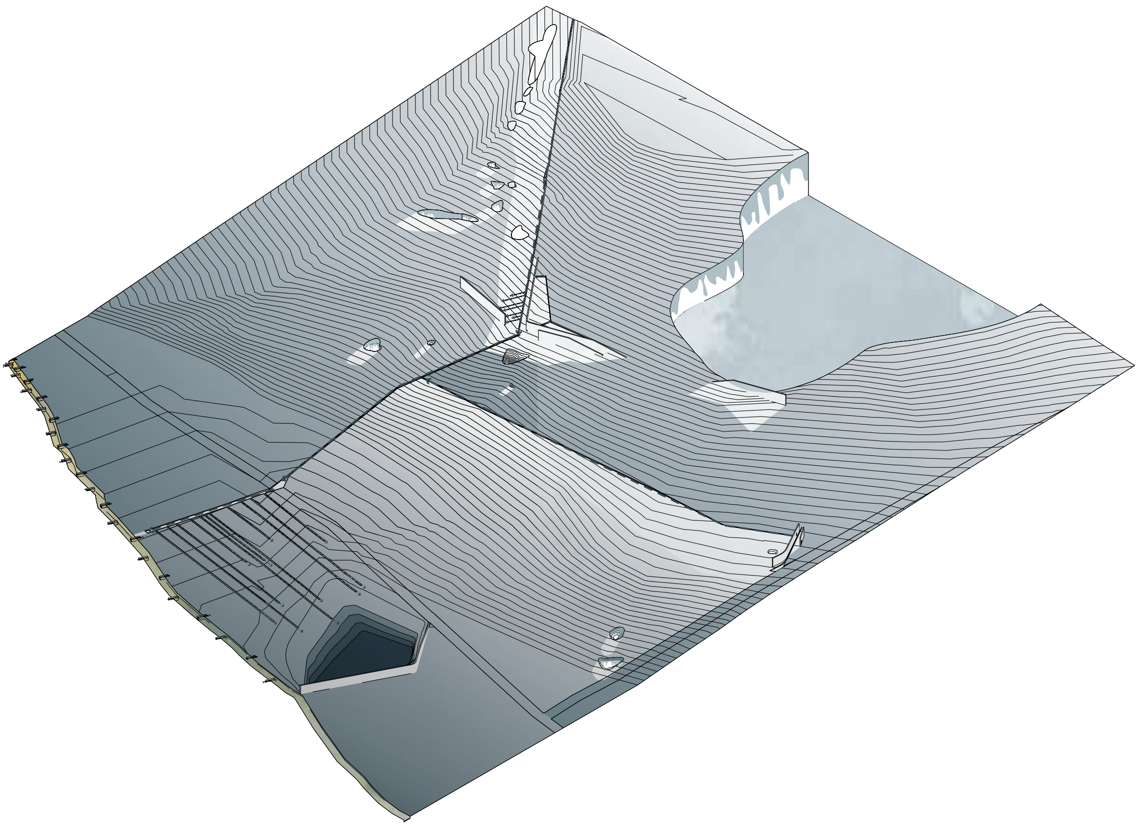
▶
FIGURE 8.6 a
SURFACE WATER COLLECTION
(Author , 2016)

▶
FIGURE 8.6 b
SURFACE WATER DIVERSION
(Author , 2016)

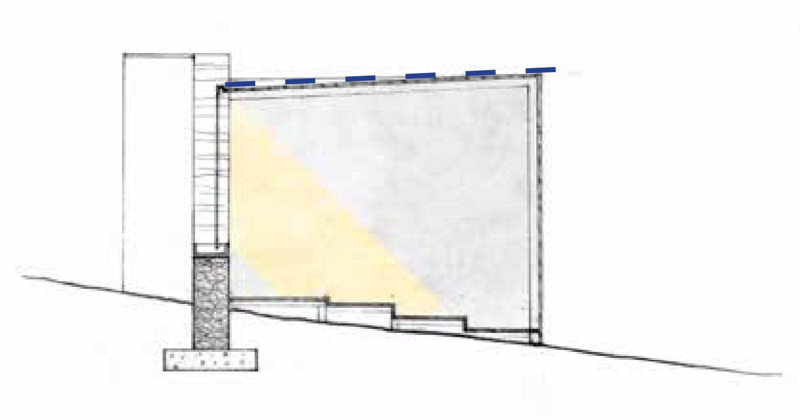


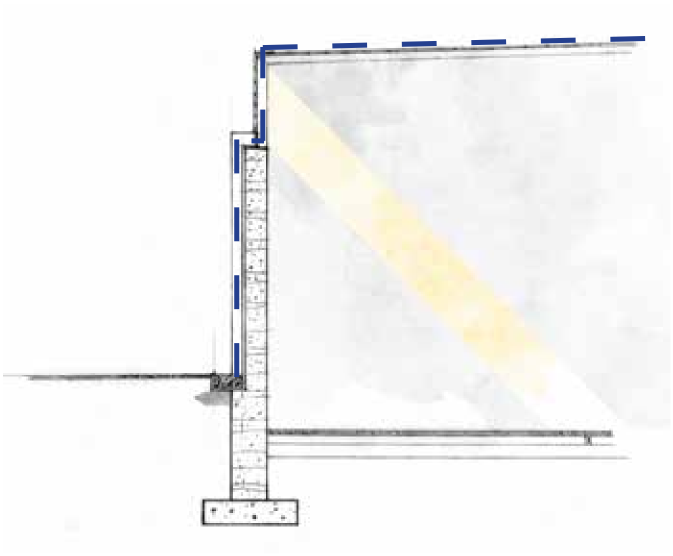


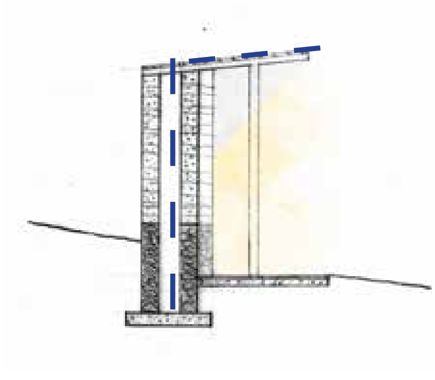
▲
FIGURE 8.7 a
SURFACE WATER
BEFORE INTERVENTION
(Author , 2016)



▲
FIGURE 8.7 b
SURFACE WATER
AFTER INTERVENTION
(Author , 2016)







◄
FIGURE 8.8 a
CONCEPTUAL WATER CATCHMENT DIAGRAM OF QUARRY PAVILION
-JUNE-
(Author , 2016)

◄
FIGURE 8.8 b
CONCEPTUAL WATER CATCHMENT DIAGRAM OF VIVARIUM
-JUNE-
(Author , 2016)

◄
FIGURE 8.8 c
CONCEPTUAL WATER CATCHMENT DIAGRAM OF FIELDWORK STATION
-JUNE-
(Author , 2016)

8.4.1.2.2 BUILDING

As water is a scarce resource, and no existing municipal waterlines are connected to Bolt’s Farm, an alternative water strategy is required. The majority of the surrounding farming community makes use of boreholes, tapping into the karst system (The South African Karst Working Group 2010:25). The Vivarium is, however, a public building, with a much higher water budget that the average farmhouse, thus the use of a borehole would alter the water quantity of the karst system to the extent that the structure might become unstable (Witthüser 2016).

The proposed individual buildings harvest rainwater from the roof-runoff as required by each building. The Vivarium requires the highest amount of water, as it accommodates ablutions, a restaurant, and laboratory spaces. The roofs of each building is sloped in two directions, allowing the water to run to a specific point, where the water is then collected and used or stored for the building specific needs.

The collected water is used in the following ways:

- the roof-runoff from Ticket Office is used for the use of the staff as well as watering the plants in the greenhouse;
- the water collected by the Quarry Pavilion is filtered through a slow-sand filter and is used by the visitors and researchers as a drinking point;
- the Vivarium roofs channel the water to a central water storage point to be stored and used throughout the buildings as needed; and
- the roof of the Fieldwork Station is sloped towards the cavity of the stone wall, to be collected and allowed to drip down the wall, making use of evaporate cooling principles to serve as a cold room for the use of the archaeologists.

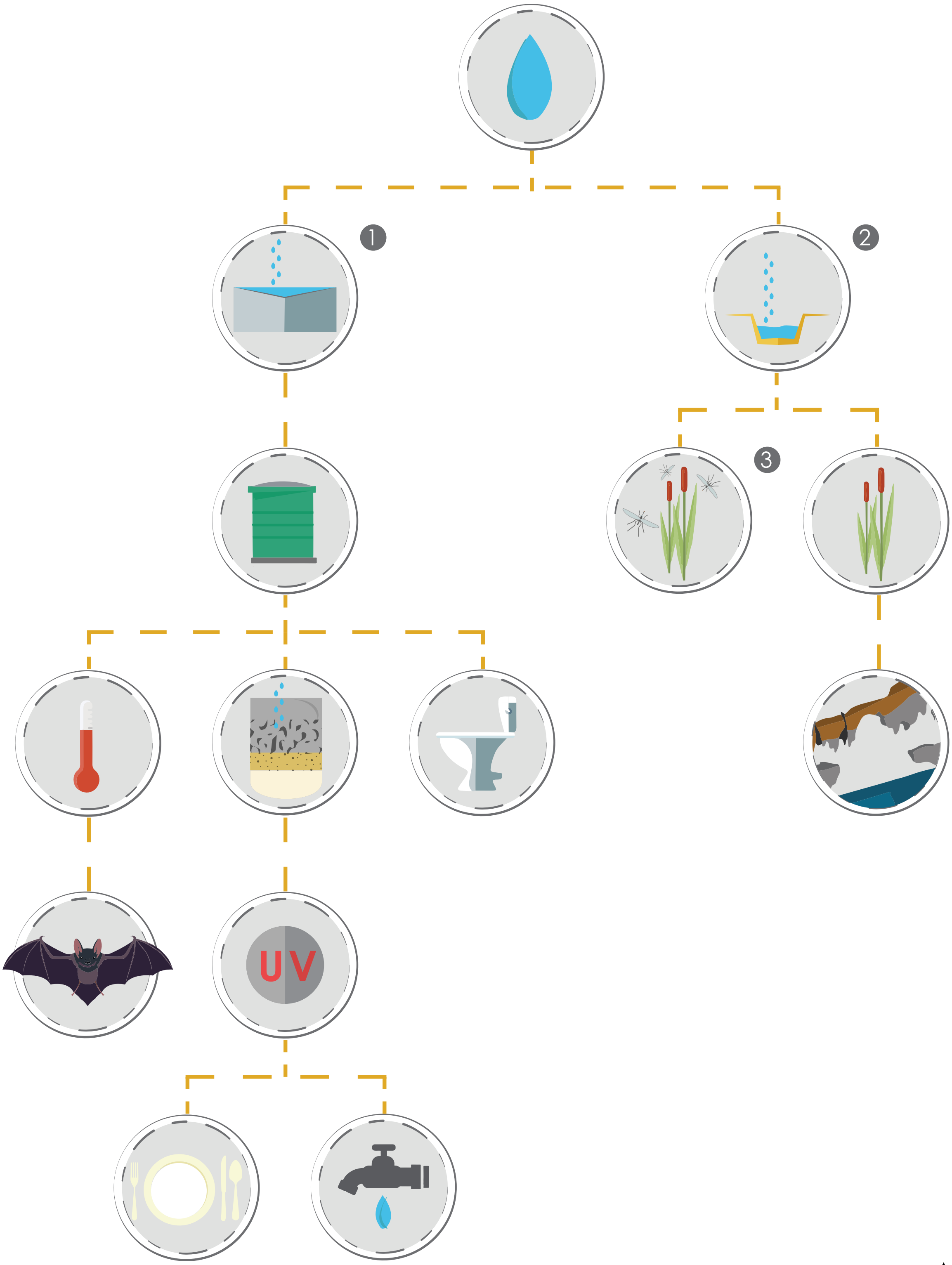
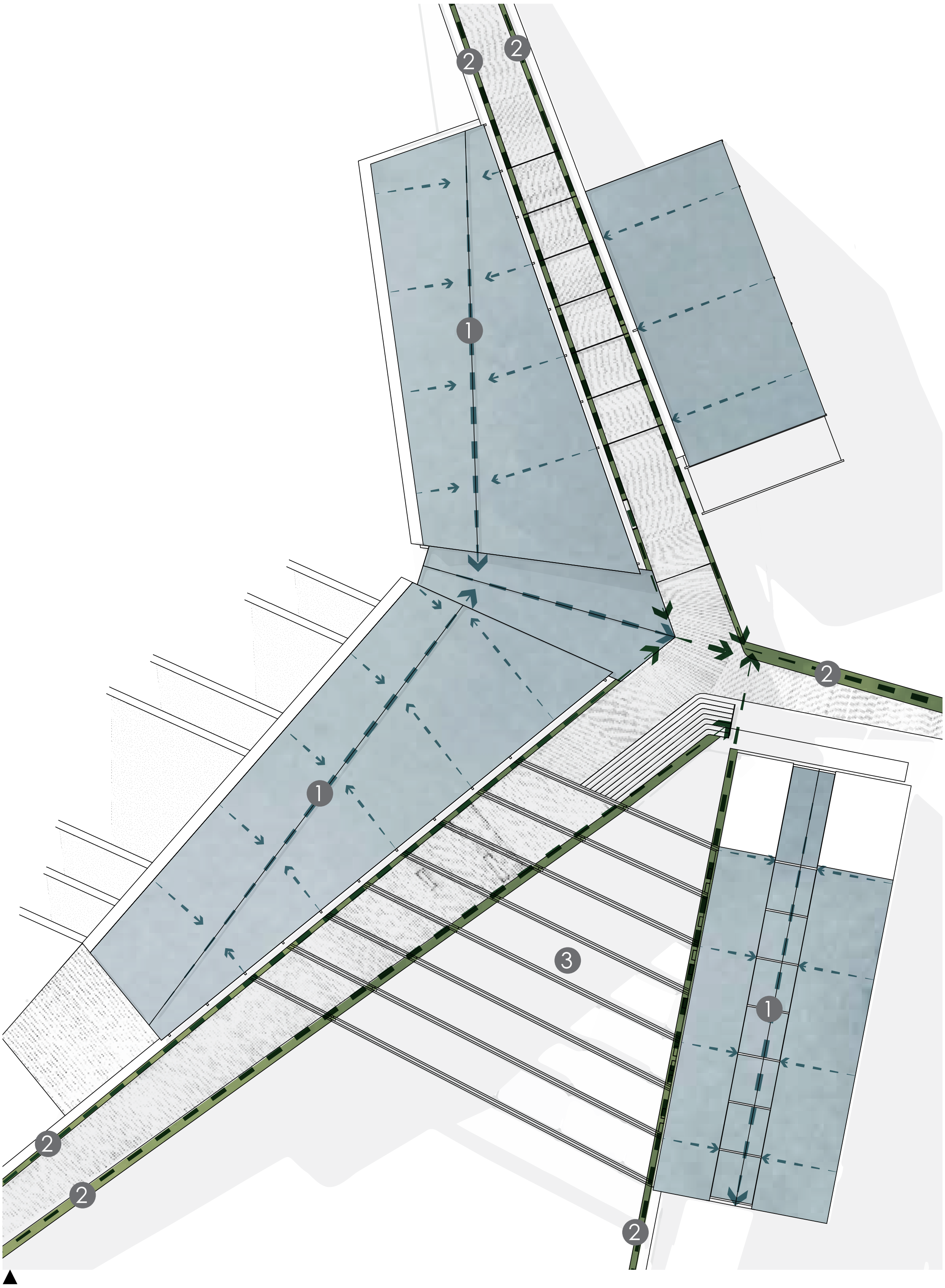
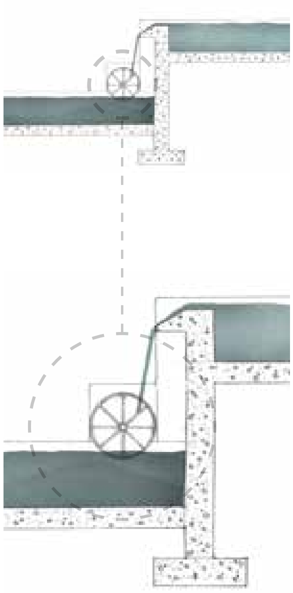
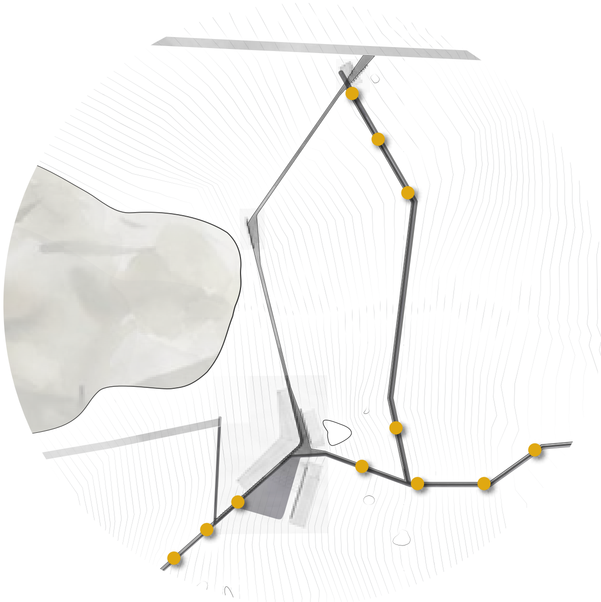


FIGURE 8.9
VIVARIUM ROOF &
DRAINAGE DIAGRAM
(Author , 2016)



▲
FIGURE 8.10
VIVARIUM ROOF & DRAINAGE PLAN
(Author , 2016)





◀
FIGURE 8.11 & 8.12
MICRO HYDRO TURBINE IN CHANNEL & PLACEMENT OF MICRO HYDRO TURBINES
(Author , 2015)

8.4.2
ENERGY & WASTE
8.4.2.1
MICRO HYDRO TURBINE

The water flowing along the water collection and diversion tunnels are used to generate hydro-electrical energy. As the water flows from the highest point of the site down to the retention dam, located at the lowest point of the site, the water rotates the series of micro-hydro turbines, connected to individual dynamos. The dynamos convert the kinetic energy of the rotating turbines to electrical energy (Natural Resources Canada 2004).

8.4.2.2
BIOGAS DIGESTER

Organic waste, including food scraps, sewage, and bat guano, is directed to a central biogas digester. The digester makes use of anaerobic bacterial processes to generate methane gas as well as a nutrient compost to be used for all non-edible plant species. The methane gas produced through the digester is used in the restaurant kitchen, with excess gas being converted to electrical energy through a controlled combustion system through a heat engine. The mechanical energy then activated a generator which in turn produces electrical energy (Gensch et al. 2010).

