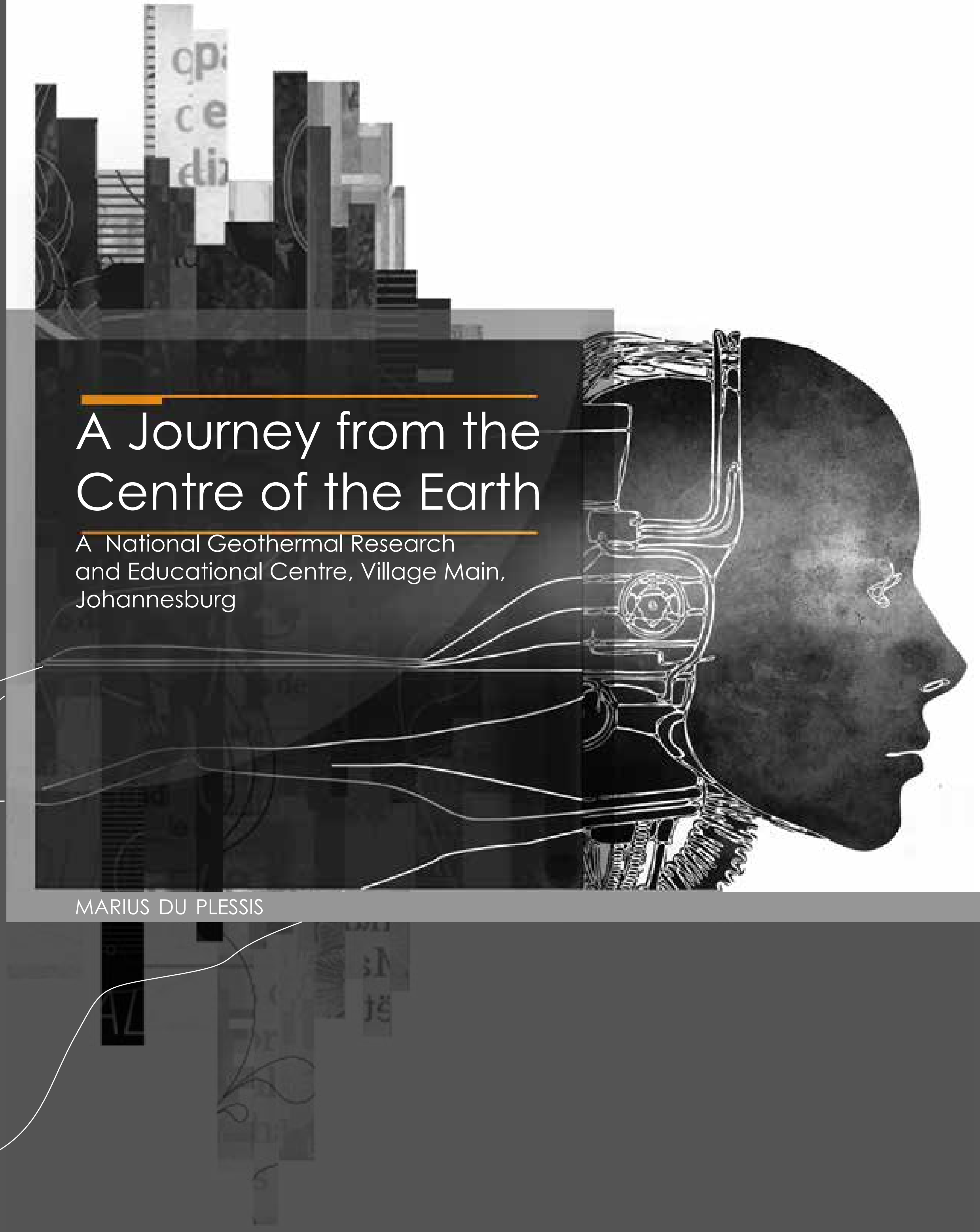

A Journey from the Centre of the Earth

A National Geothermal Research and Educational Centre, Village Main, Johannesburg

MARIUS DU PLESSIS

A Journey from the Centre of the Earth

A National Geothermal Research and Educational Centre, Village Main, Johannesburg

The thesis is submitted in partial fulfilment of the requirements for the degree Master in Architecture (Professional).

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Declaration of original authorship:
This dissertation is submitted in partial fulfillment of the requirements for the degree Magister in Architecture (Professional) at the University of the Free State. Unless stated otherwise the research in this document is entirely the author's work.