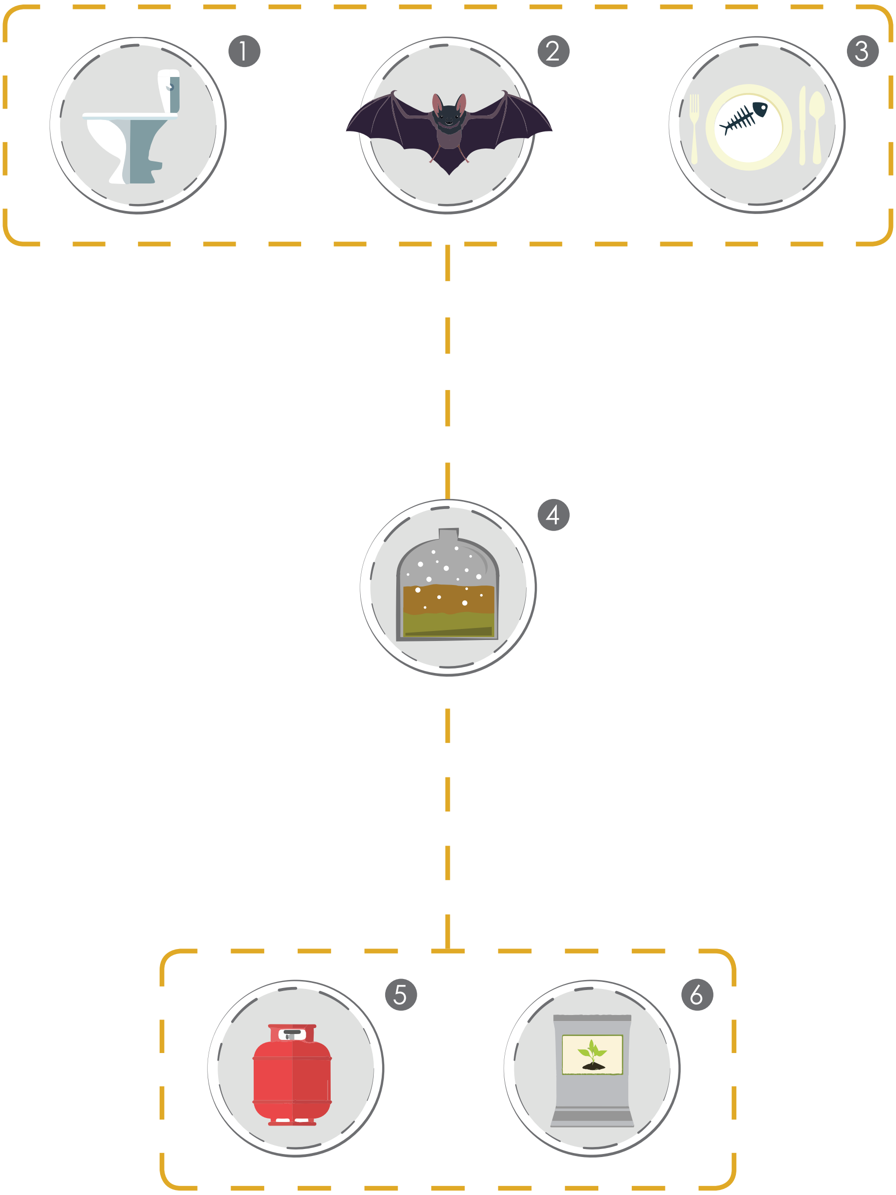
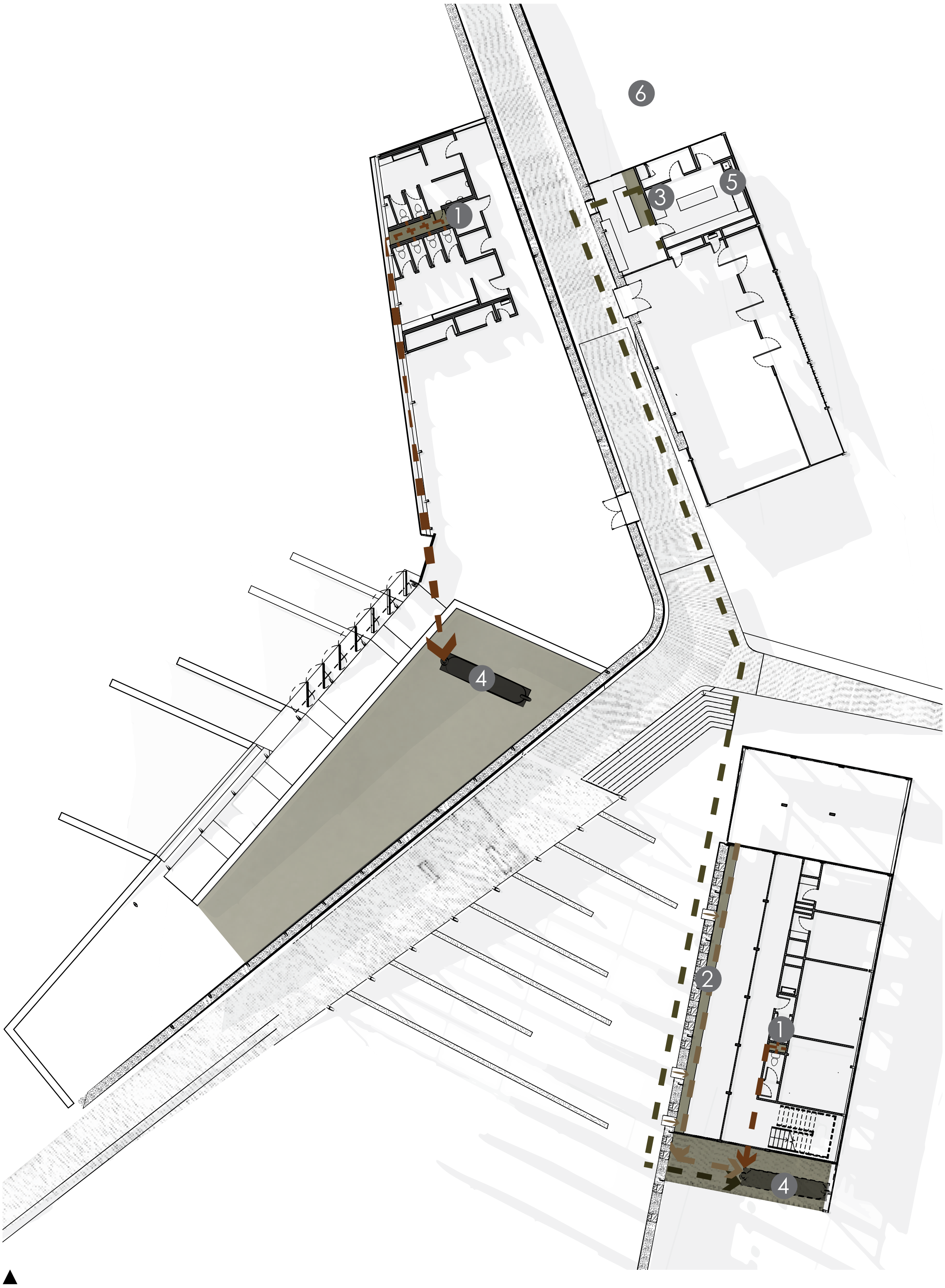
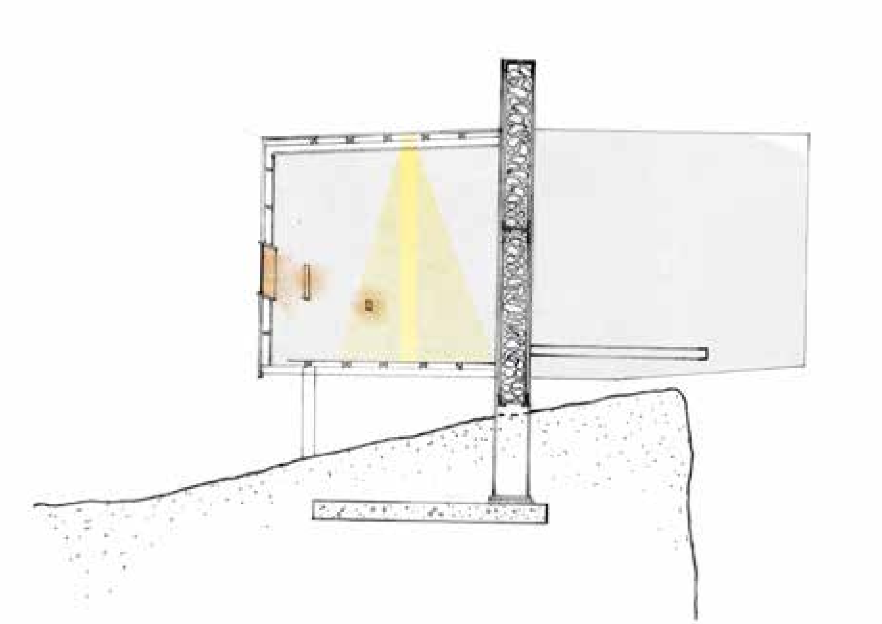
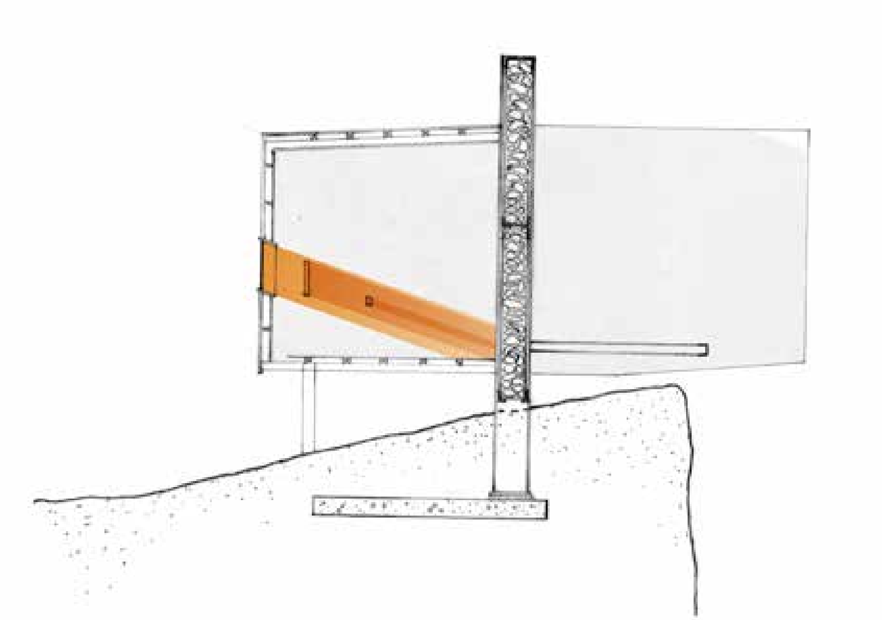


FIGURE 8.13
BIOGAS DIGESTER DIAGRAM
(Author , 2016)



▲
FIGURE 8.14
WASTE & BIOGAS DIGESTER PLAN
(Author , 2016)





8.4.4 DAYLIGHTING

Daylighting principles are applied to the various buildings situated on the route, making use natural lighting as an experiential device, or to illuminate interior spaces.

8.4.4.1 QUARRY PAVILION

◀
FIGURE 8.15 a
QUARRY PAVILION
SUMMER MIDDAY
(Author , 2016)

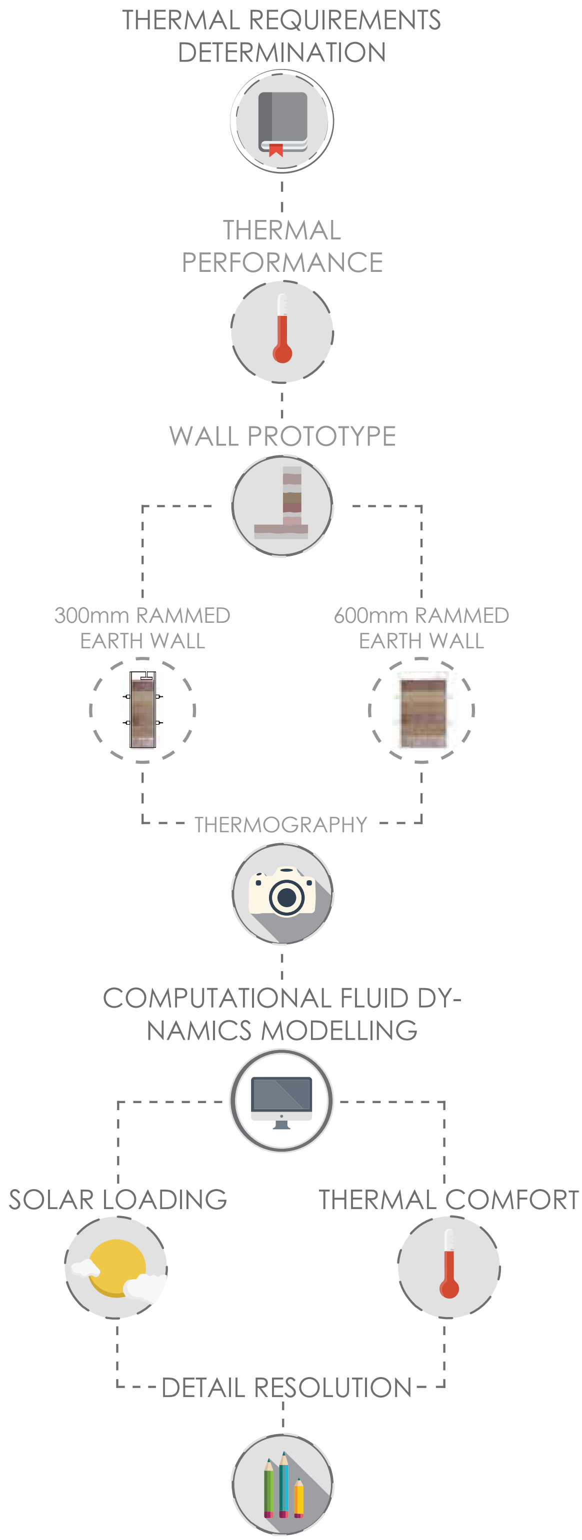
The Quarry Pavilion makes use of daylighting throughout various times of the day, taking into account the lighting quality produced during dawn and dusk. Three orange glazed openings are found on the Eastern façade, allowing early morning sunlight to filter into the pavilion. A narrow opening in the roof of the pavilion tapers in with the pathway through the pavilion, leading the visitor to the edge of the quarry. The lookout point, placed at the edge of the quarry allows visitors a view of the quarry as the sun sets in the west.

8.4.4.2 VIVARIUM OFFICE SPACE

Unlike the laboratory and exhibition spaces of the Vivarium, the office space situated to the south-west of the building requires natural daylighting. The building is planned on a north-south axis, due to the direction of the fall of the contours and the route running through all of the structures placed on site.

◀
FIGURE 8.15 b
QUARRY PAVILION
WINTER MORNING
(Author , 2016)

To reduce glare and heat-gain from afternoon Western sun, the Western façade is made up of a series of screens. The mechanically operated screens open to the north, blocking western sun, while allowing for the northern light to illuminate the interior of the office space.


THERMAL REQUIREMENTS DETERMINATION
THERMAL PERFORMANCE
WALL PROTOTYPE
300mm RAMMED EARTH WALL
600mm RAMMED EARTH WALL
THERMOGRAPHY
COMPUTATIONAL FLUID DY-NAMICS MODELLING
SOLAR LOADING
THERMAL COMFORT
DETAIL RESOLUTION

◀
FIGURE 8.16
THERMAL ANALYSIS
RESEARCH DIAGRAM
(Author , 2016)

8.5
CHIROPTERA HABITAT

In order to create a favourable environment to attract the Schreiber's long-fingered bat, the thermal comfort of the internal spaces of the Chiroptera roosts becomes the most important environmental requirement (Bat Conservation Trust n.d.). Bats generally roost at temperatures between 30-40°C, this takes into consideration the heat generated by the body mass of the bats increases the internal temperature.

The dissertation aims to propose a design for Chiroptera roosts which relies on as little as possible mechanical heating and cooling strategies, creating the optimal internal thermal comfort with the use of passive heating and cooling strategies, including the use of thermal mass and shading devices where needed.

To determine the thermal properties of the proposed construction materials as well as the influence of these materials on the internal temperature and humidity of the Chiroptera Roosts, Infrared Thermography and Computational Fluid Dynamics (CFD) modelling was used.

◄
FIGURE 8.17
PROTOTYPE CONSTRUCTION PROCESS PHOTOGRAPHS
(Author , 2015)

8.5.1
INFRARED THERMOGRAPHY

The study is based on the principle of thermal mass; a material's ability to gain and store thermal energy. A material with a high thermal mass absorbs and retains heat, re-radiating the heat as the surrounding area cools down.

Infrared thermography was used to study the effect of solar heat gain and loss on a series of three wall prototypes, differing in either construction material or in wall thickness, e.g. thermal mass.

Infrared thermography is a process in which an infrared imaging system (an infrared camera) converts the spatial variations in infrared radiance from a surface into a two-dimensional image, in which variations in radiance are displayed as a range of colours or tones. As a general rule, objects that are lighter in colour are warmer, and darker objects are cooler.

A diurnal & nocturnal thermal imagery study of the three prototypes allowed for the analysis of surface radiance and absorption over a period of 24 hours. The three prototypes analysed included the following:
- 300mm stabilised earth wall,
- 230mm clay brick wall,
- 600mm stabilised earth wall,

The 600mm stabilised earth wall was selected as the most suitable material and material thickness for the construction of the wall hosting the Chiroptera roosts. The 600mm stabilised earth wall was selected because of its high thermal mass, allowing for less fluctuation of the internal temperature of the Chiroptera roosts.

a] clean a mason jar
b] fill the jar halfway with soil
c] fill the rest with water
d] tighten the lid and shake
e] let it rest 4-5 hours

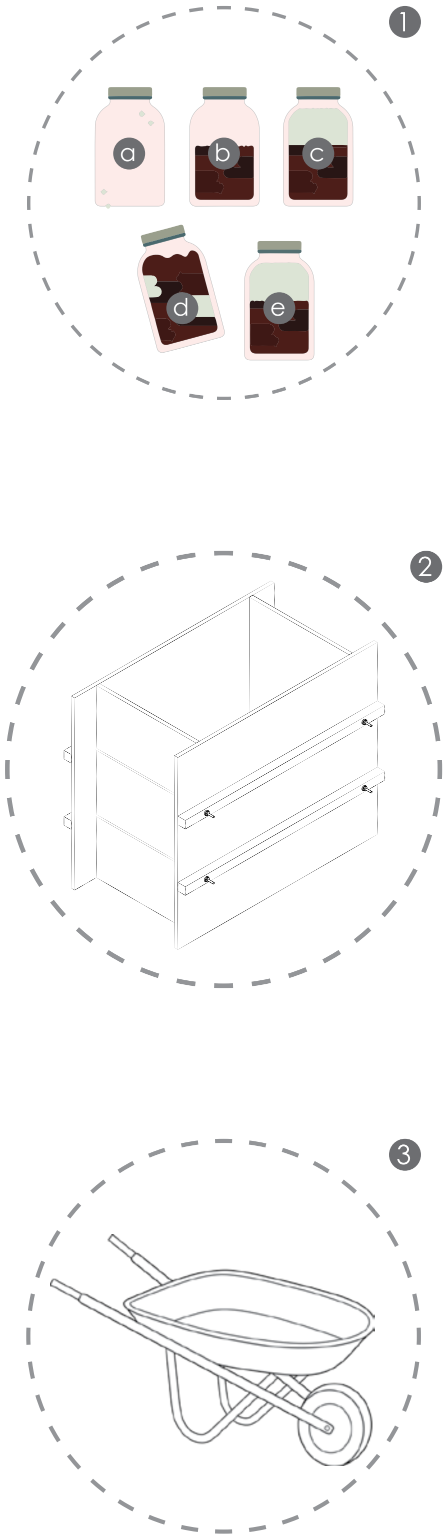
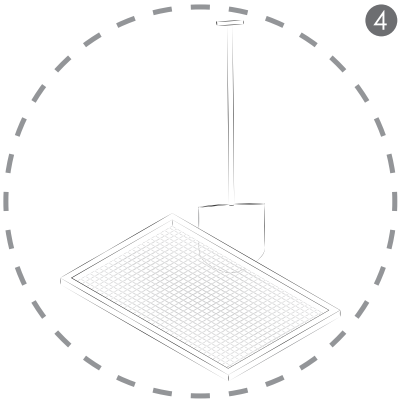
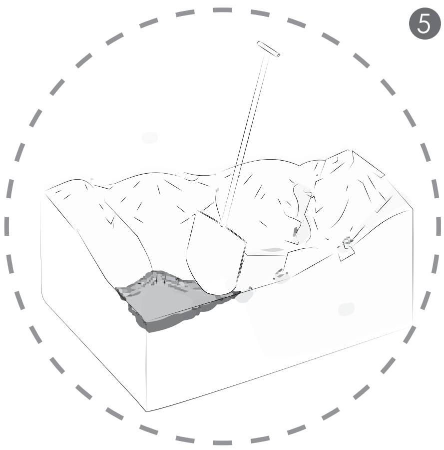
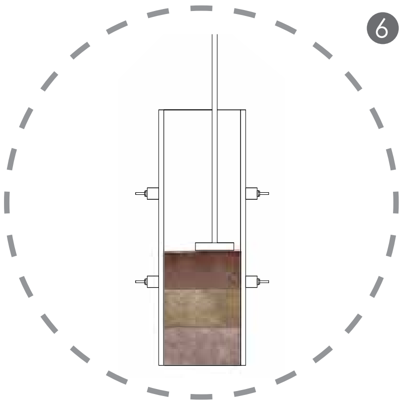


FIGURE 8.18
PROTOTYPE CONSTRUCTION
PROCESS DIAGRAM
(Author , 2015)







SEDIMENTATION TEST 1

FORMWORK 2

COLLECTING SOIL 3

SIEVING SOIL 4

MIXING SOIL 5

RAMMING SOIL IN FORMWORK 6

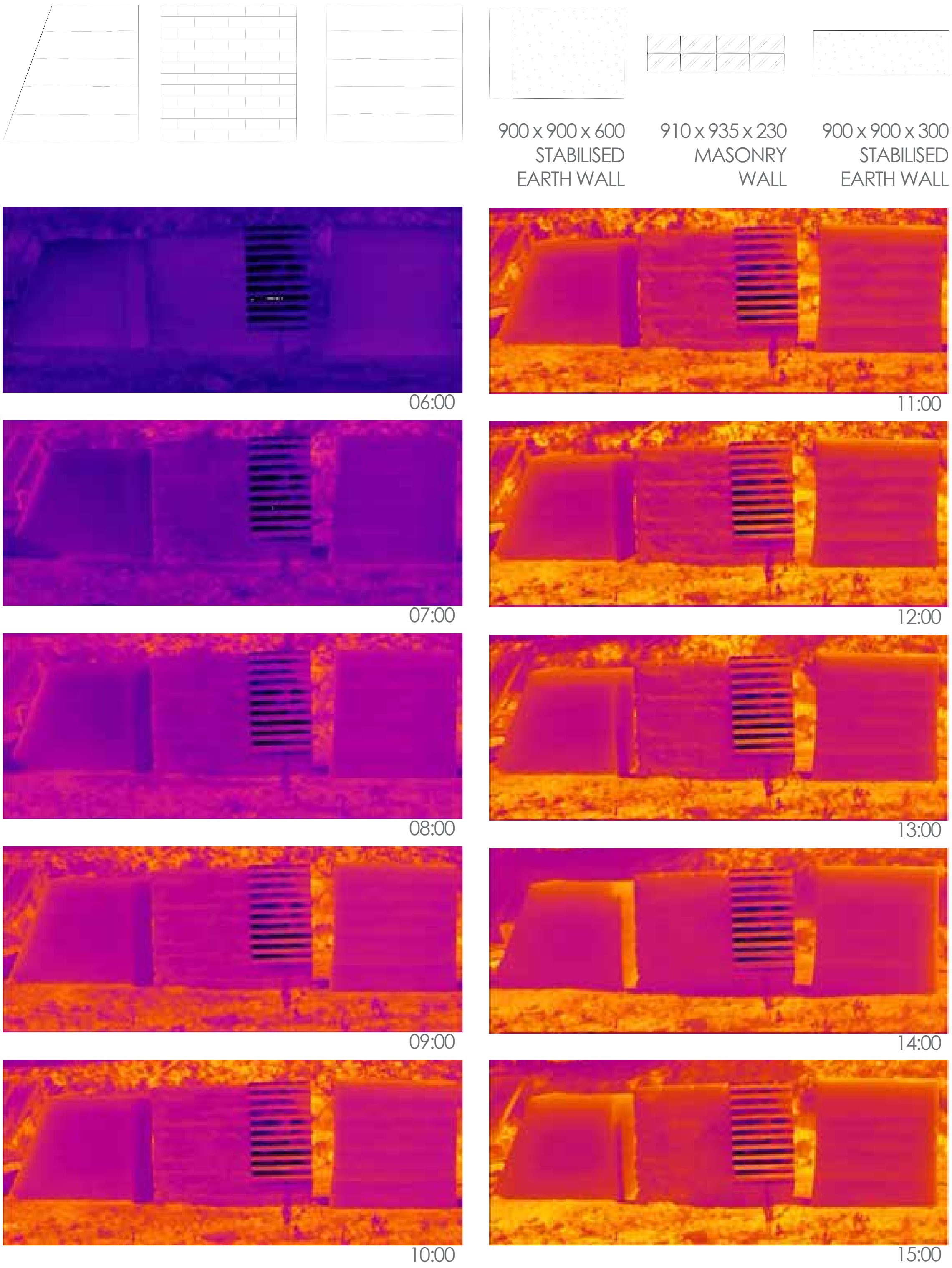
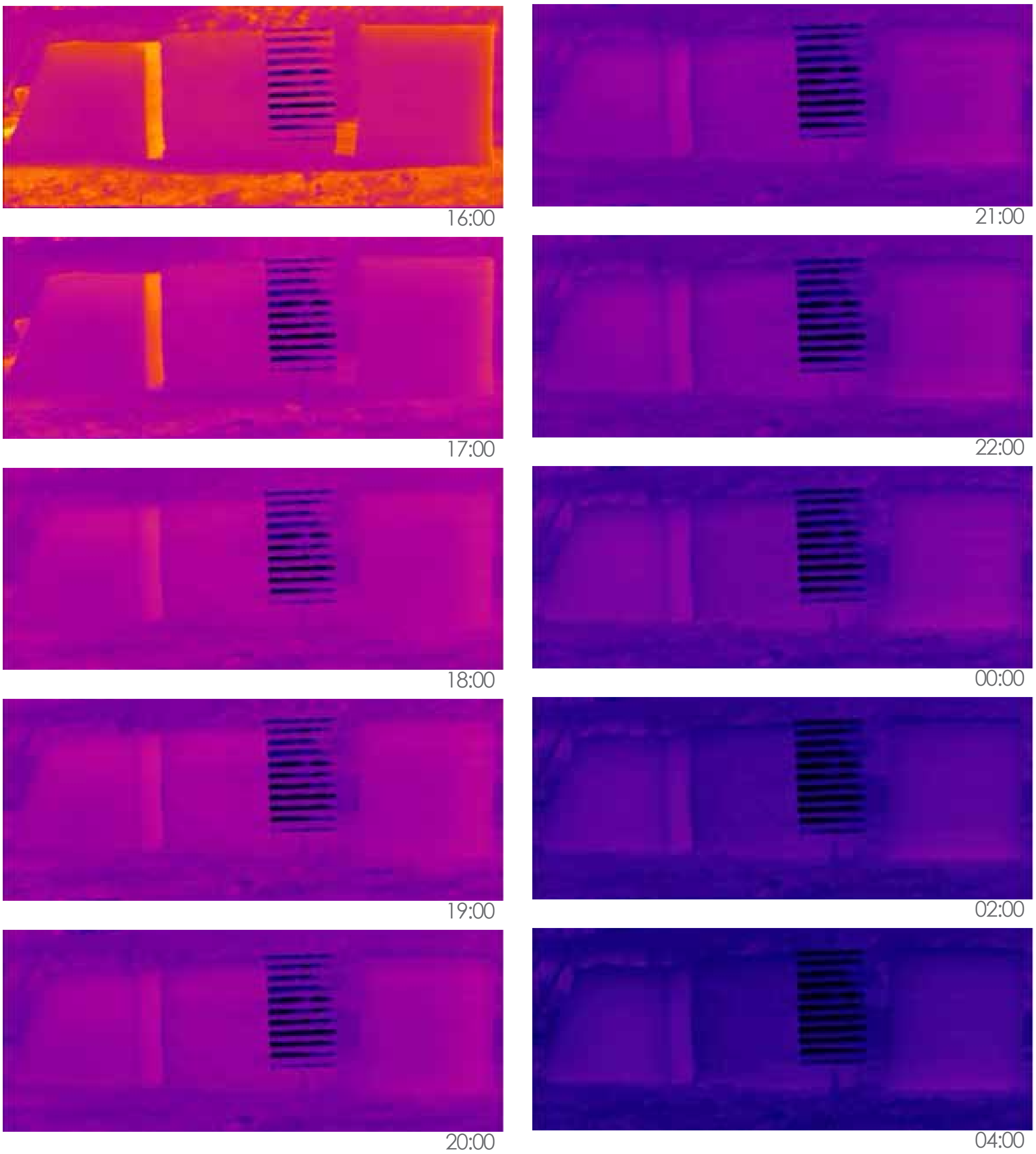

900 x 900 x 600
STABILISED
EARTH WALL
910 x 935 x 230
MASONRY
WALL
900 x 900 x 300
STABILISED
EARTH WALL
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00

FIGURE 8.19
INFRARED THERMOGRAPHY RESULTS
(Author , 2015)
▼



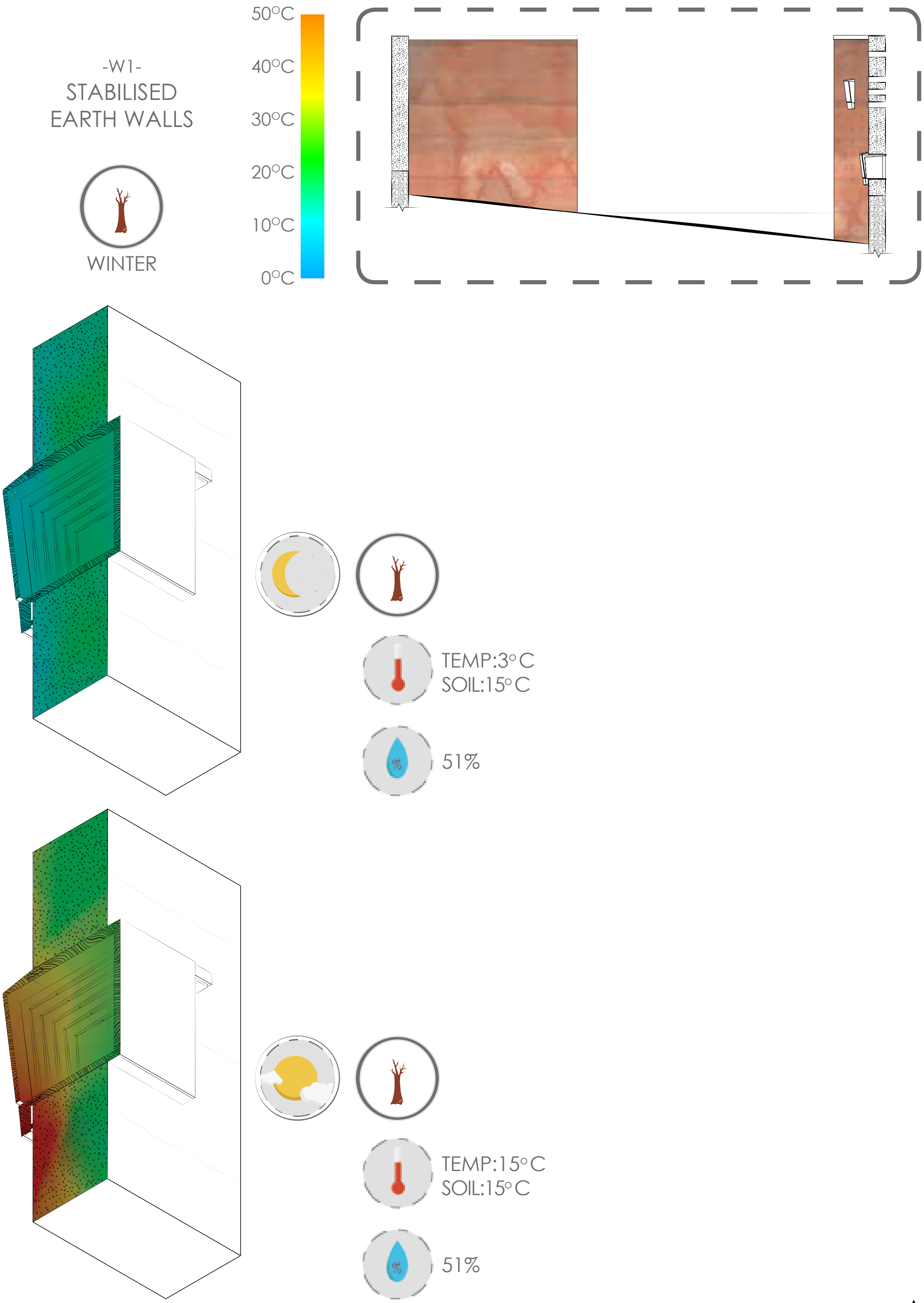


FIGURE 8.20
WINTER CFD ANALYSIS OF
STABILISED EARTH WALLS
(Author , 2015)

8.5.2 COMPUTATIONAL FLUID DYNAMICS (CFD) MODELLING

CFD is a computer-based mathematical modelling tool capable of dealing with fluid flow problems and predicting heat transfer, and physical fluid flows, including air. CFD modelling is used as a tool to evaluate the indoor environment of a building and its interaction with the building envelope. In the case of the Vivarium, CFD modelling is used to evaluate the internal temperature and humidity of the Chiroptera roost.

CFD works by dividing a space into a grid containing a large number of 'cells'. The grid of cells is surrounded by boundaries that simulate the surfaces and openings that enclose the space. The software simulates the flow of air from each cell to the cells surrounding it, and the exchange of heat between the boundary surfaces and the cells adjacent to them. After a series of iterations, the model reaches a steady state that represents the distribution of temperature expected to be found within the space (Cao & Chitty 2014).

The study simulates the average summer and winter conditions of the region in which the project is situated, including air temperature, humidity, and soil temperature. Through a series of design iterations, the study aims to simulate the ideal conditions of the Chiroptera roosts.

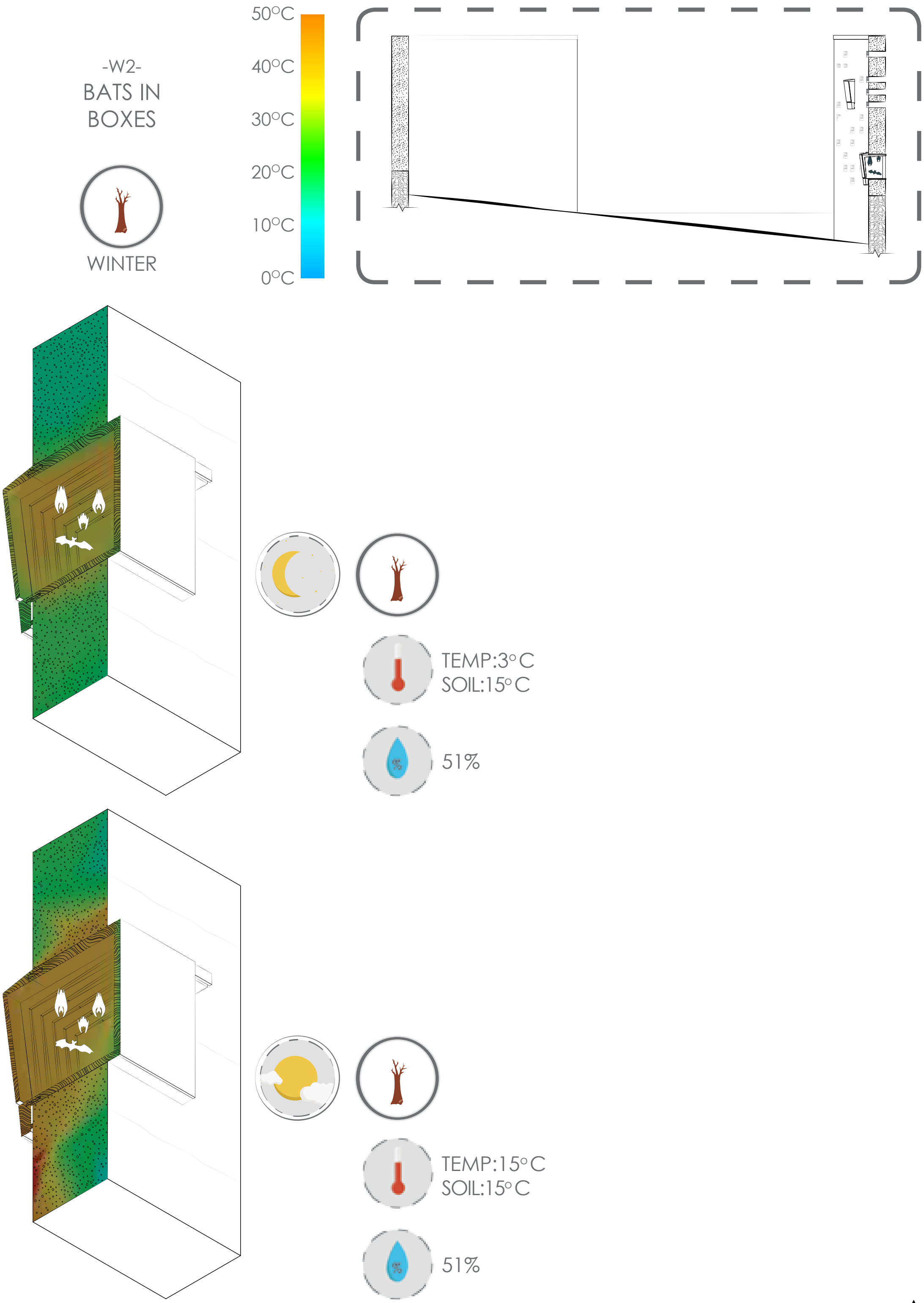
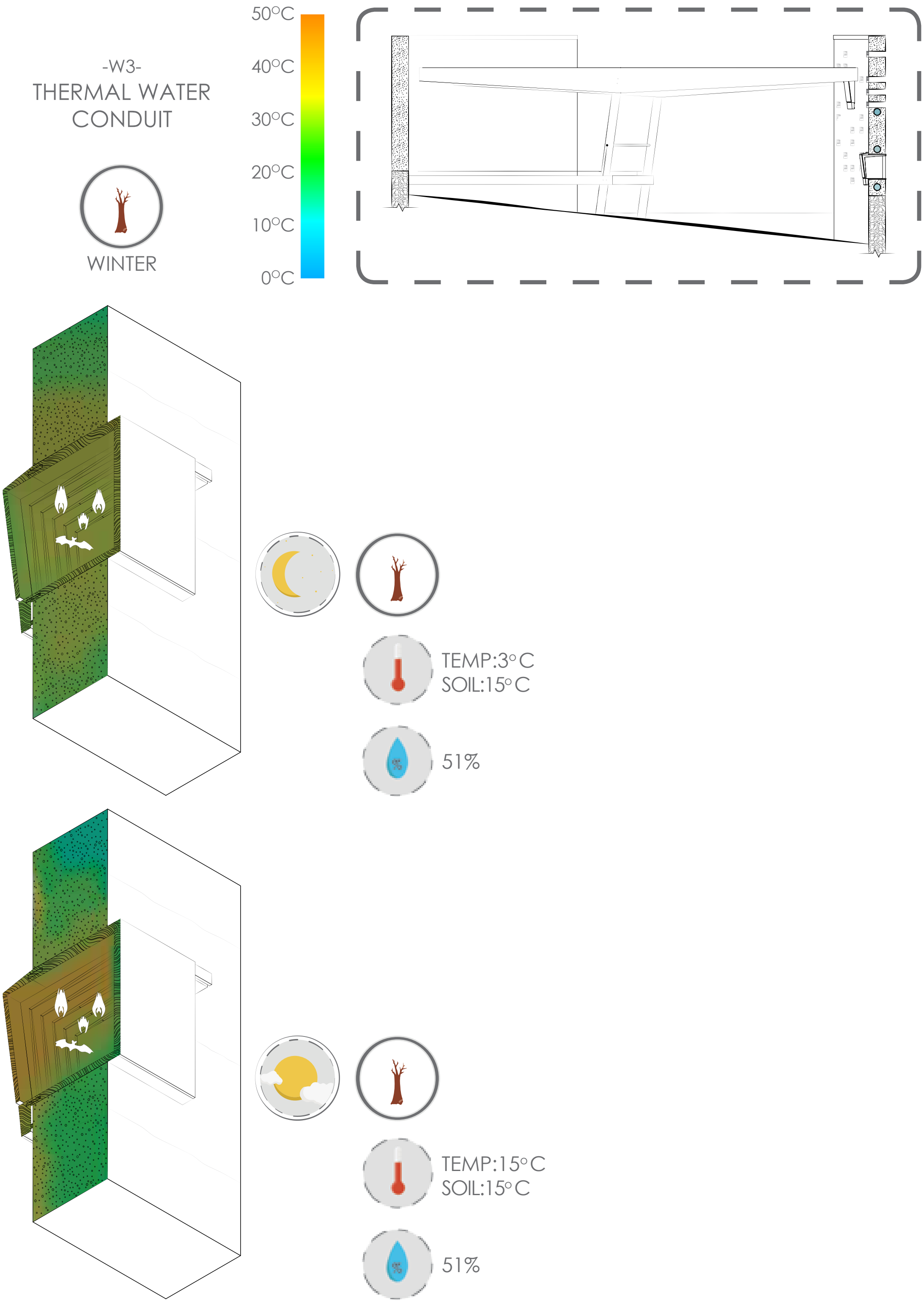


FIGURE 8.21
WINTER CFD ANALYSIS OF HEAT
GENERATED BY BAT BODY MASS
(Author , 2015)



▲
FIGURE 8.22
WINTER CFD ANALYSIS OF
THERMAL WATER CONDUIT
(Author , 2015)

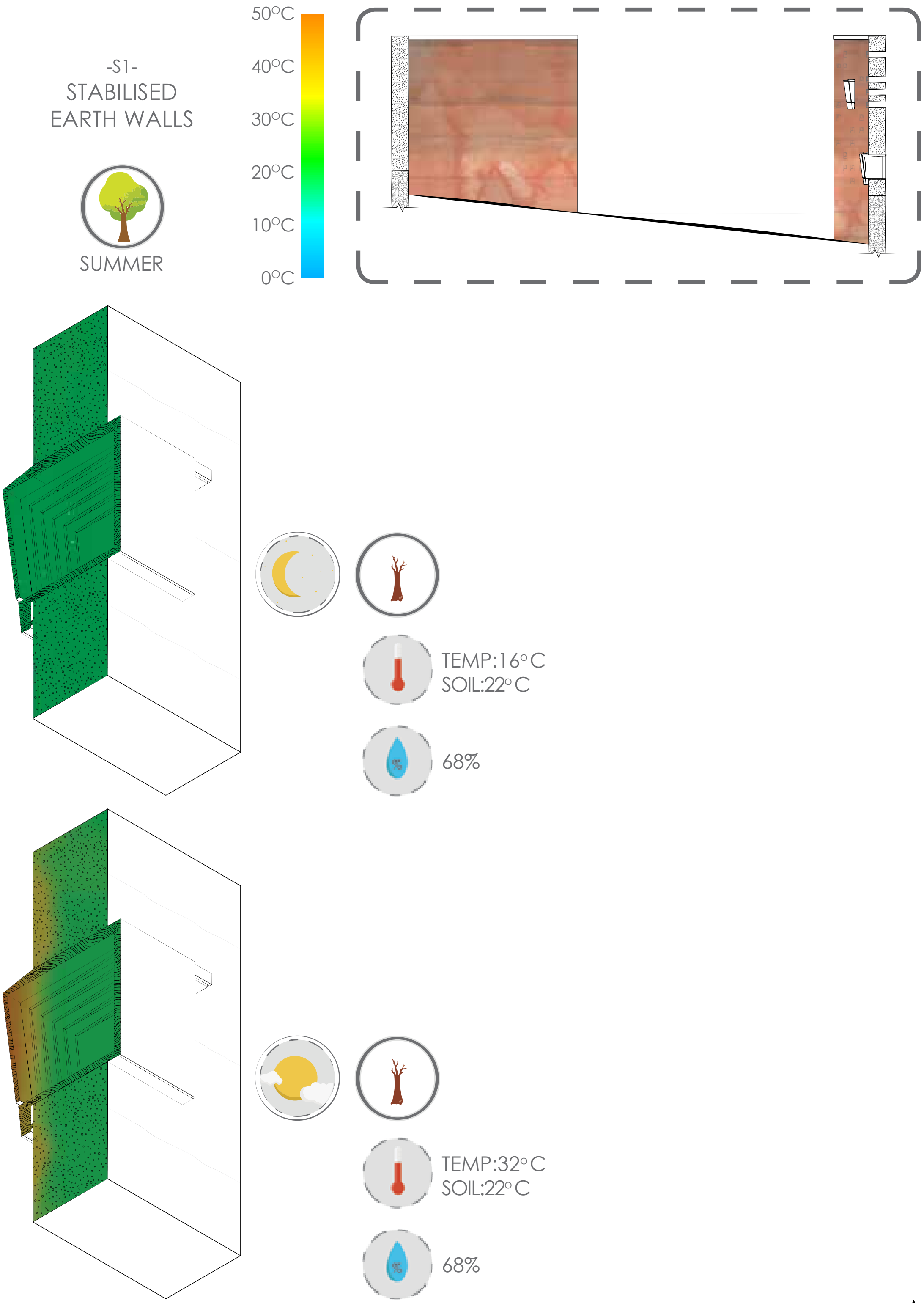
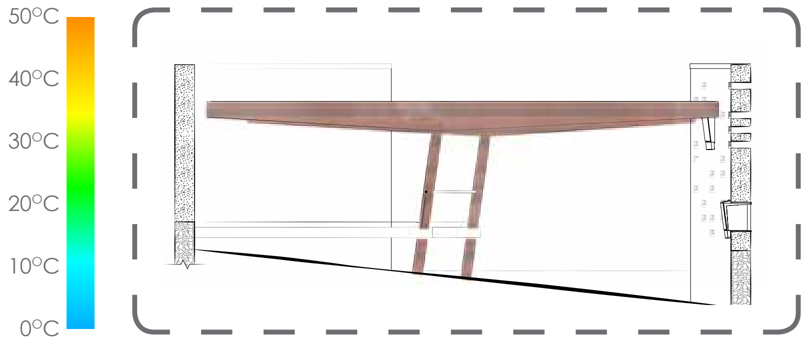
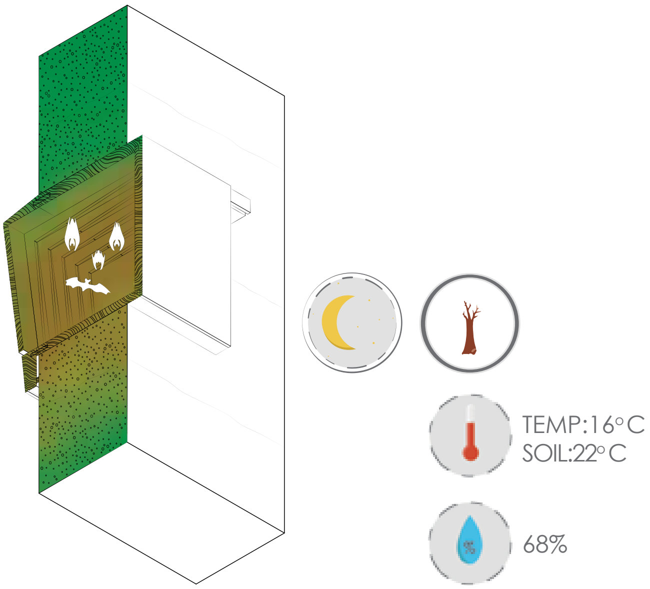