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Abstract

This thesis aims to answer the following question: "How can development be seen as true progress if something is damaged in the process?" But in order to do so, the following questions must also be answered:

- What is development?
- What is environment?

Development can be described as our attempt to improve our surroundings within our habitation and the environment in which we live. If we want to improve the place where we live, then development and environment should not be separated. Development should occur in such a way that the needs of contemporary society are met without denying the same for future generations. By definition conservation implies preserving something for the future. Geothermal energy can contribute by protecting our environment from drastic changes in order to save the depleting resources for our future generations.

Geothermal energy is thermal energy generated and stored in the earth. The word geothermal originates from the Greek words geo, which means earth, and therme, meaning heat (Energy4me, 2014: online). The earth's heat can be attributed to friction caused by colliding plates or fluid magma to some degree, but the vast majority of heat is caused by radioactive decay (Ochse, 2013).

Strictly speaking, geothermal energy is not renewable as we cannot make new energy sources to replace it, but it is however essentially inexhaustible and the correct term should actually be a persistent energy source (du Plessis, 2014). It can be considered renewable though, because it does not prey on fossil fuel reserves such as coal, oil and gas do. Unlike the burning of fossil fuels, the process emits no greenhouse gases or pollution. The recovery of high-enthalpy reservoirs can be achieved while hot fluid or heat is extracted from the same site. Generally the environmental impacts of geothermal power generation are minor, controllable and renewable. The closed loop circulation of fluids is not environmentally harmful. It is sustainable, because geothermal energy is made by the nuclear reactions taking place deep inside the earth. This causes heat energy in the core of the earth and the heat moves around inside the earth through convection.

Sustainability is a journey and a process that cannot be achieved within a short period of time. It is a way of life, a way of being and a way of constantly becoming – a path of continual improvement.

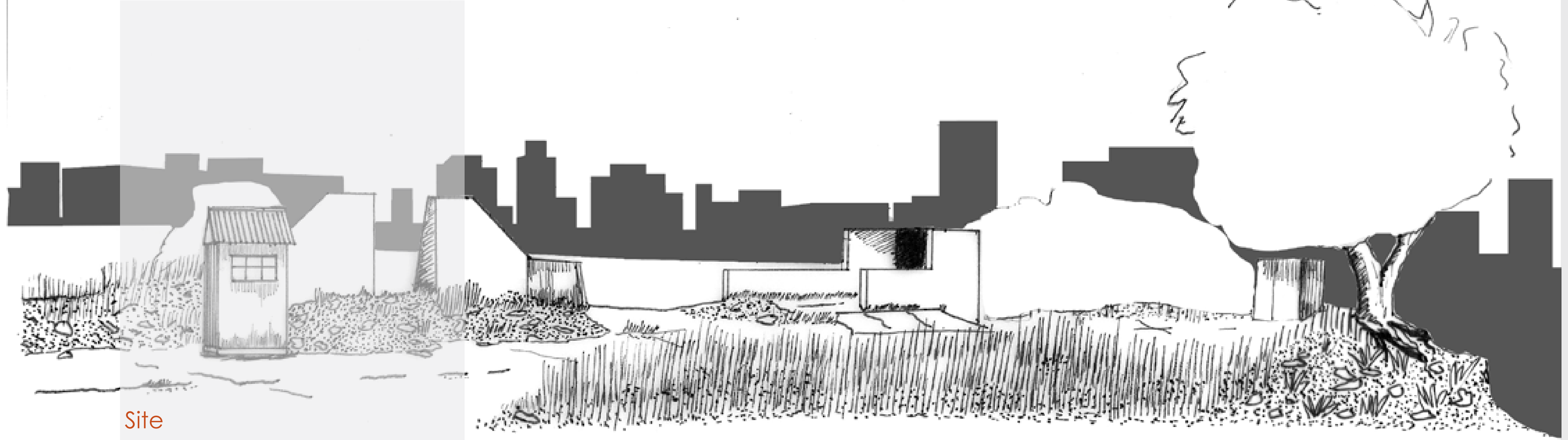
This thesis seizes the opportunity to explore the potential of the geothermal energy to be extracted from an abandoned Witwatersrand mine and to discover a path that leads to the fulfilment of a unique situation – to be respectful of the building site, harmonious with the natural environment, and responsive and sensitive to the program in such a way that the design turns out to be a powerful agent for change.