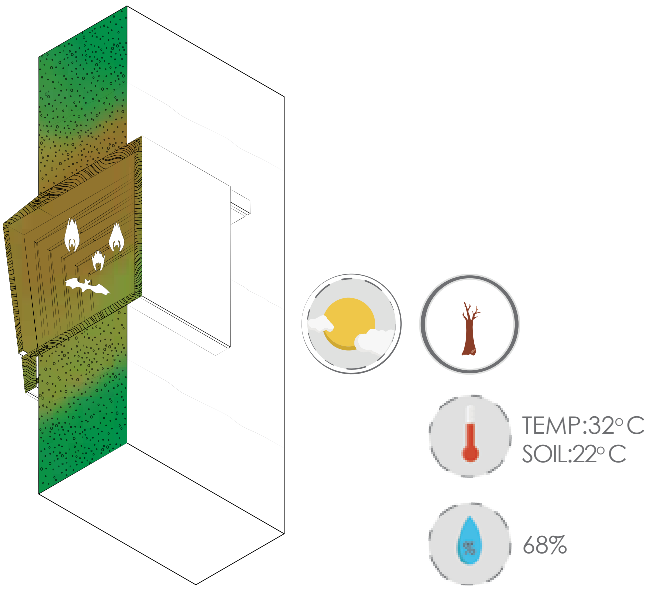
FIGURE 8.23
SUMMER CFD ANALYSIS OF
STABILISED EARTH WALLS
(Author , 2015)

-S2-
BAT PERGOLA BEAMS

SUMMER







▲
FIGURE 8.24
SUMMER CFD ANALYSIS OF SHADING PERGOLA BEAMS
(Author , 2015)

1 UNTREATED

2 BOILED ALOE VERA

3 UNBOILED ALOE VERA

4 LINSEED OIL

5 SURFACTANT: SURFACE COATED

6 SURFACTANT: MIXED THROUGH

◀
FIGURE 8.25
STABILISED EARTH
TEST BLOCKS
(Author , 2015)

8.5.3
STABILISED EARTH SURFACE TREATMENT TEST CUBES

With the selection of rammed earth as the most suitable material for the construction on the Chiroptera Roost, five stabilised test blocks where treated with a series of sealants, including both boiled and fresh Aloe Vera coating, linseed oil, and a surfactant. Through a series of weathering tests the surfactant used as a surface treatment was selected as the most suitable sealant.

CONCLUSION

▲
FIGURE 9.1
CHAUVE-SOURIS D'ÉGYPTE
[BATS OF EGYPT]
(St Hilaire, G. & Bouquet, A. 1809)

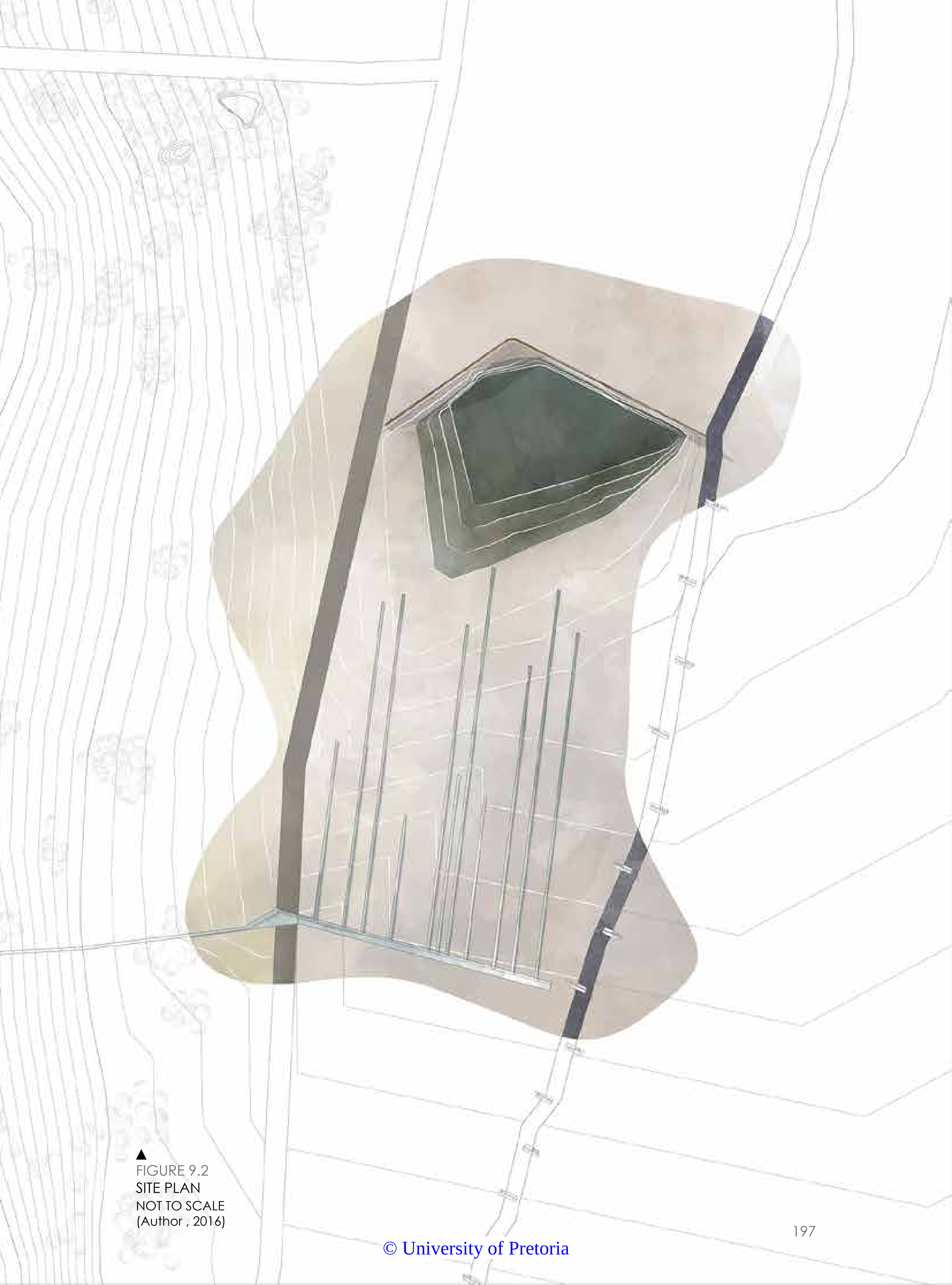
-9-
CONCLUSION

The dissertation set out to question the current relationship between humankind and nature, investigating an alternative understanding of humankind as part of nature, acknowledging the impact humankind has on the geological make-up of the earth, forming part of our current geological epoch, the Anthropocene. The dissertation, however, challenges the negative connotation of this impact on geology, and investigates how the impact of human beings in landscape might positively contribute to the landscape, thereby becoming an integral part in the workings of the landscape.

The site was approached through a regenerative lens, taking into account the existing networks of the site in order to build on these networks and to mediate and withstand the threats to this landscape. The programme was developed through the application of regenerative principles, discovering and utilising inherent place-bound potential to inform a new approach to remediation, education, and recreation through architecture. This led to the design of a tourism route, which builds on the social landscape of the Cradle, while protecting the historical and natural landscapes, through the remediation of the destructive impact of the economic landscape. The tourism route introduces visitors to the site through the three layers of the landscape, and aims to create a take-home experience for the users. The main focus of the programme is a Chiroptera Vivarium, a constructed habitat designed for the purpose of a bat research and visitor centre.

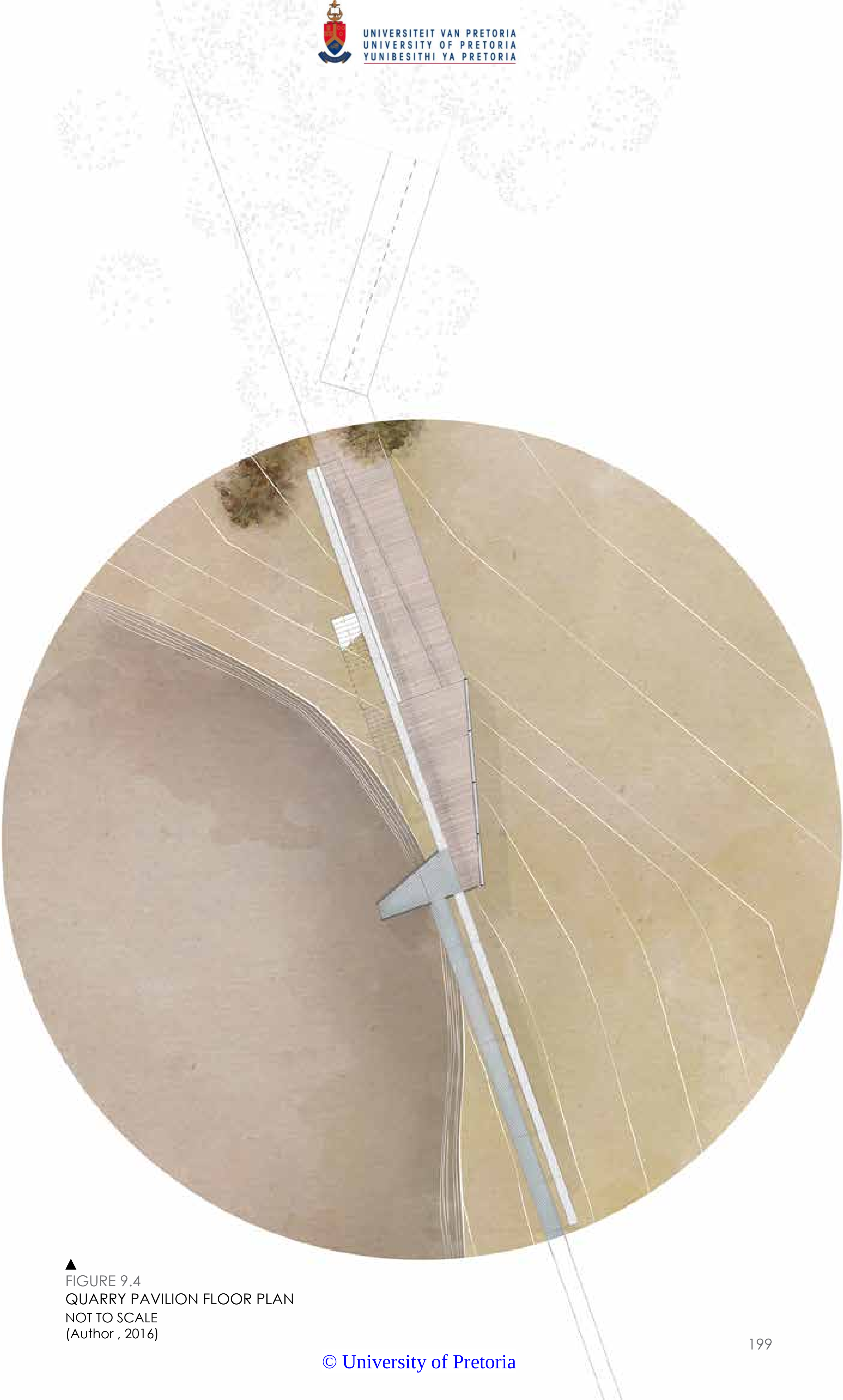
Concepts were drawn from the geological make-up of the landscape, the first being the creation of geology, the second the forming of habitat through the karst system, and the last the idea of the mountain and the grotto, relating to the human experience of a landscape. These three concepts were translated to the three sequential architectural concepts of protecting, creating habitat, and accommodating. Throughout the dissertation the concept of 'revealing the hidden' is carried through, from the larger context of the Cradle of Humankind, to the method through which each building is put together.

The project establishes a precedent for the 21st century tourism industry, moving away from the tourism as commodified experience, to an industry that can contribute to the landscape in which it is situated. The project proposes an architecture that allows for the co-evolution of humankind together with other living beings, creating spaces that are mutually beneficial for all of the components of the living systems.



▲
FIGURE 9.2
SITE PLAN
NOT TO SCALE
(Author , 2016)

FIGURE 9.3
TICKET OFFICE FLOOR PLAN
NOT TO SCALE
(Author , 2016)



▲
FIGURE 9.4
QUARRY PAVILION FLOOR PLAN
NOT TO SCALE
(Author , 2016)

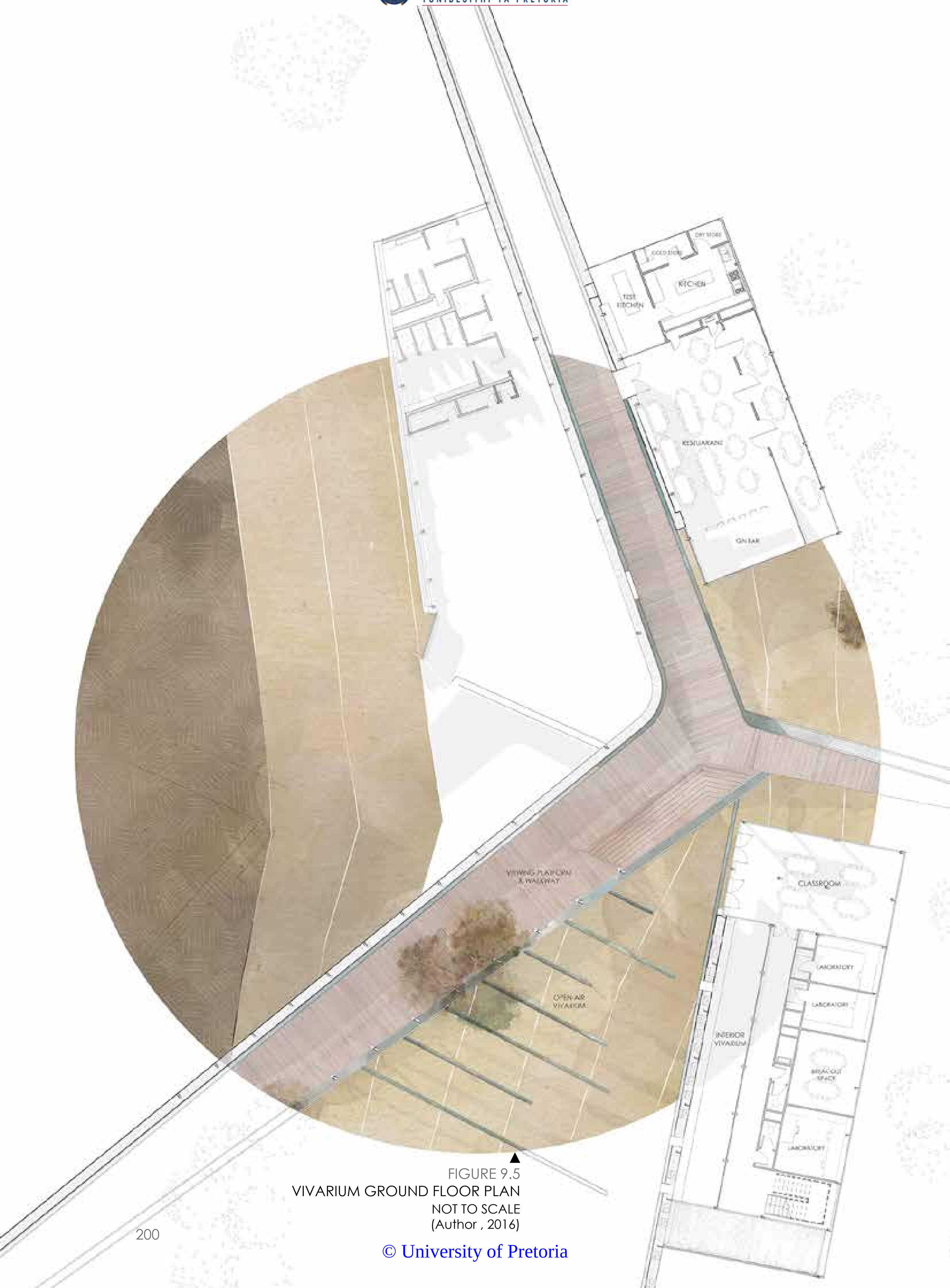


FIGURE 9.5
VIVARIUM GROUND FLOOR PLAN
NOT TO SCALE
(Author , 2016)

▲
FIGURE 9.6
VIVARIUM MEZZANINE FLOOR PLAN
NOT TO SCALE
(Author , 2016)

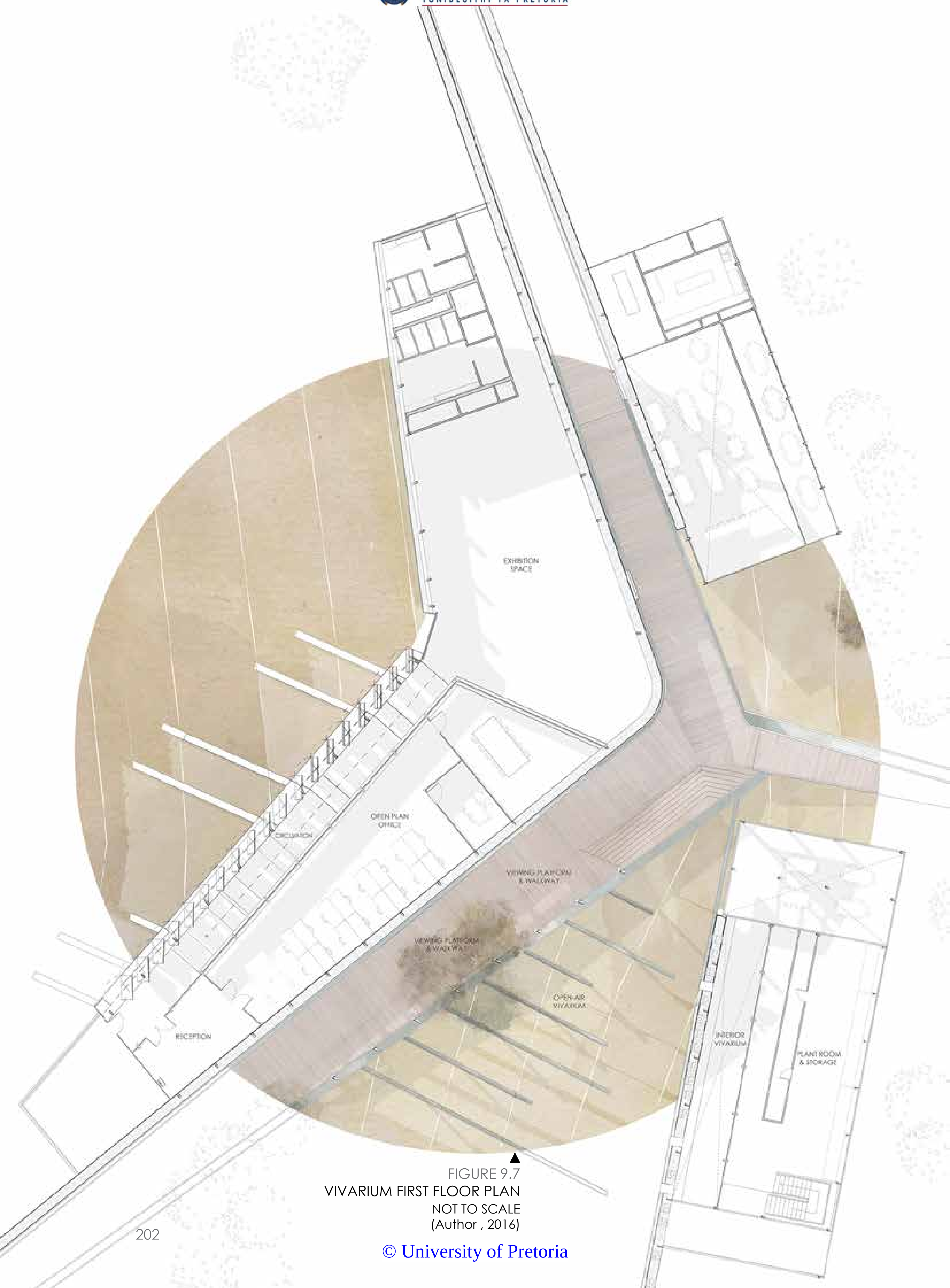
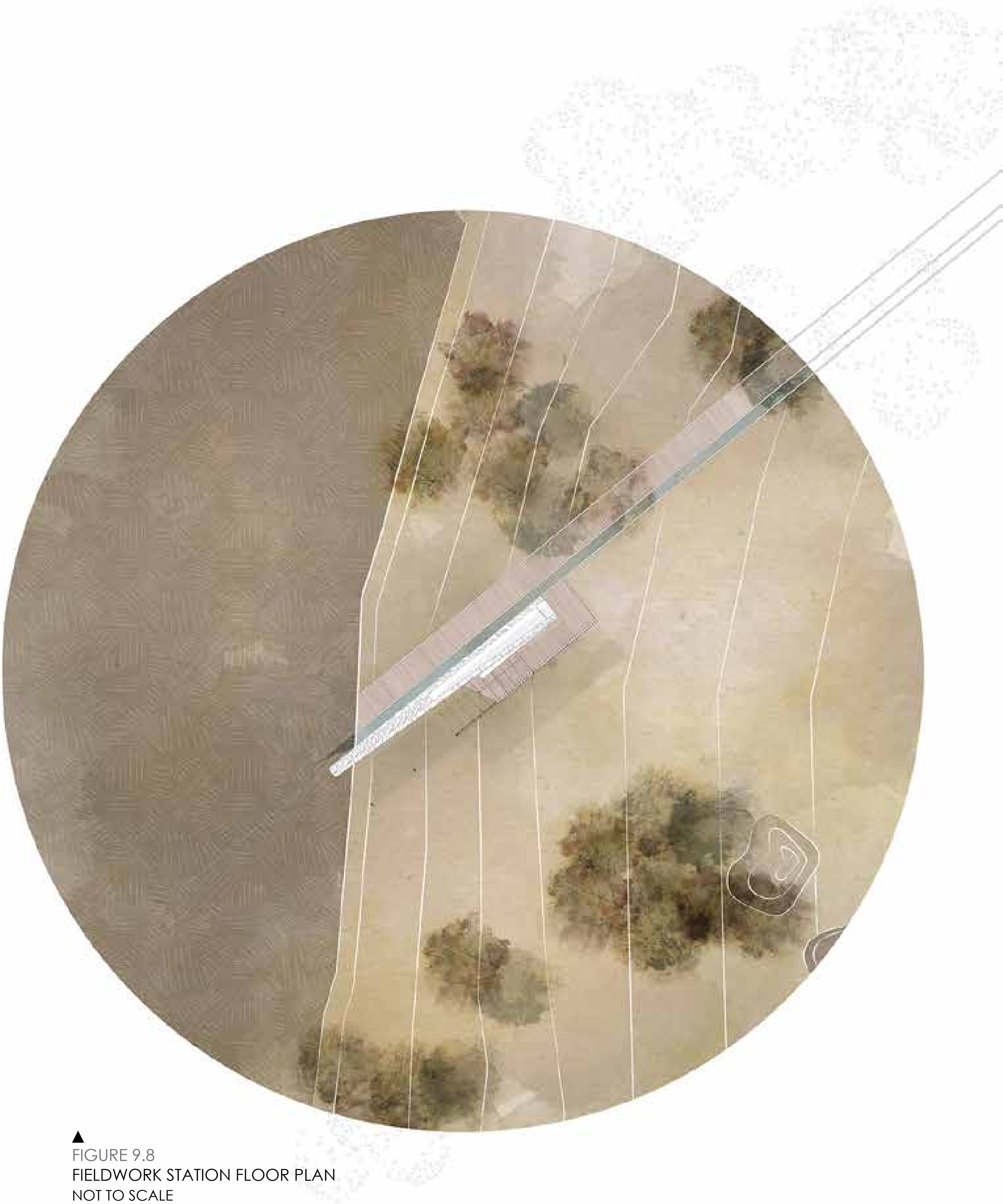


FIGURE 9.7
VIVARIUM FIRST FLOOR PLAN
NOT TO SCALE
(Author , 2016)



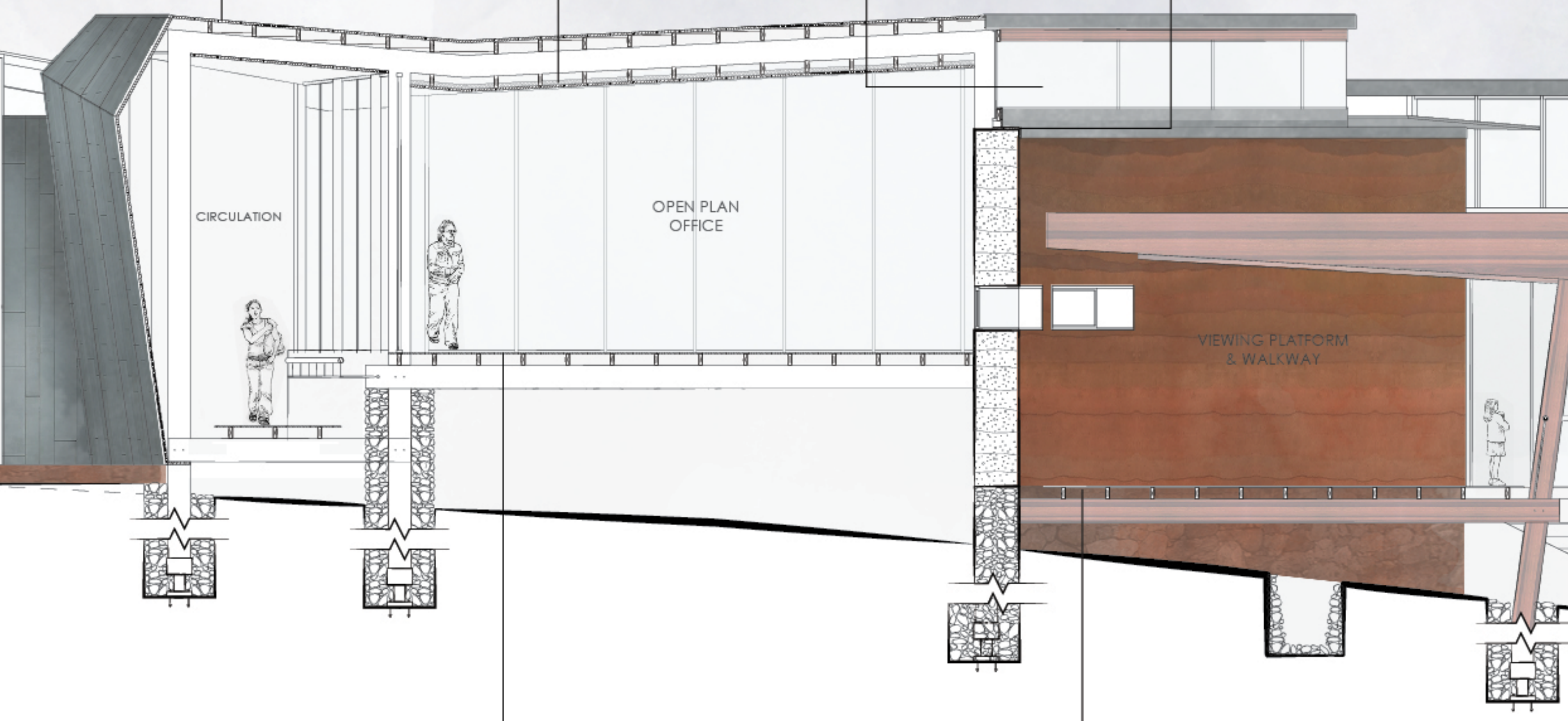
▲
FIGURE 9.8
FIELDWORK STATION FLOOR PLAN
NOT TO SCALE
(Author , 2016)

ROOF NOTE:
Roof sheeting to be PROTECT Graphite-Grey 0.8mm Rheinzink-Flat Lock tile system on Air-Z structured mat, with concealed fixing to 38x3000mm plywood boarding, screwed to 150x50mm SA pine purlins @ 600mm c.c. screwed to 300x100mm laminated Red Grandis Saligna beam @ 3000mm c.c.

CEILING NOTE:
114x38 Saligna slats fixed to 150x50mm SA pine purlins @ 600mm c.c. screwed to 300x100mm laminated Red Grandis Saligna columns @ 3000mm c.c with 50mm sound absorption panels laid between SA pine purlins on top of Saligna slats.

GLAZING NOTE:
12mm double glazed un-openable aluminium window frame section fixed to interior of 150x50mm SA pine purlins @ 600mm c.c. screwed to 300x100mm laminated Red Grandis Saligna columns @ 3000mm c.c.

COPING NOTE:
Coping to be PROTECT Graphite-Grey 0.8mm Rheinzink-Flat Lock tile system on Vapozink structured underlay, with concealed fixing to 38x300mm angled SA pine insert, fixed with 24mm Ø SA pine dowels @ 750mm c.c to 600mm lime stabilised earth wall, with 150mm overlap past earth wall, crimped and folded back to external façade of earth wall. Rheinzink sheets not to exceed 700x3000mm sections.

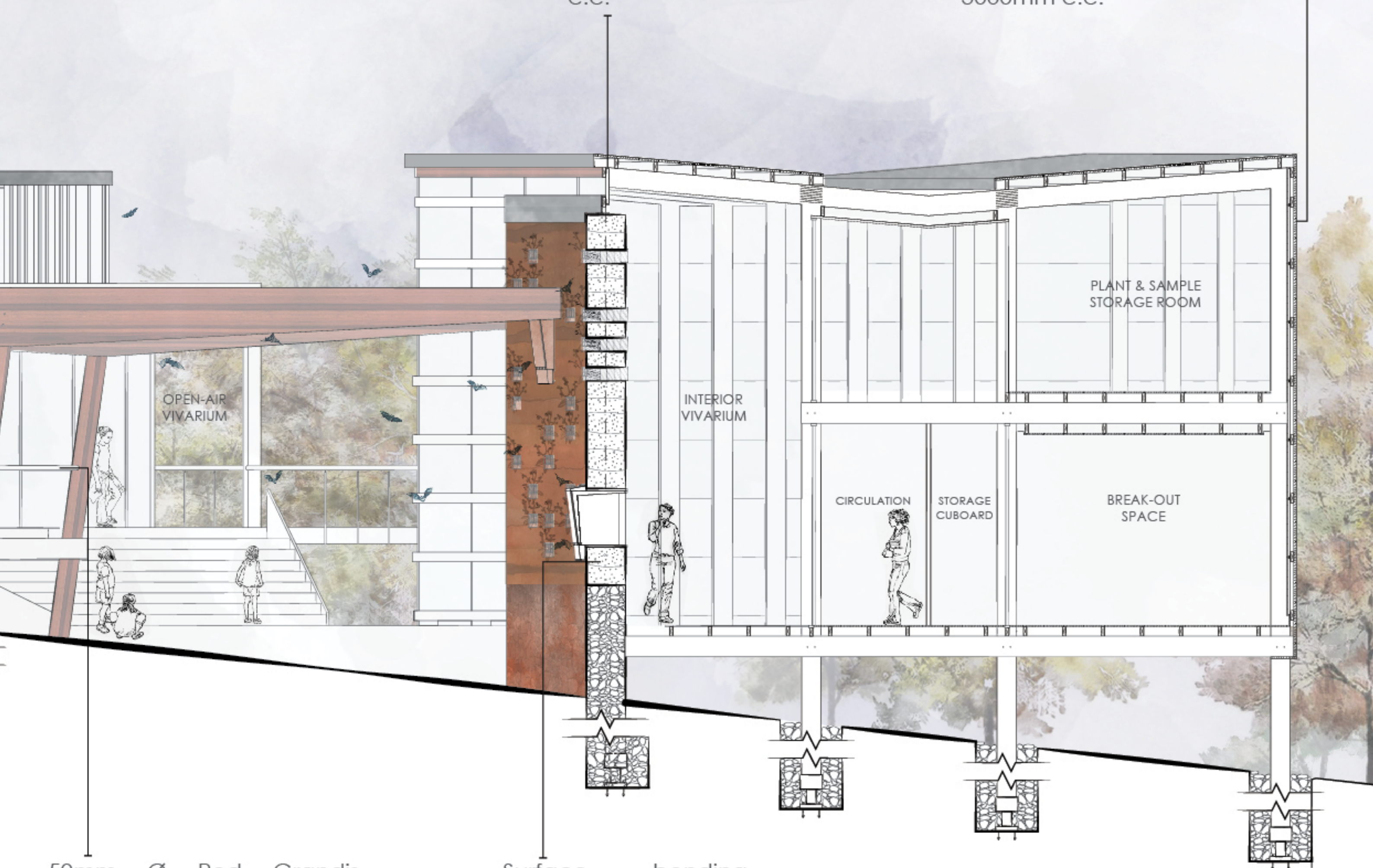


38x114mm Saligna tongue and groove boards conceal fixed to 150x50mm SA pine floor joists @ 600mm c.c. screwed to 300x100mm laminated SA pine bearer @ 3000mm c.c.

Woodoc 35 Exterior Polywax Sealed 100x22mm Saligna open joint decking fixed to 150x50mm Saligna floor joist @ 600mm c.c. screwed to 300x100mm laminated SA pine bearer @ 3000mm c.c. bolted to 300x100mm laminated Red Grandis Saligna columns @ 3000mm c.c.

GLAZING NOTE:
Opal 12mm celled polycarbonate sheeting fixed to white powder coated aluminium U-channel clip fixed to interior of 150x50mm SA pine purlins @ 600mm c.c. screwed to 300x100mm laminated Red Grandis Saligna columns @ 3000mm c.c.

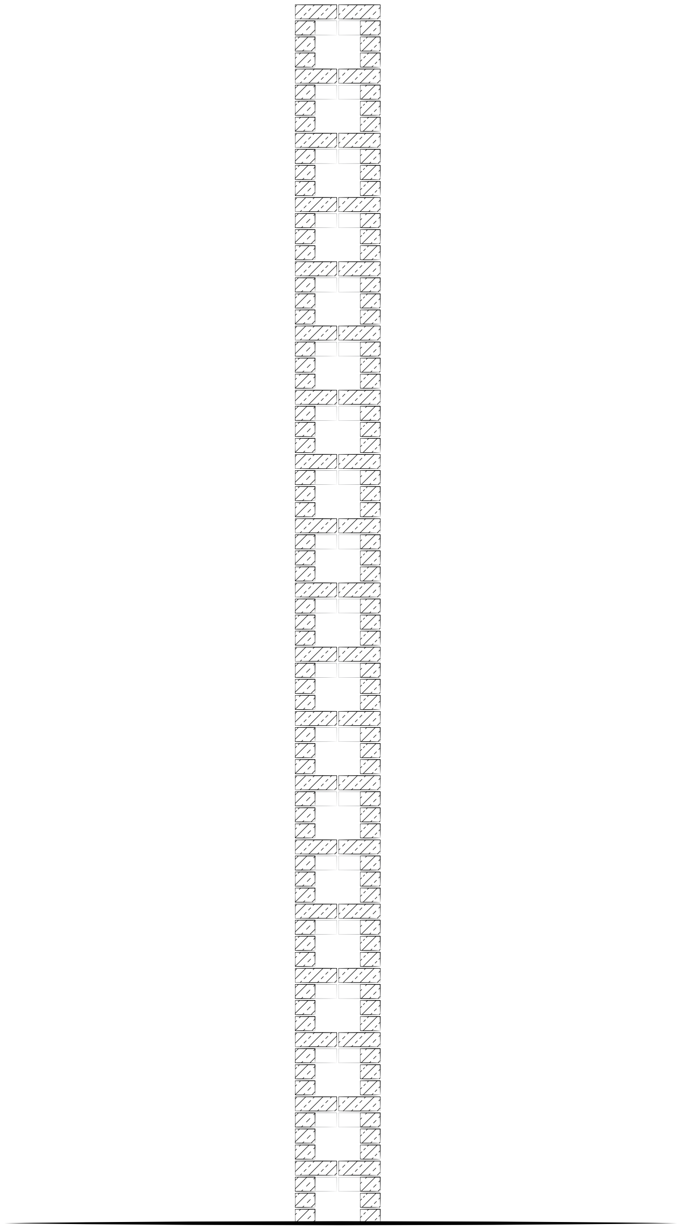
FAÇADE NOTE:
Façade cladding to be PROTECT Graphite-Grey 0.8mm Rheinzink-Flat Lock tile system on Vapozink structured underlay, with concealed fixing to 38x3000mm plywood boarding, screwed to 150x50mm SA pine purlins @ 600mm c.c. screwed to 300x100mm laminated Red Grandis Saligna columns @ 3000mm c.c.



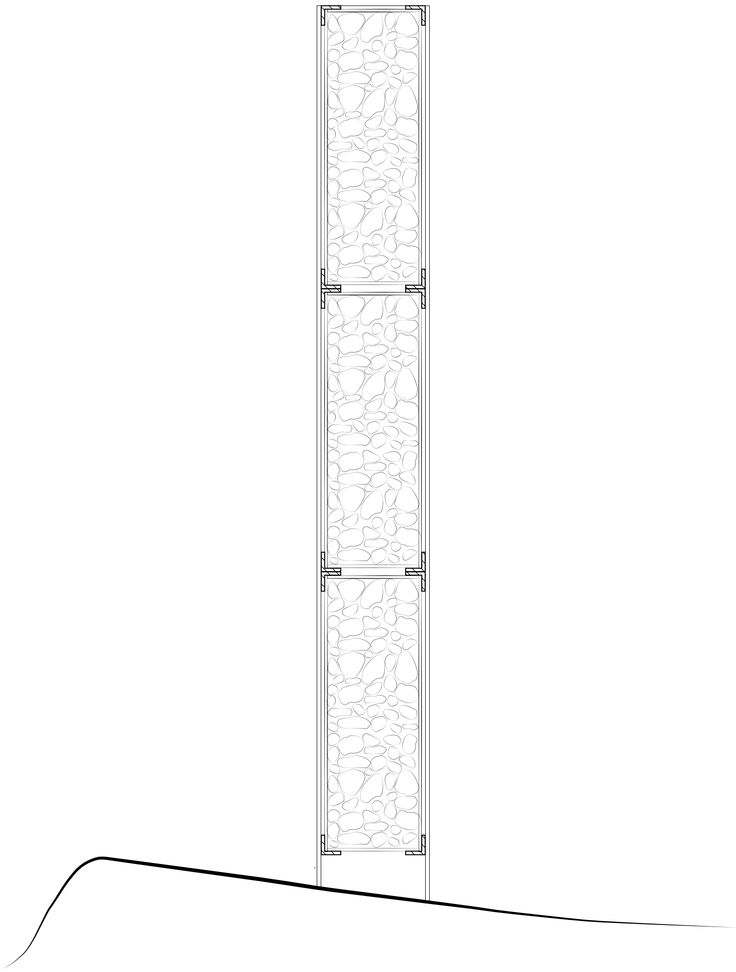
50mm Ø Red Grandis Saligna circular grabrail @ min 900mm fixed with epoxy to 10mm galvanised steel pin connection, fixed to 25mm Ø galvanised steel post, welded to 50x50mm steel baseplate, bolted to 300x100mm laminated SA pine bearer @ 3000mm c.c.