Storyline

A Journey from the Centre of the Earth

REBIRTH AND MOVEMENT:

VIA AN ARCHITECTURAL JOURNEY OF RECYCLING SPACE AND UTILISING INFINITE ENERGY IN A SUSTAINABLE WAY …

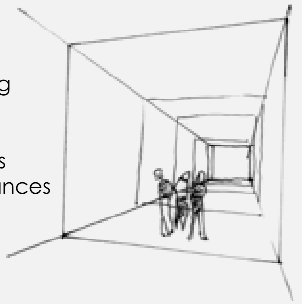


Site

Abandoned mine near CBD of Johannesburg

Exploring the journey through

Geometry
Movement through building
Entrance
Openings
Served and Servant Spaces
Viewed from different distances
Materials and Texture
Light



Precedents

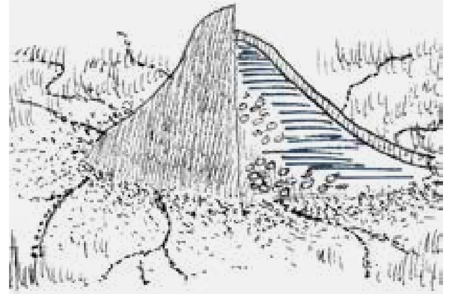
C-Mine Expeditie (NU architectuuratelier)
La Tourette (Le Corbusier)
T Bailey Office (Tom Kundig)
Castelvecchio (Carlo Scarpa)
Apartheid museum (Mashabane Rose Architects I GAPP Architects and Urban Designers et al.)

Problem statement

This project takes the reader on a journey of discovering energy conversion along a path that will lead to sustainability and at the same time it also comments on rehabilitating one of the many abandoned mines in South Africa.

Concept

Sustainable journey of an ant



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(Artunite.com, 2014)

Proposed Project Parameters & Design Challenges

01

1.1 Preface

The energy crisis and the drive for renewable-energy sources lead to the possibility of generating energy from heat that is readily available from the earth. This crisis calls for a national geothermal research and educational centre. This geothermal research centre focuses on research into geothermal systems with ground source heat pumps within a high performance thermal earth crust envelope for constant heating and cooling purposes. Given the nature of such a research centre, it inevitably becomes a comment on alternative sustainable energy sources.

The research centre would investigate using the heat of the earth as the central theme along with a sensitive and strategic approach to regenerate and rehabilitate an abandoned mine site within the city of Johannesburg.

The very visible site between an industrial area and the CBD of Johannesburg asks for flexibility in design. A delicate balance must be created between sustainability, technology, science, rehabilitation and education. Usability in the community will be increased by close proximity to the Johannesburg Fresh Produce Market – the largest in the Africa - which needs cooling and heating systems.

As a geothermal research and educational centre, the future users of the building and the society at large will have to be taken into consideration. Not only must attention be paid to the human interaction within the building and the interaction of man with the urban environment, but a focus on sustainability and an in-depth knowledge of the scientific operations of geothermal research are also necessary. Although geothermal sources are nothing new world wide, it is a new and underutilised idea in South Africa.