Surface bonding surfactant coated 600mm lime stabilised earth wall compacted in layers of 300mm, on 600mm mosaic stonework wall bedded and joined in class 2 mortar

▲
FIGURE 9.9
VIVARIUM CROSS SECTION
(Author , 2016)



▲
FIGURE 9.10
TICKET OFFICE MASONRY BRICK
SCREEN WALL SECTION
NOT TO SCALE
(Author , 2016)



▲
FIGURE 9.11
QUARRY PAVILION WIRE MESH &
STONE WALL SECTION
NOT TO SCALE
(Author , 2016)

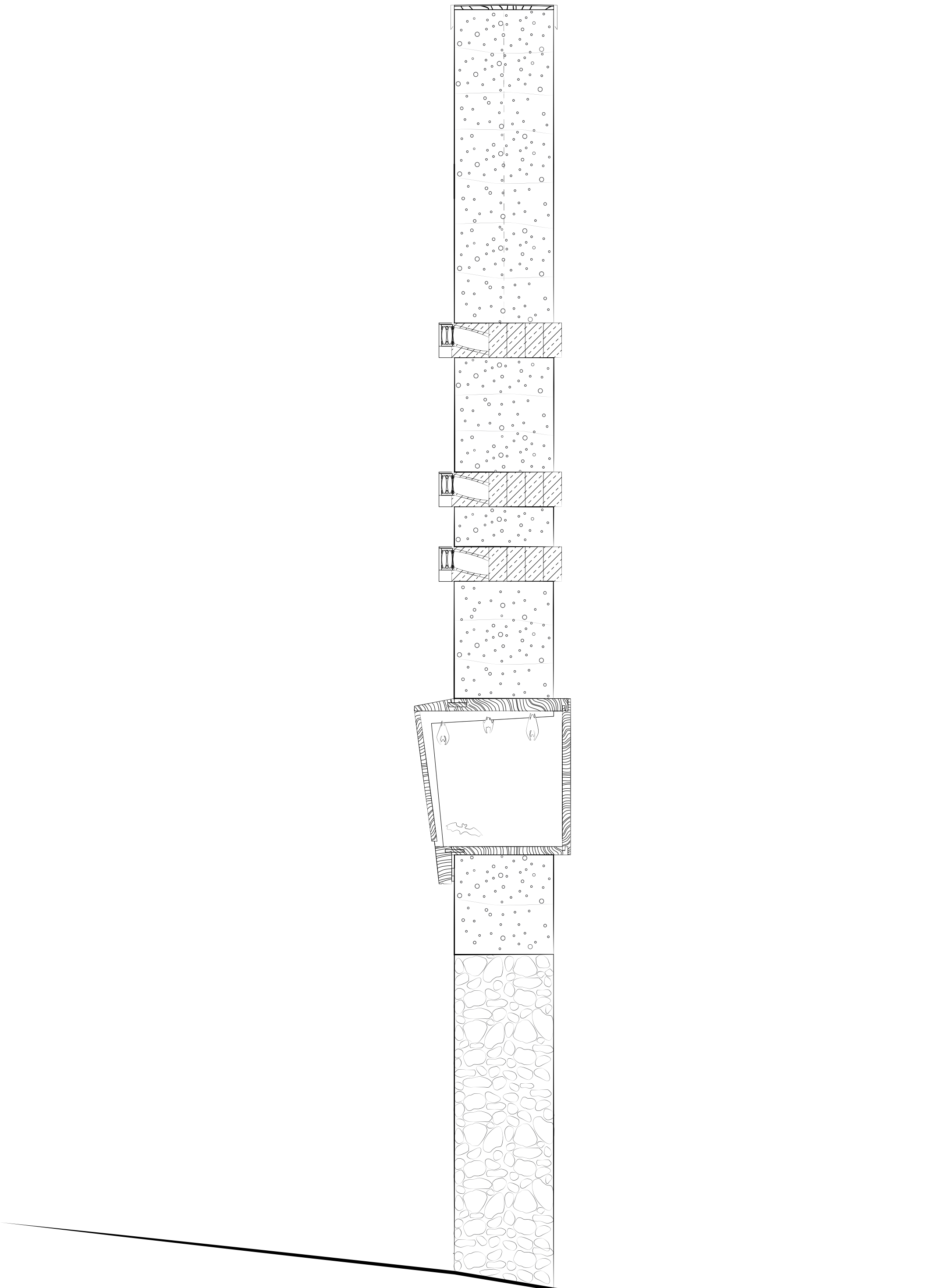
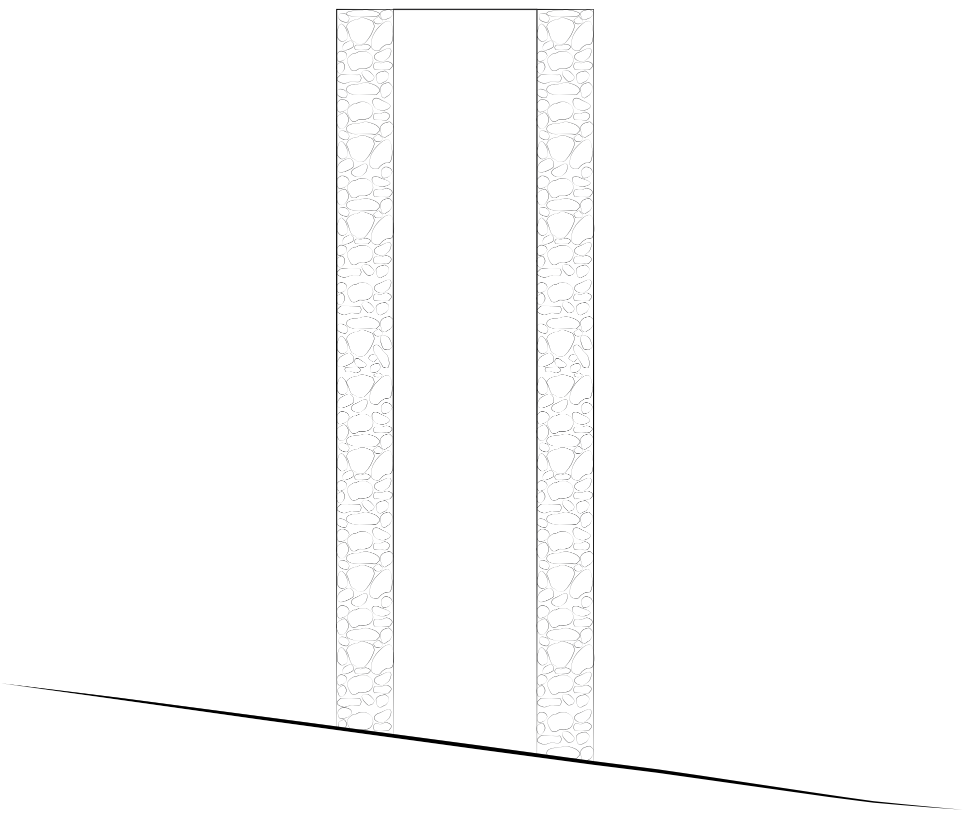


FIGURE 9.12
VIVARIUM CHIROPTERA ROOST
STABILISED EARTH WALL SECTION
NOT TO SCALE
(Author , 2016)



▲
FIGURE 9.13
FIELDWORK STATION CAVITY STONE WALL SECTION
NOT TO SCALE
(Author , 2016)

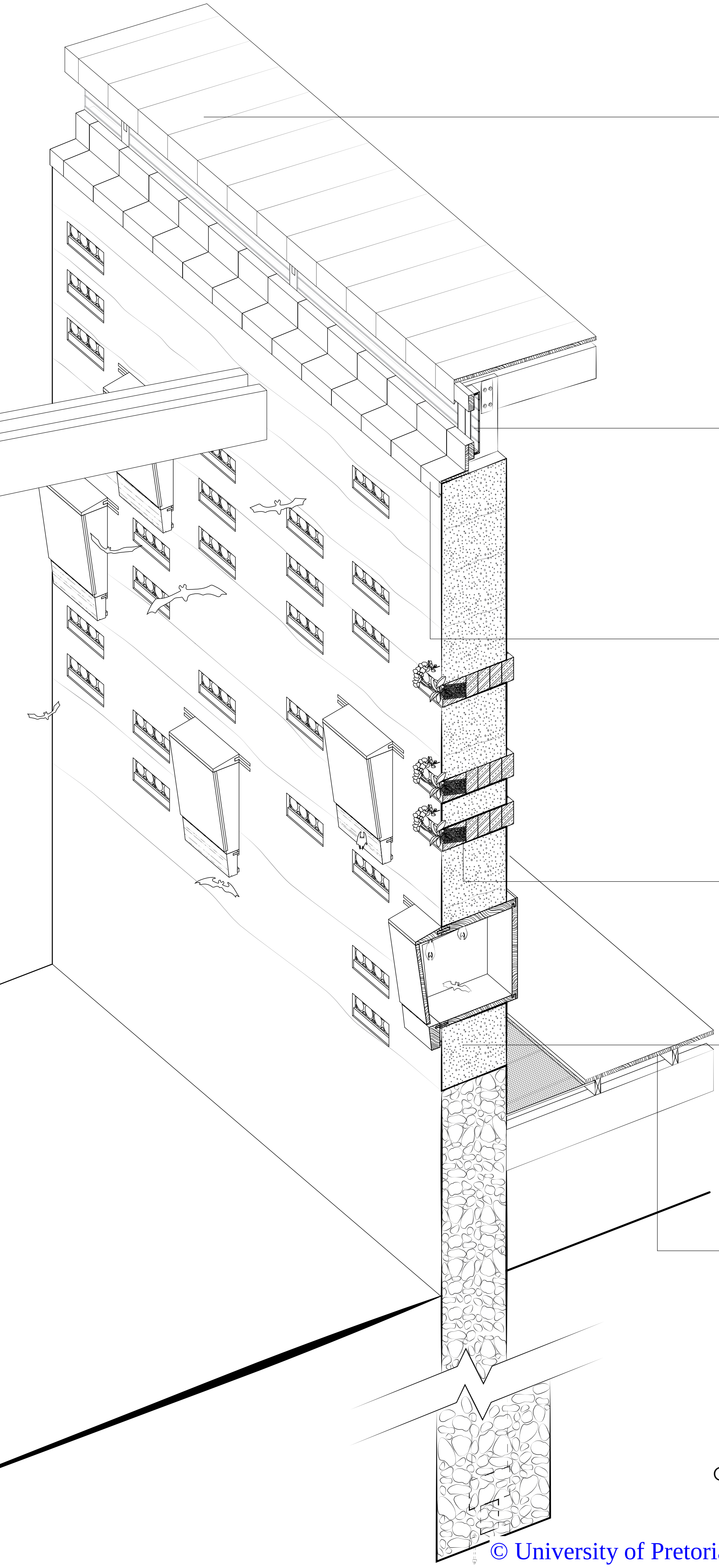
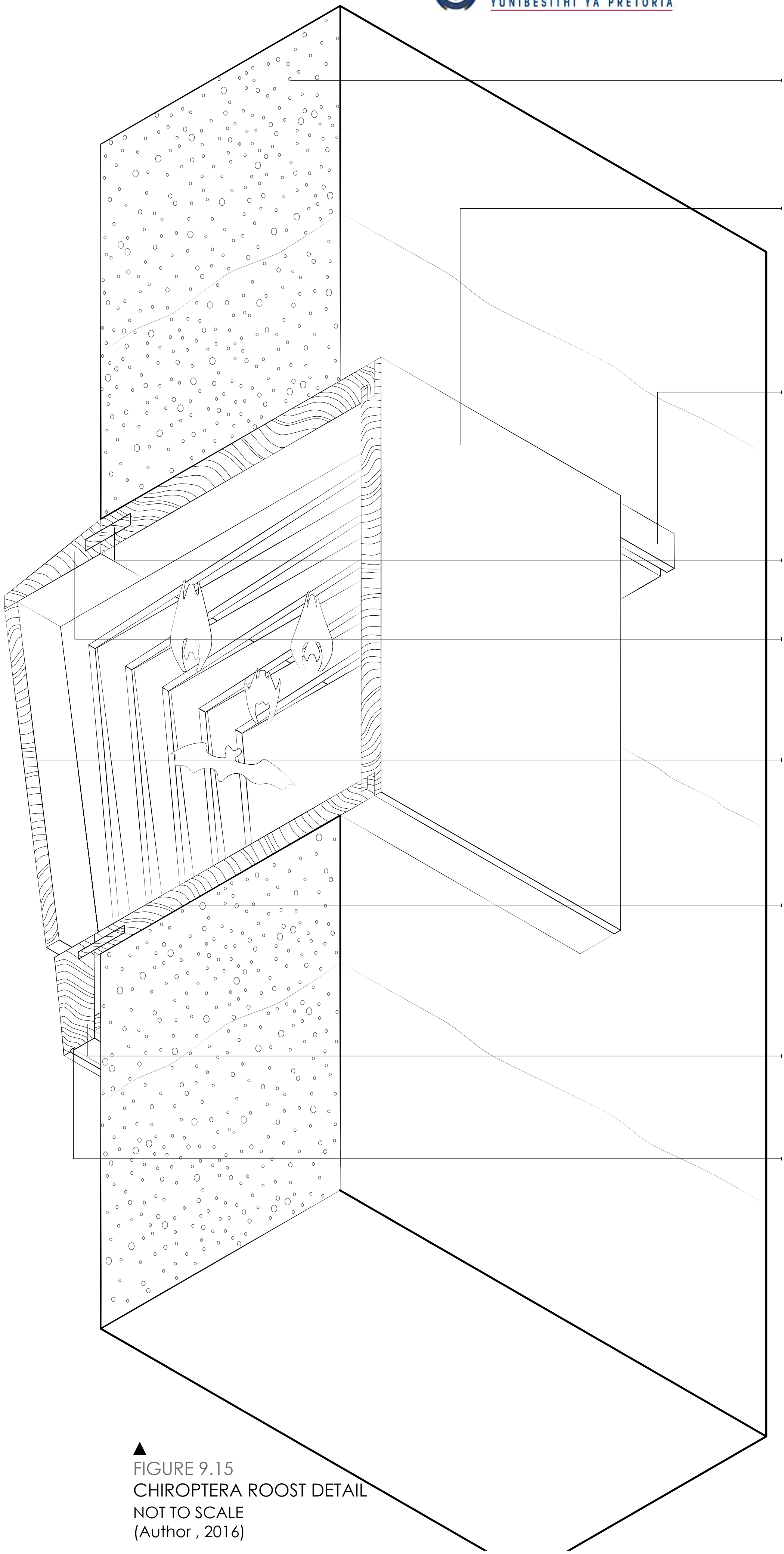


FIGURE 9.14
CHIROPTERA HABITAT DETAIL SECTION
NOT TO SCALE
(Author , 2016)



▲
FIGURE 9.15
CHIROPTERA ROOST DETAIL
NOT TO SCALE
(Author , 2016)

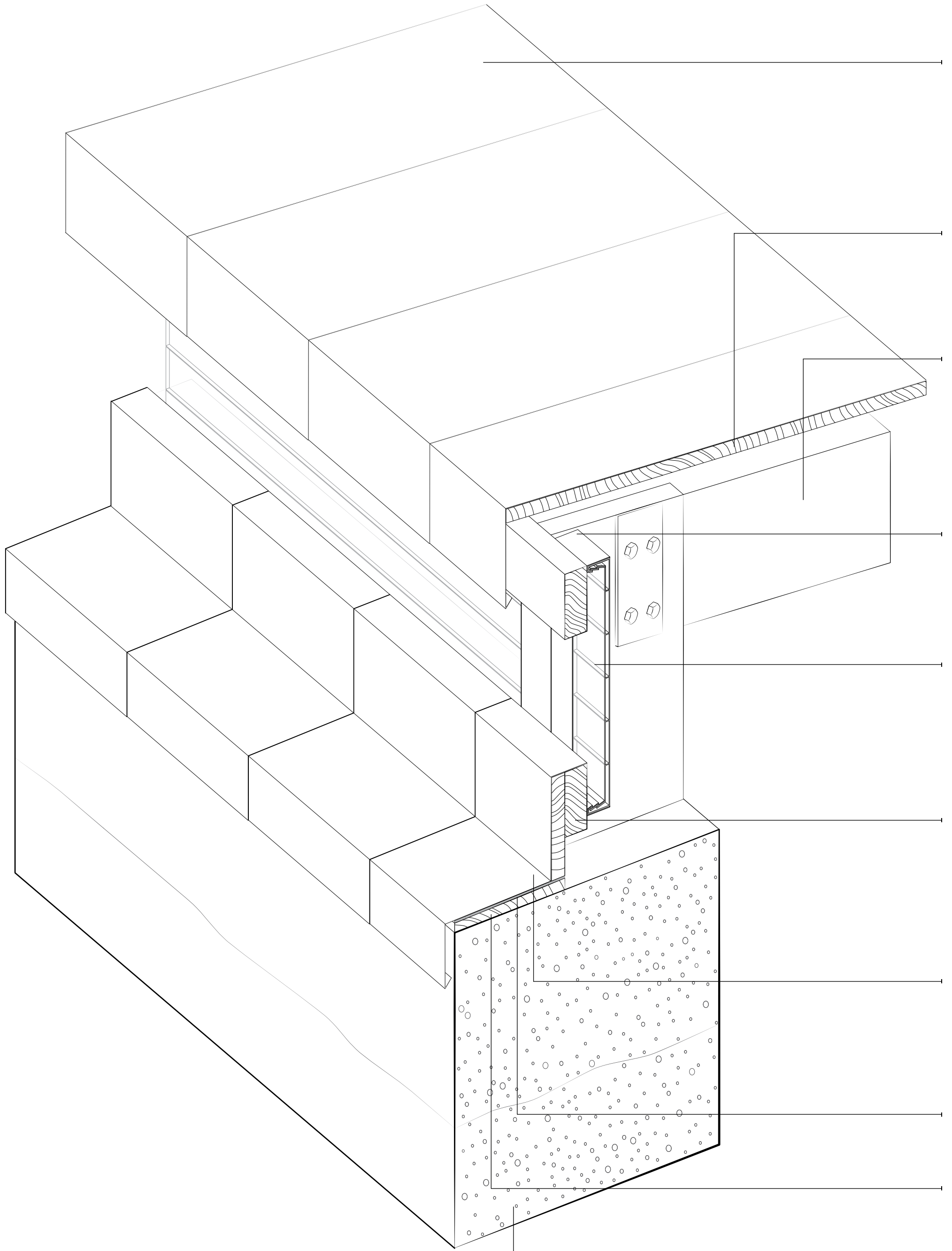
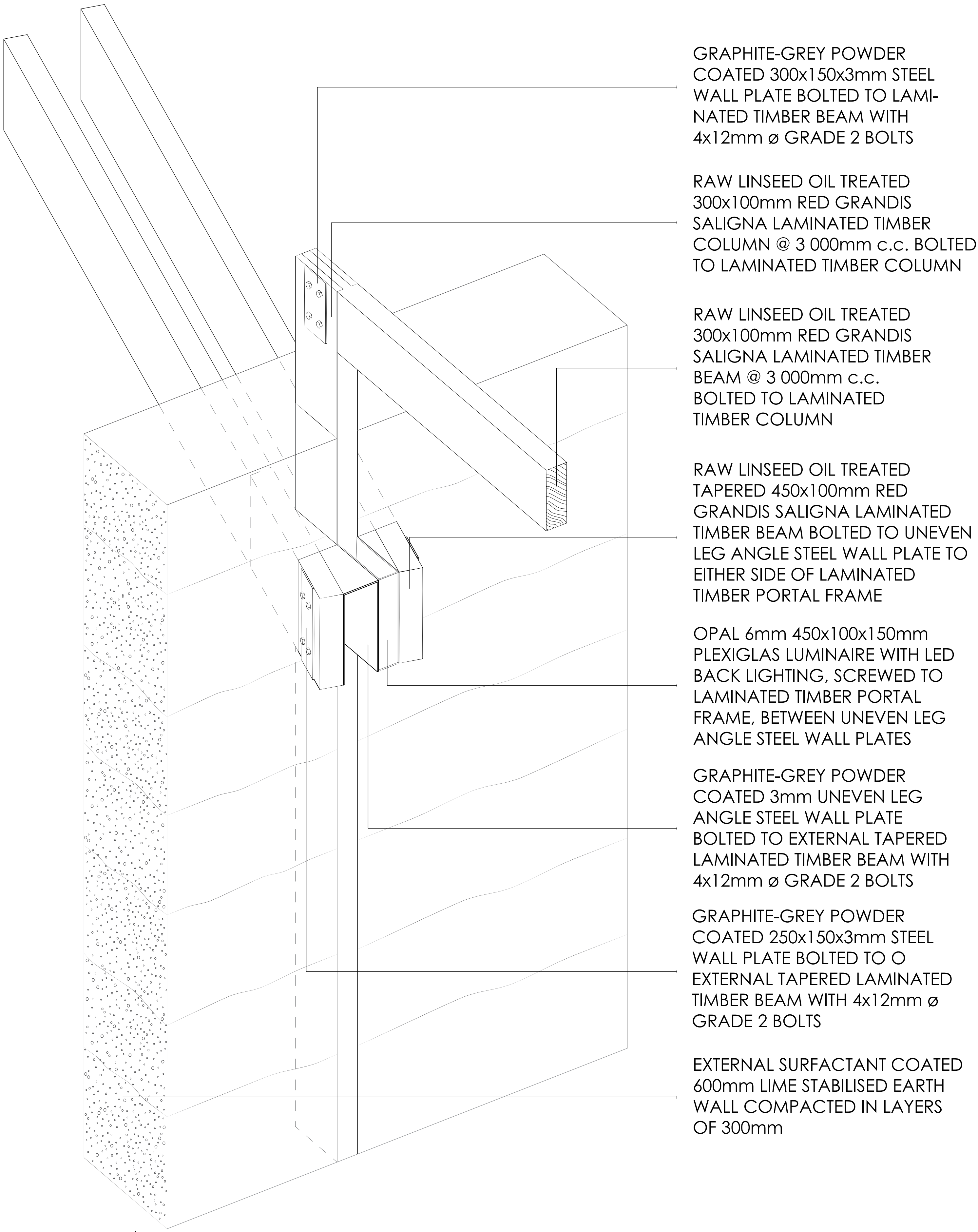


FIGURE 9.16
CHIROPTERA ROOST WALL DETAIL
NOT TO SCALE
(Author , 2016)



▲
FIGURE 9.17
PERGOLA BEAM & STABILISED EARTH WALL CONNECTIONS
NOT TO SCALE
(Author , 2016)

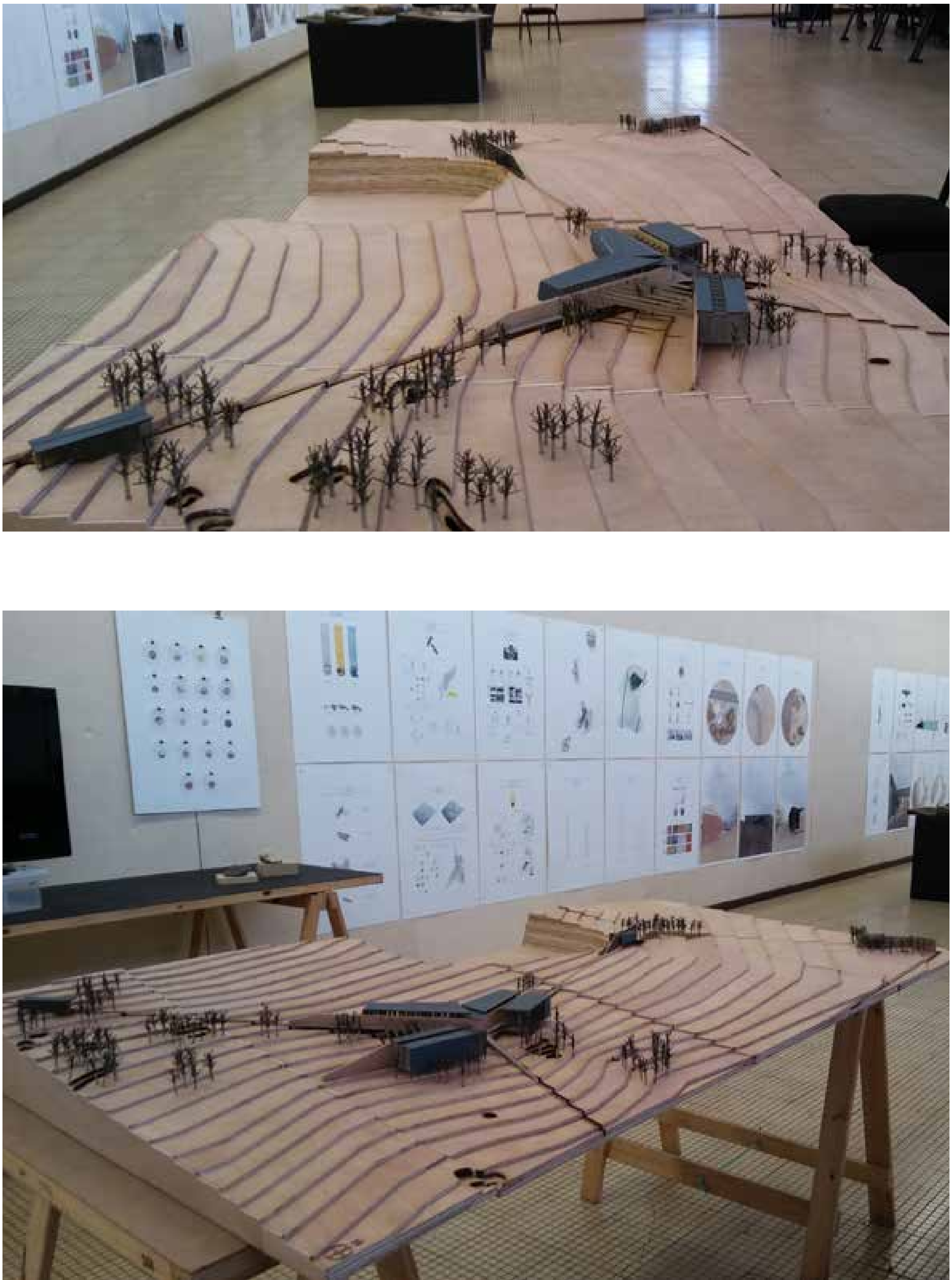


FIGURE 9.18
FINAL MODEL
(Author , 2016)

ACKNOWLEDGEMENTS

THANK YOU

To everyone who supported me through the years of architecture school

SPECIAL THANKS TO

To my Creator, for granting me this opportunity,

Dr. Arthur Barker, for sharing his wisdom & inspiration,

Dr. Edna Peres, for introducing me to regenerative thinking, her enduring patience and her encouragement

Genevieve Wood, for proofreading and editing,

Anthony Orelowitz and Dewald Veldsman, for their mentorship,

Tinus Vorster, for years of model building support

My fellow colleagues and friends, for advice, coffee, and laughs,

My parents and dearest sisters, for their never-ending support, for their kindness, love and tea,

My best friend, and fellow adventurer, Paul, for site visits, model building, and all the rest.

LIST OF FIGURES

BIBLIOGRAPHY

Abalos, I., Bressani, M. and Picon, A. *Cambridge Talks VI-Under: Architecture and Geology*.

Afritecture (2015). *Twyfelfontein Visitors Center,* Afritecture [Online]. Available at: http://www.afritecture.org/architecture/twyfelfontein-visitors-center [Accessed: 11 July 2016].

ArchDaily (2013). *Stonehenge Visitor Centre,* Denton Corker Marshall [Online]. Available at: http://www.archdaily.com/461242/stonehenge-visitor-centre-denton-corker-marshall/ [Accessed: 12 July 2016].

Ballantyne, R., Packer, J. and Sutherland, L.A. (2011). Visitors' memories of wildlife tourism: Implications for the design of powerful interpretive experiences. *Tourism Management* 32:770–779.

Bat Conservation Trust *Roost* [Online]. Available at: http://roost.bats.org.uk/ [Accessed: 8 June 2016].

Cobbing, J.E., Hobbs, J., Rascher, J. and Oelofse, S.H.H. (2007). The pollution and destruction threat of gold mining waste on the Witwatersrand: A West Rand case study.

Cole, R.J., Oliver, A. and Robinson, J. (2013). Regenerative design, socio-ecological systems and co-evolution. *Building Research & Information* 41:237–247.

Cooke, H.B.S. (1993). Fossil proboscidean remains from Bolt's Farm and other Transvaal cave breccias. [Online]. Available at: http://wiredspace.wits.ac.za/handle/10539/16233 [Accessed: 20 March 2016].

CSIR (2014). *State of Conservation Report of the Fossil Hominid Sites of the South African World Hetitage Site (The Sterkfontein, Swartkrans, Kromdraai and Environs Component)*. Pretoria: Department of Environmental Affairs, Republic of South Africa.

Daily Mail (2013). *Stonehenge Visitor Centre to Open in Time for Winter Solstice* [Online]. Available at: http://www.dailymail.co.uk/travel/article-2438896/Stonehenge-visitor-centre-open-time-winter-solstice.html [Accessed: 1 August 2016].

Durand, J. (2007). *Challenges Associated with Living in Karst Environments, such as the Historical Cradle of Humankind.* Johannesburg: University of Johannesburg.

Durand, J., Fourie, M. and Meeuvis, J. (2010). The threat of mine effluent to the UNESCO status of the Cradle of Humankind World Heritage Site. *The Journal for Transdisciplinary Research in Southern Africa* 6:73–92.

Eloff, G. (2010). *The Phytosociology of the Natural Vegetation Occuring in the Cradle of Humankind World Heritage Site, Gauteng, South Africa*. University of South Africa.

Esposito, R. (2011). Visitor Centre Building, Twyfelfontein, Namibia 2005-2007. GIZMO [Online]. Available at: http://www.gizmoweb.org/2011/12/postcard-from-tywfelfontein/ [Accessed: 11 July 2016].

Fallon, L.D. and Kriwoken, L.K. (2003). Community involvement in tourism infrastructure—the case of the Strahan Visitor Centre, Tasmania. Tourism Management 24:289–308.

Fraser, H. (2009). Nelson Mandela Museum Pavilions. In: *10 Years + 100 Buildings: Architecture in a Democratic South Africa*. First Edition. Cape Town: Bell-Roberts Publishing.

Frearson, A. (2012). *Trollstigen Tourist Route by Reiulf Ramstad Architects* [Online]. Available at: http://www.dezeen.com/2012/07/07/trollstigen-by-reiulf-ramstad-architects/ [Accessed: 18 July 2016].

Gauteng Provincial Government *Updated Fossil Site Management Plan for Bolt's Farm Klinkerts*. 2009: Cradle of Humankind World Heritage Site Cultural Heritage Resources Management.

Gensch, R., Paclijan, S.. and Sacher, N. (2010). Biogas Electricity (Small Scale). [Online]. Available at: http://www.sswm.info/content/biogas-electricity-small-scale [Accessed: 8 September 2016].

Gommery, D., Kgasi, L., Potze, S., Prat, S. and Senegas, F. (2010). Bolt's Farm: The Kingdom of Large Cats in the Cradle of Humankind.

Gommery, D. and Potze, S. (2013). *Bolt's Farm-Greensleaves Permit Renewal (2013-2016)*. Pretoria: HOPE Research Unit.

Grahl, B. (2012). Twyfelfontein: Engraved in Rock. *Gondwana Collection Collection Namibia* [Online]. Available at: http://www.gondwana-collection.com/blog/index.php/twyfelfontein-engraved-in-rock/ [Accessed: 1 August 2016].

Hessler, J. and Lehner, N. (2009). *Planning and Designing Research Animal Facilities.* First Edition. Oxford: Elsevier.

Hobbs, :J. (2011). Situation Assessment of the Surface Water and Groundwater Rewource Environments in the Cradle of Humankind World Heritage Site. Gauteng, South Africa: Department of Economic Development.
IUCN (2008). *Miniopterus Schreibersii: The IUCN Red List of Threatened Species 2008.* Available at: http://www.iucnredlist.org/details/13561/0 [Accessed: 7 June 2016].

Jagnow, D.H. (1998). Bat Usage and Cave Management of Torgac Cave, New Mexico. *Journal of Cave and Karst Studies* 60:33–38.
Krige, A. and van Wyk, B. (2005). The mystery of the silver vegetation. *Veld & Flora*:134–137.

Krige, E. (2016). Other Wild Flowers of Sterkfontein – Sterkfontein Country Estates. [Online]. Available at: http://sterkfonteincountryestates.org.za/flora/other-wild-flowers-of-sterkfontein/ [Accessed: 26 July 2016].

Landorf, C. (2009). Managing for sustainable tourism: a review of six cultural World Heritage Sites. *Journal of Sustainable Tourism* 17:53–70.

Lanting, F. *Twyfelfontein* [Online]. Available at: http://franslanting.photoshelter.com/search?I_DSC=Twyfelfontein&_ACT=-search&I_DSC_AND=t [Accessed: 1 August 2016].

Leyland, R.C. (2008). *Vulnerability Mapping in Karst Terrains, Exemplified in the Wider Cradle of Humankind World Heritage Site*. Pretoria: University of Pretoria.

Lovair (2015). *Case Study: Stonehenge Visitor Centre Washrooms* [Online]. Available at: http://www.lovair.com/en/blog/case-study-stonehenge-visitor-centre-washrooms.html [Accessed: 1 August 2016].

Macarthur, J. (2014). *Melting into Air: Stonehenge Visitor Centre* [Online]. Available at: /articles/stonehenge-visitor-centre-1/ [Accessed: 12 July 2016].

Mang, N.S. (2007). *The Rediscovery of Place and Our Human Role within It*. Saybrook Graduate School and Research Center.

Mang, P. and Reed, B. (2012). Designing from place: a regenerative framework and methodology. *Building Research & Information* 40:23–38.

Mogale City Local Municipality (2011). *Mogale City Local Municipality Status Report*. Available at: http://www.mogalecity.gov.za/ [Accessed: 16 February 2016].

Naidu, M. (2008). Creating an African Tourist Experience at the Cradle of Humankind World Heritage Site. *Historia* 53:182–207.

Nhauro, G. (2010). *Characterization of the Elemental Deposits in Fossils from the Cradle of Humankind in South Africa and Modern Bones from the Same Geological Area*. Thesis. Available at: http://wiredspace.wits.ac.za/handle/10539/8489 [Accessed: 8 January 2016].

Pearce, L. (2004). The Functions and Planning of Visitor Centres in Regional Tourism. The *Journal of Toursim Studies* 15.

Pedersen, A. (2002). Managing Tourism at World Heritage Sites: a Practical Manual for World Heritage Site Managers. *World Heritage Manuals* 1:96.

Pennisi, L.A., Holland, S.M. and Stein, T.V. (2004). Achieving Bat Conservation Through Tourism. *Journal of Ecotourism* 3:195–207.

Pretorius, E. (2012). *Determining the Diversity of Nocturnal Flying Insects of the Grassland in the Krugersdorp Nature Reserve.* Thesis. Available at: https://ujdigispace.uj.ac.za/handle/10210/4685 [Accessed: 7 March 2016].

Reiulf Ramstad Architects (2012). *Trollstigen Visitor Centre* [Online]. Available at: http://www.reiulframstadarchitects.com/trollstigen-visitor-centre/ [Accessed: 18 July 2016].

Ross, S. and Wall, G. (1999). Ecotourism: towards congruence between theory and practice. *Tourism Management* 20:123–132.

Stark, S., Petitto, J. and Darr, S. (2013) *Animal Research Facility: Whole Building De-*

sign Guide [Online]. Available at: https://www.wbdg.org/design/animal_research.php [Accessed: 30 July 2016].

The Hub (2016). *Stonehenge Visitor Centre* [Online]. Available at: http://www.thehublimited.co.uk/project/stonehenge-visitor-centre [Accessed: 1 August 2016].

The National Institutes of Health (2008). Design Requirements Manual for Biomedical Laboratories and Animal Research Facilities. [Online]. Available at: https://www.orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualPDF.aspx [Accessed: 1 October 2016].

The South African Karst Working Group (2010). The Karst System of the Cradle of Humankind World Heritage Site. [Online]. Available at: http://www.wrc.org.za/KnowledgeHubDocuments/ResearchReports/KV20241-10.pdf [Accessed: 14 December 2015].

UNESCO World Heritage Centre (2008). *Stonehenge, Avebury and Associated Sites* [Online]. Available at: http://whc.unesco.org/en/list/373 [Accessed: 12 July 2016].

UNESCO World Heritage Centre (2007). *Twyfelfontein or /Ui-//aes* [Online]. Available at: http://whc.unesco.org/en/list/1255 [Accessed: 11 July 2016].

Wager, J. (1995). Developing a strategy for the Angkor World Heritage Site. *Tourism Management* 16:515–523.

Whatley, G. (2015). Kromdraai Gold Mine Museum Tour.

Witthüser, K. (2016). The Karst System of the Cradle of Humankind.

World Heritage Committee (2013). *State of Conservation of World Heritage Properties Inscribed on the World Heritage List*. Phnom Penh, Cambodia: United Nations Education, Scientific and Cultural Organization.

Yusoff, K. (2013). Geologic Life: Prehistory, Climate, Futures in the Anthropocene. *Environment and Planning: Society and Space* 31:779–795.

ANNEXURE A

PERI-URBAN FRAMEWORK

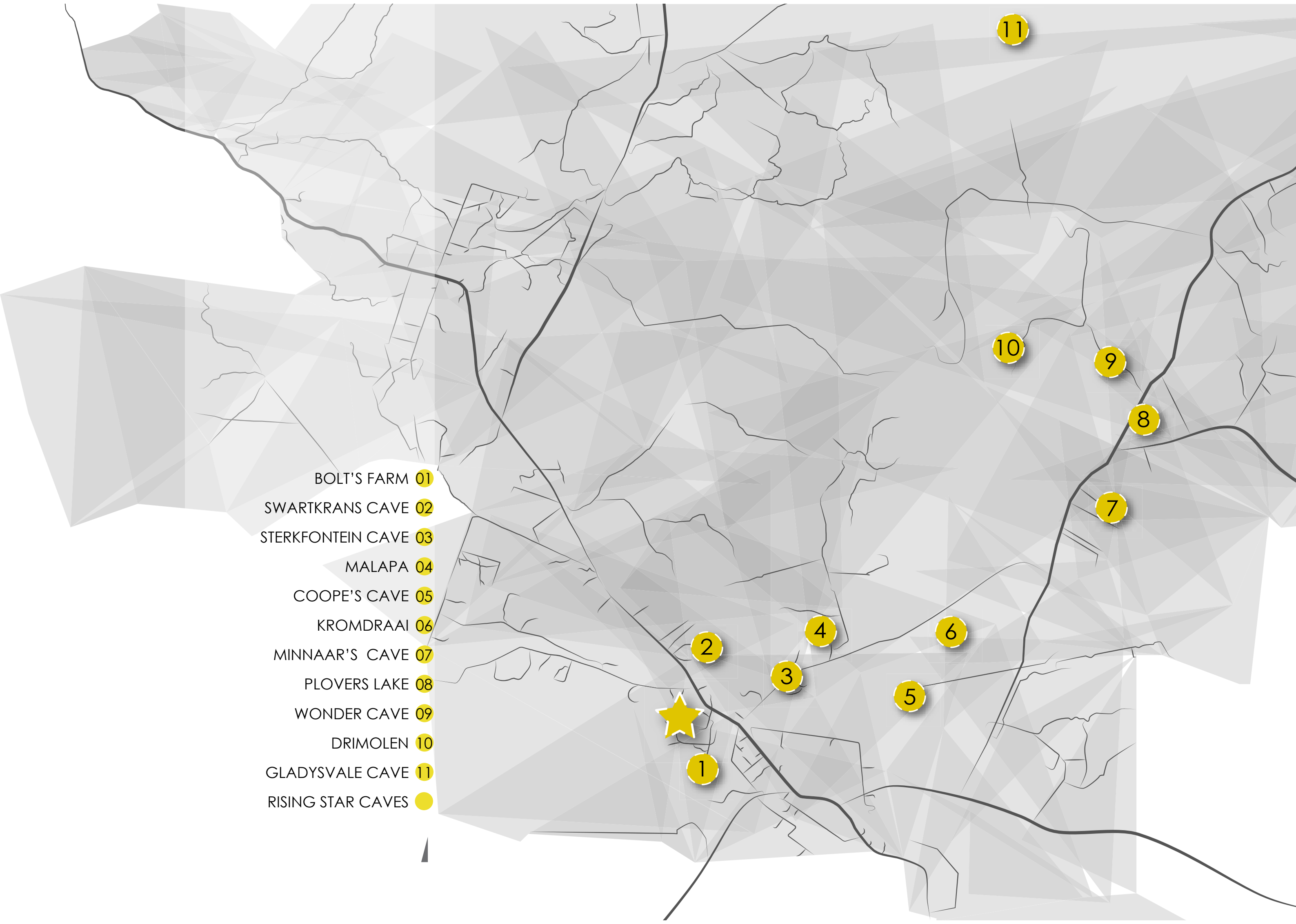


FIGURE AA.1
CRADLE OF HUMANKIND
FOSSIL FINDS
(Author , 2016)

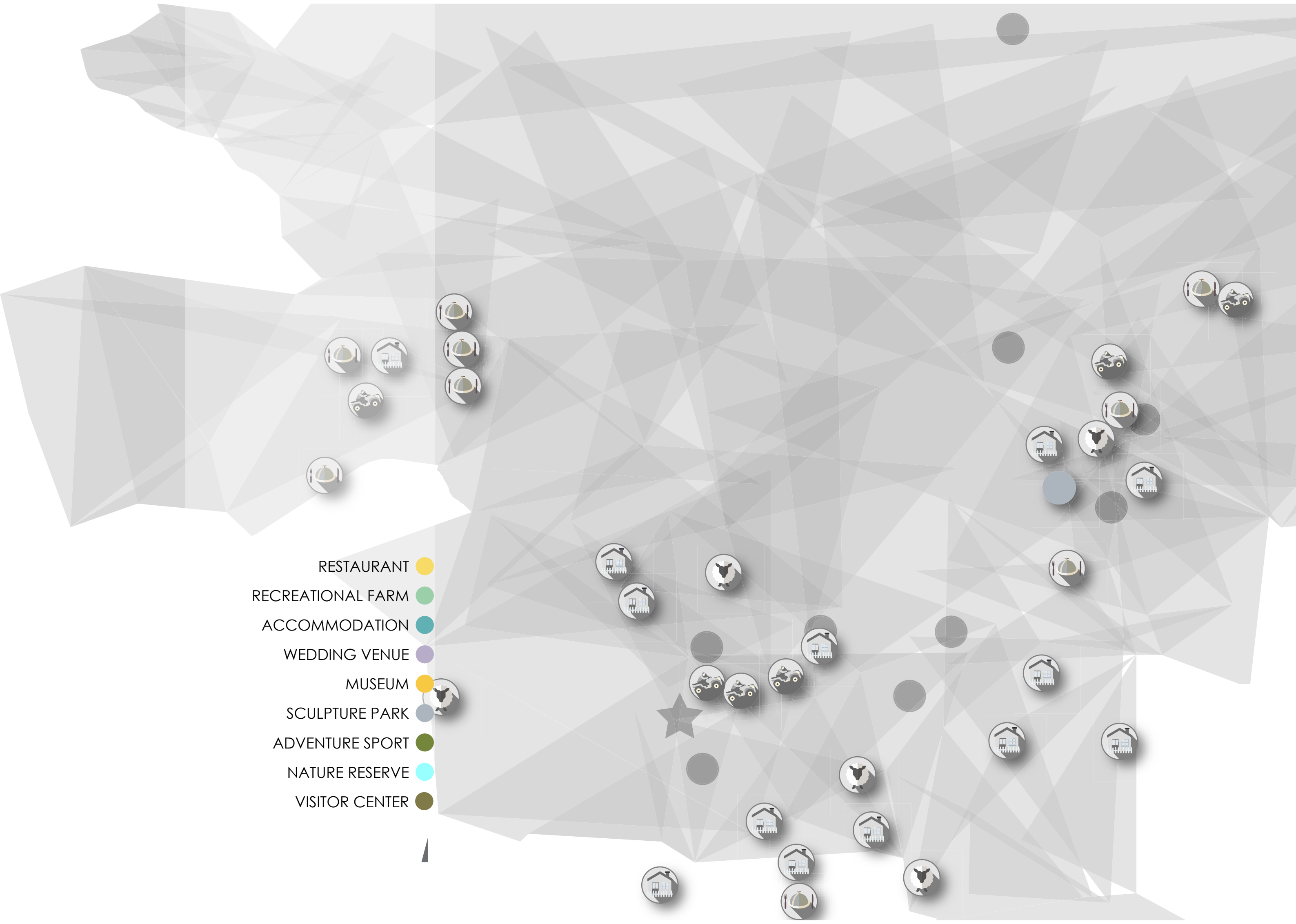
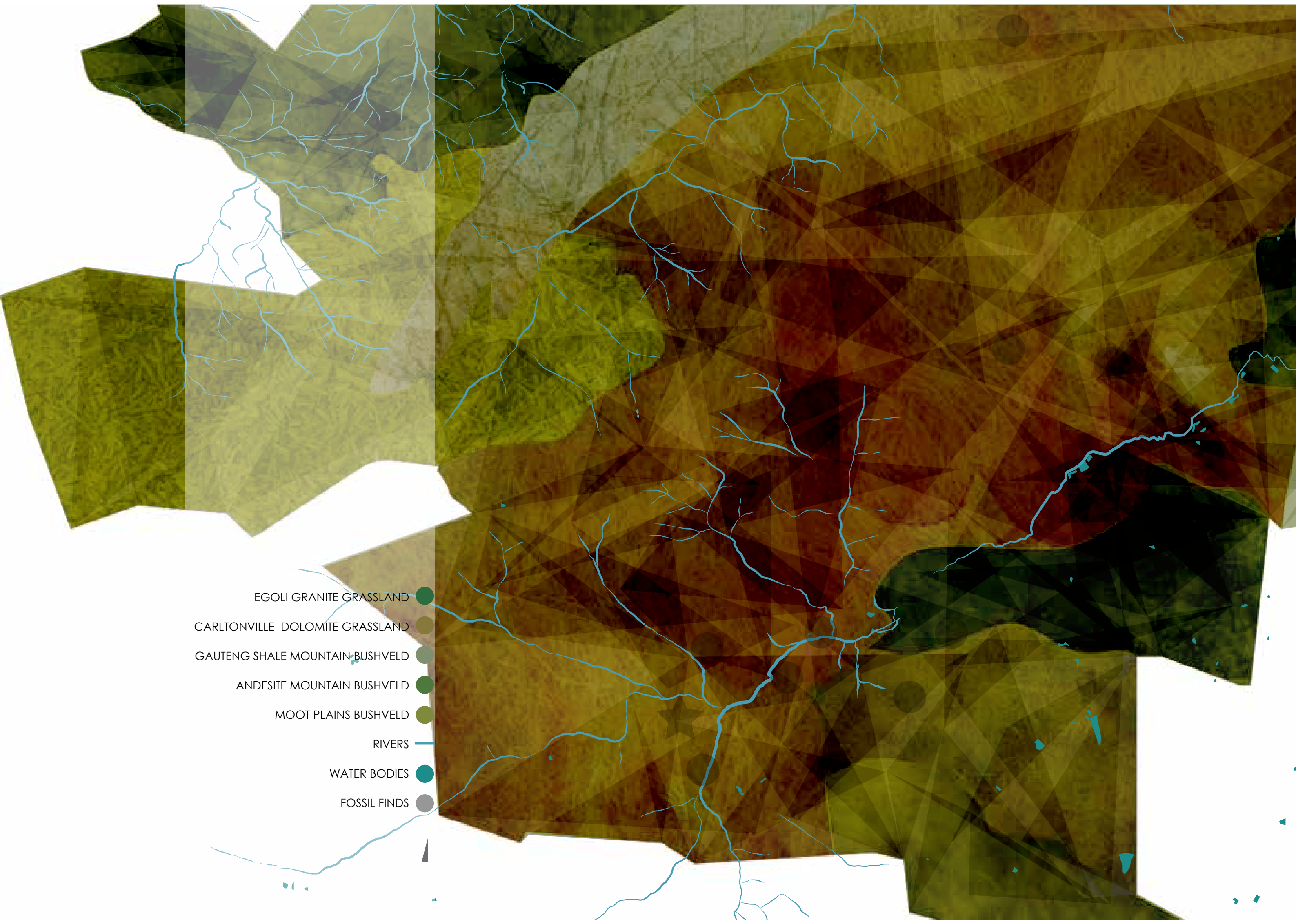


FIGURE AA.2
CRADLE OF HUMANKIND
TOURSIT ATTRACTIONS
(Author , 2016)

FIGURE AA.3
CRADLE OF HUMANKIND
RIVERS & WATER BODIES
(Eloff 2010:19)



▲
FIGURE AA.4
CRADLE OF HUMANKIND
VEGETATION
(Eloff 2010:19)

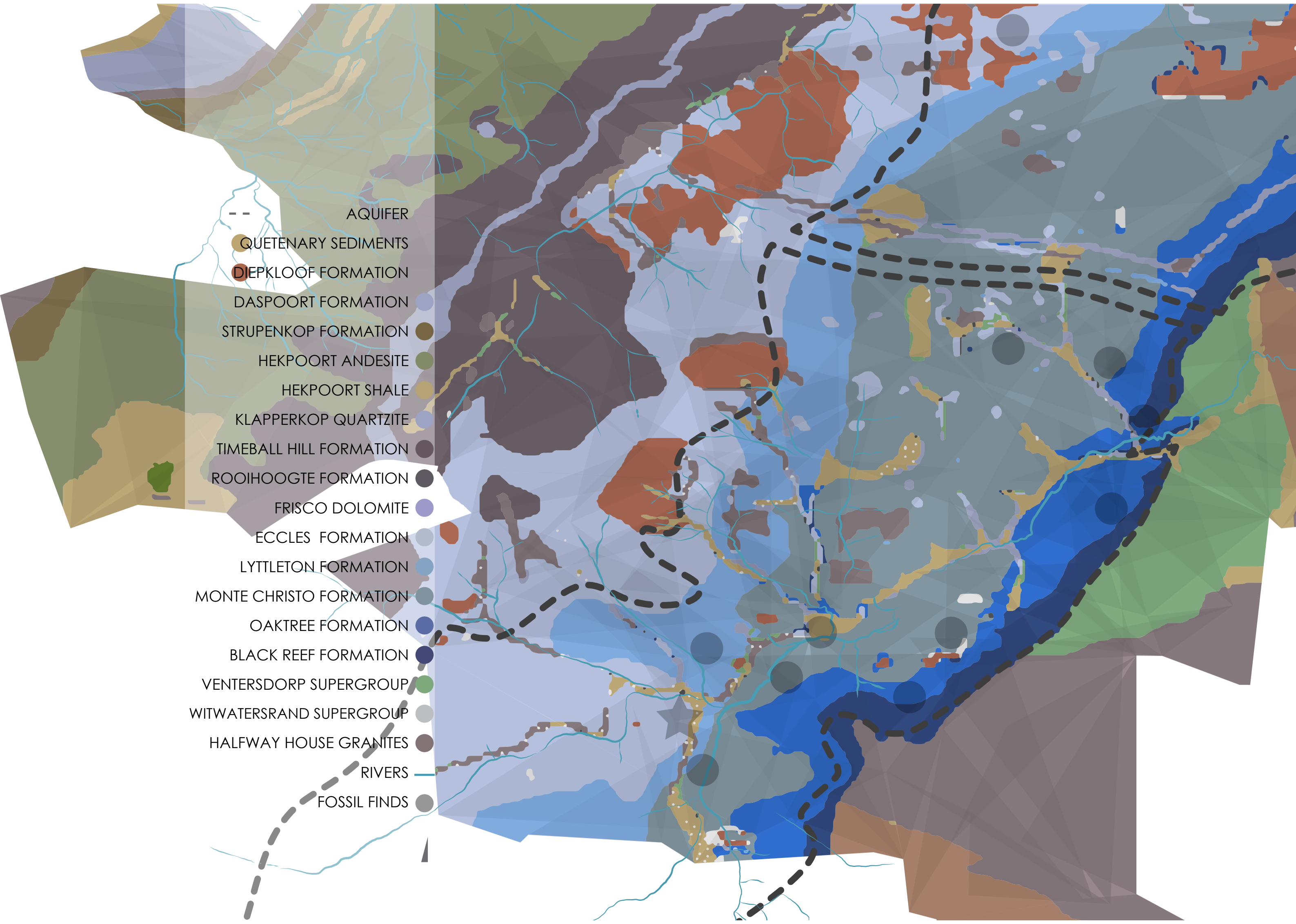


FIGURE AA.5
CRADLE OF HUMANKIND
GEOLOGY
(Leyland 2008:67)

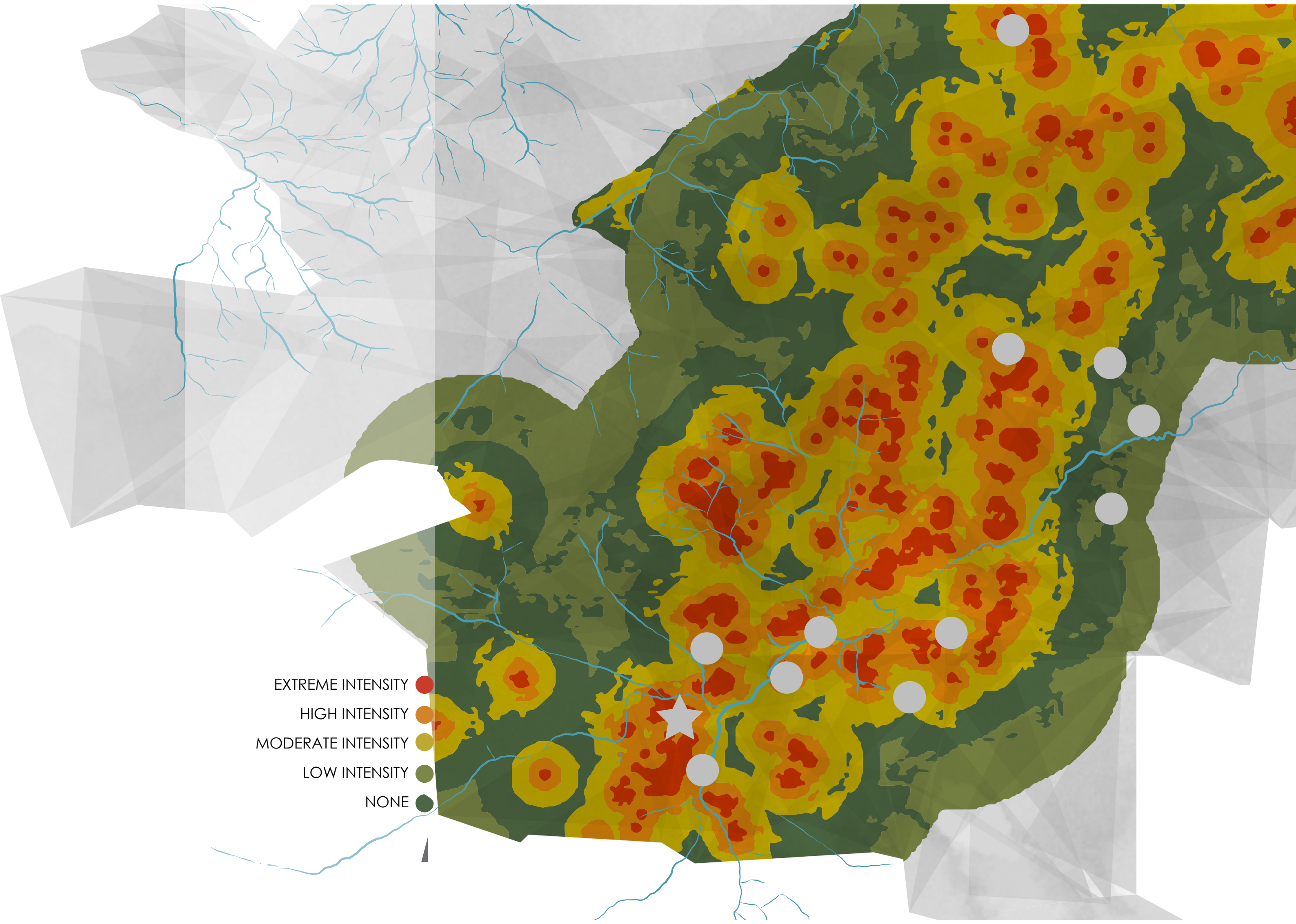


FIGURE AA.6
CRADLE OF HUMANKIND CONCENTRATION OF SURFACE WATER FLOW
(Eloff 2010:19)

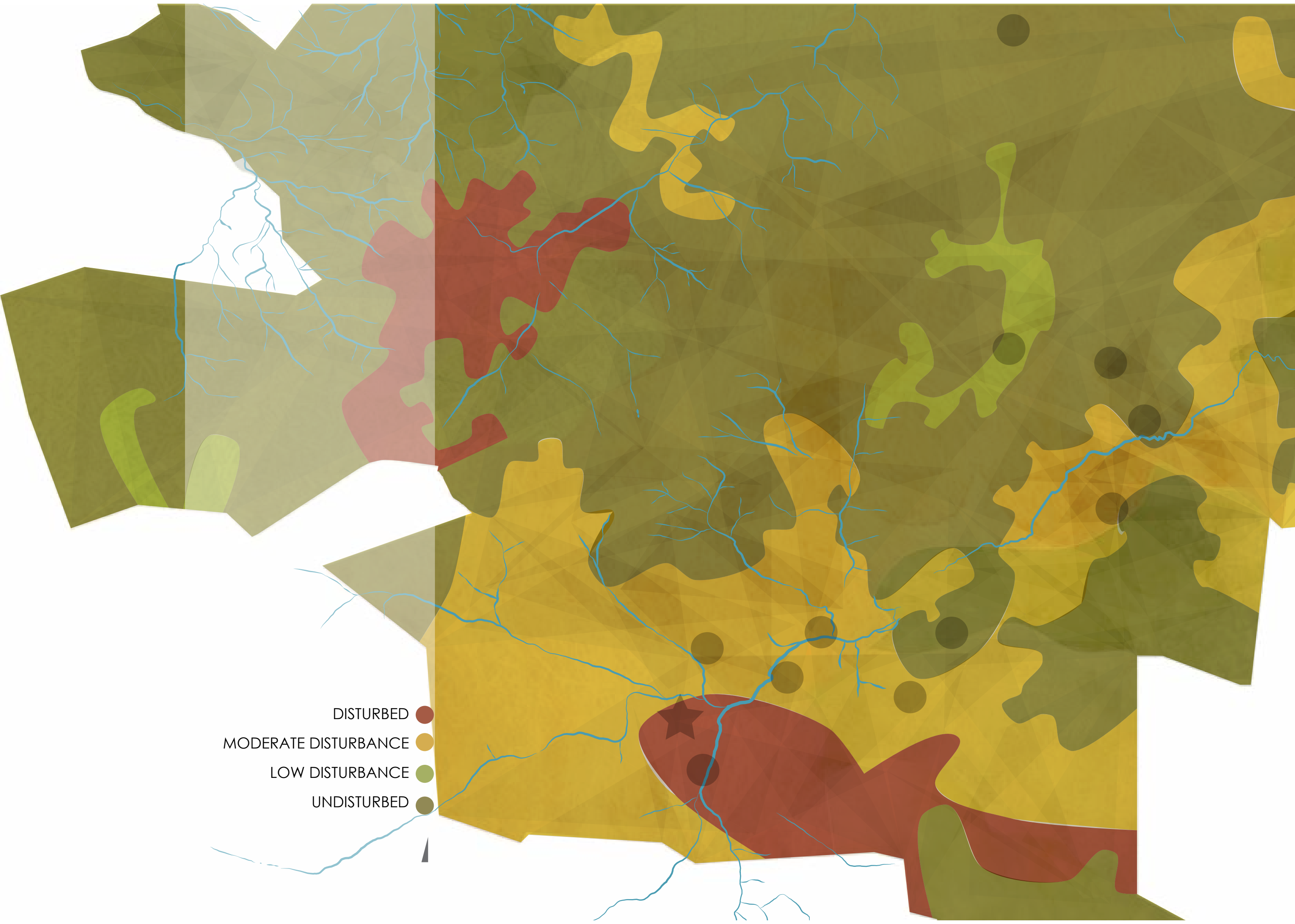


FIGURE AA.7
CRADLE OF HUMANKIND
ENVIRONMENTAL INTEGRITY
(Eloff 2010:19)

▲
FIGURE AA.8
CRADLE OF HUMANKIND
ACCESS ROUTES
(Eloff 2010:19)

ANNEXURE B

PRESSURES & RISKS TO BOLT'S FARM

TABLE 1: MANAGEMENT AND MONITORING TASK FOR BOLT'S FARM FOSSIL SITE

ISSUES	THREATS OR RISKS	DESIRED OUTCOMES	MANAGEMENT MEAUSURES	PRIORITY
Surface environment				
Access- legal access to property	• Pedestrian access is a sensitive issue	Maintenance of cordial relations with landowners regarding access		Necessary
Unauthorised access	• Removal of rock, fossils and artefacts • Removal of edible and medicinal plants • Theft of moveable property (when researchers are working on site)	Access to fossil sites controlled	• Landowner to maintain surveil-lance • Researchers and field staff to main-tain surveillance	Desirable
Rangeland condition	• Deterioration of rangeland due to overstock-ing, overgraz-ing or too frequent fires	Rangeland in op-timum condition	• GDACE can advise • Plan for acquiring baseline data against can be assessed • Plant species list required noting edible, medicinal, toxic and econom-ically significant species	Desirable

Retention of topsoil, surface drainage, surface erosion	• Loss and dispersal of topsoil makes revegetation difficult	Fossil site free of erosion	• Check all tracks and pathways for erosion • Check for surface drainage and distribution of runoff over surface • Implement erosion control as suggested in general management plan operation guidelines	Necessary
Fire Management	• Too frequent fires have a negative effect on vegetation • Blackened areas are unsightly • Fire is a threat to moveable property	Proper fire regime for Bakenveld maintained, site free from fire hazards	• Implement a fire management policy which includes firebreaks • Record fire frequency and intensity • Take precautionary measures to contain domestic fires started on site • Brief residents on what to do in such a situation • Ensure that suitable beaters for research staff and farm workers are available	Desirable

Red data species, rare and economically significant plants	• Loss of edible and medicinal plants, and botanical information • Many important plant species are not on RED DATA list	Preservation of biodiversity	• Surveillance of indigenous plant use • Drawn up a species list of medicinal, poisonous, edible and economically significant species • Map occurrence and preferred microhabitats • Monitor collection and utilization	Desirable
Invasive alien plant species	• Invasion of avens and other habitats by alien species • Loss of biodiversity • Unattractive landscape • Inaccessible breccias • Obscures deposits and makes them difficult to access	Fossil site free of invasive alien species	• Make a list of all invasive plant species • Map and prioritise infestations • Determine best eradication or control programme • Implement control and clearance programme	Desirable
Weeds and shrub growth in excavation site	• Roots destabilise breccias in time • Plants reduce visibility of noteworthy sections	Weed-free fossil site	• Pull weeds by hand, or "skoffel" • Destroy in a manner that does not spread seed further	Desirable
Development in "viewshed"	• Negative visual impact	Preservation of sense of place and natural qualities of viewshed	• COH WHS to monitor all new development plans	Desirable
Habitat protection: removal of stromatolites	• Loss of heritage material and site significance • Loss of micro-habitats	Preservation of Pelindaba stone, stromatolites and associated microhabitats	• Landowner, research scientists and field staff to maintain surveillance • Heritage monitors to be alerted	Desirable

Subterranean Environment				
Presence of breeding colonies of bats	• Loss of colony- sensitive to human interference • Species involved (miniopteris natalensis) is declining in numbers	Preservation of breeding colonies of Miniopteris natalensis	• Take care when extending excavations into cave and aven entrances to underground systems • Ensure that excavations only takes place when risk of disturbing breeding season is low • Ensure that bats have free access into and out of caves and avens	Future concern
Porcupine lairs and owl roosts	• Disturbance and displacement of animals • Porcupine lairs and owl roosts are important as modern analogues for taphonomic processes of the past	Preservation of porcupine lairs and owl roosts of actualistic studies	• Protect any porcupine lairs and roosts on site • Encourage that their behaviour and lair contents are studies without disturbing animals	Desirable
Infrastructure				
Ablutions	• Lack of ablutions is problematic to research scientists	Site free from pollution	• VIP or Environloo to be installed in time • Management is required to ensure that this would not burn down in frequent fires	Necessary

Waste management and disposal	• Litter • Cattle and wild animals die from ingesting plastic bags	Site free from litter	• Provide litter bins or holders • Collect and remove all litter regularly • Best practice would require sorting and recycling litter	Necessary
Signage adequacy	• Poor tourist/ visitor experience if site adequately interpreted	Appropriate site interpretative signage	• Site not open to general public at current time, specialist tour operator and permitted scientist provide site interpretation	Future concern
Visitor impacts	• Littering • Pollution • Erosion of pathways • Disturbance of excavations • Theft of fossils • Graffiti	Mitigation or elimination of visitor impacts (future)	• Potential impacts not present at current time	Future concern
Infrastructure: water	• All has to be carried by hand • Inadequate water supply inhibits excavation • Water needed for drinking and ablutions • Water needed to control dust	Provision of sufficient water to enable research	• It is extremely difficult to solve the water problem on site	Necessary

(Gauteng Provincial Government n.d)

TABLE 2: IDENTIFIED HAZARDS A& ASSOCIATED WEIGHTING VALUES FOR THE COH WHS

NO.	HAZARD DISCRIPTION	WEIGHTING VALUE
1.1.2	Urbanization without sewer systems	70
1.1.3a	Detached houses without sewer systems	45
1.1.3b	Semi-informal housing	55
1.1.3c	Informal housing	60
1.1.4	Septic tank, cesspool, latrine	45
1.3.6a	Petrol station	60
1.3.6b	Car workshops	50
1.4.1	Road, unsecured	40
1.4.4	Car parking area (incl. boat, and airplane storage)	35
1.4.9	Runway	35
1.5.1	Tourist urbanization	30
1.6.4	Transformer station (incl. cell towers)	30
2.2.3	Quarry	25
2.4.7	Rubber & tyre industry (& asphalt plants)	65
2.4.11	Light industries	40
3.1.1	Animal barn (shed, cote, sty)	30
3.1.2	Feedlot	30
3.1.3	Factory farm	30
3.1.4	Manure heap	45
3.2.1	Open silage	25
3.2.2	Closed silage	20
3.2.3	Stockpiles of fertilisers & pesticides	40

(Hobbs 2011:182

ANNEXURE C

FLORA OF THE CRADLE OF HUMANKIND

TABLE 1: FLORA IDENTIFIED ON BOLT'S FARM

NAME	STATUS	EDIBLE/MEDICINAL
Pineapple Flower *(Eucomis autumnalis)*	Not Evaluated	Medicinal
Botterblom *(Gazania krebsiana)*	Least Concern	Edible & medicinal
Wild Hibiscus *(Hibiscus microcarpus)*	Least Concern	Edible & medicinal
Bitterwortel *(Pachycarpus schinzianus)*	Least Concern	Edible & medicinal
Bobbejaanuintjie *(Babiana hypogea)*	Near Threatened	none
Platvoetaasblom *(Brachystelma barberiae)*	Least Concern	Edible & medicinal
Birdcage Flower *(Brachystelma circinatum)*	Least concern	Edible
Wild Sweetpea *(Sphenostylis angustifolia)*	Least concern	none
Patrysuintjie *(Gladeolus permeabilis)*	Least concern	Edible bulbs
Swartteebossie *(Gerbera piloselloides)*	Least concern	none
Slymuintjie *(Albuca setosa)*	Least concern	Medicinal
Rooi-opslag *(Hermannia depressa)*	Least concern	Medicinal
Bloutulp *(Moraea thomsonii)*	Least concern	none