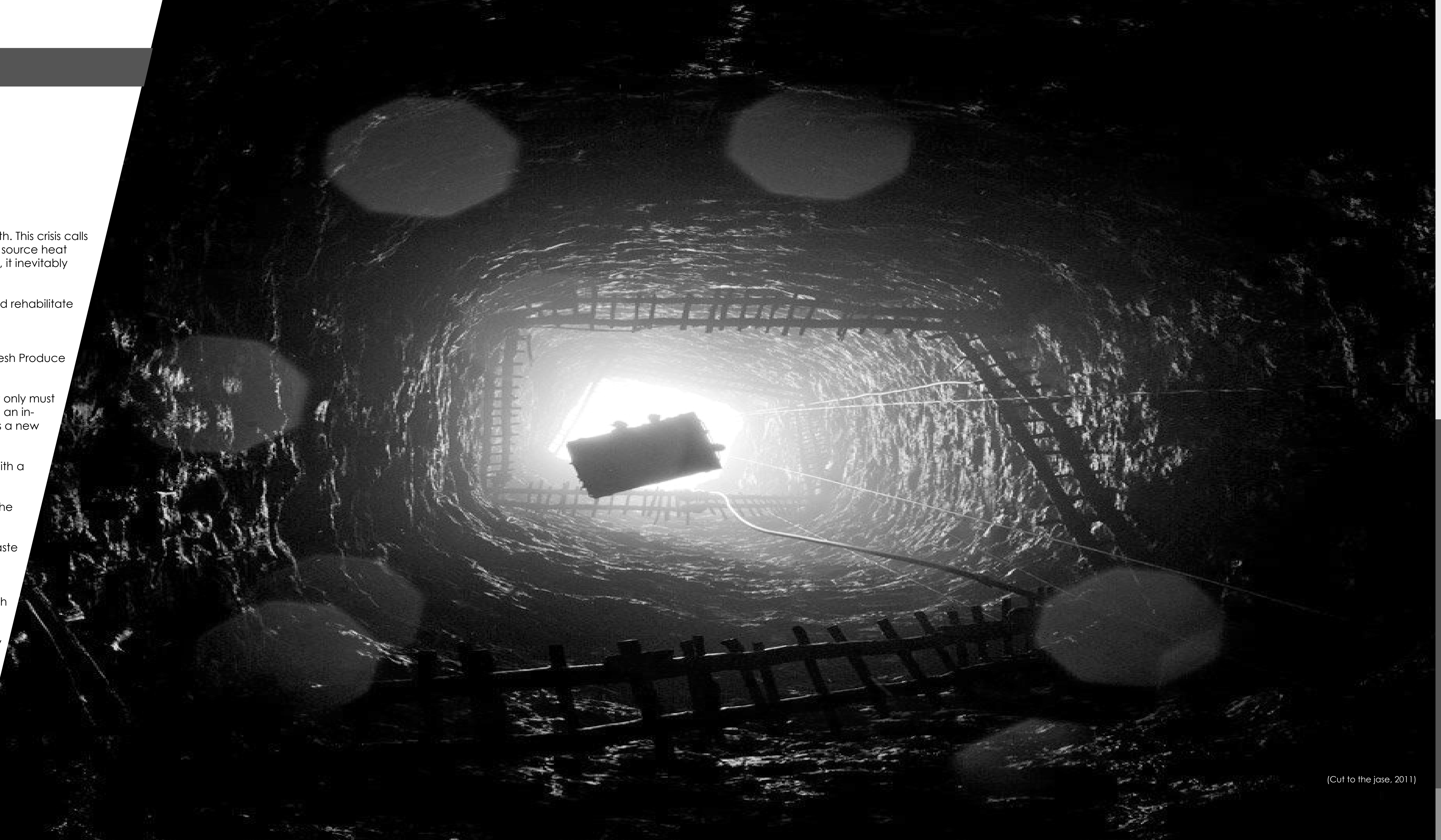
The companies listed below have been identified as possible clients. Each client has a different need and the building design addresses these needs. With a joint venture of expertise, the first geothermal research centre can be developed in South Africa.

- Village Main - The owner of the abandoned mine will not only provide financial assistance to the project, but will assist with the necessary plans of the mine. Village Main will also be responsible for future maintenance of the site and access control.

- HRP Geothermal Power - A company focused on providing solutions to generate electricity, using either geothermal energy as a heat source or waste heat recovery from industrial processes. HRP is able to contract in as a specialist service or technology provider as part of a larger project. Once a project is completed, HRP will be able to ensure the continued operation of the installed plant under certain agreements.

- Wits Mining Research Institute – This institute will expand mining research from the centre, ranging from geology, energy and technical studies, which include the social and health impacts of mining and land rehabilitation, to community development and labour issues.

- Johannesburg Fresh Produce Market – The Market is always in need of extended cooling facilities to fulfil its mission of providing a world-class facility and service to the fresh produce industry. They will provide on-going technical assistance and maintenance.



(Cut to the jase, 2011)

1.2 Aim

This project has the ability to engage in the search for a way to use energy in a sustainable way, by:

- Creating a Geothermal Energy Plant – a research, information and educational centre to comment on sustainable energy practices.
- Generating energy for using in heating and cooling purposes for Johannesburg Fresh Produce Market.
- Rehabilitating an abandoned mine and, in so doing, transforming a void into a place.
- Granting consideration to the practical implications of the design of the research centre regarding the layout of the machinery and accommodation for all its clients.
- Using architecture to invite the public to become more knowledgeable about sustainable energy. Its architecture contributes to how a building shapes human experience and the impacts architecture has on our inherent sense of place.

1.3 Methodology

The following methods have been used in conducting the research for this thesis:

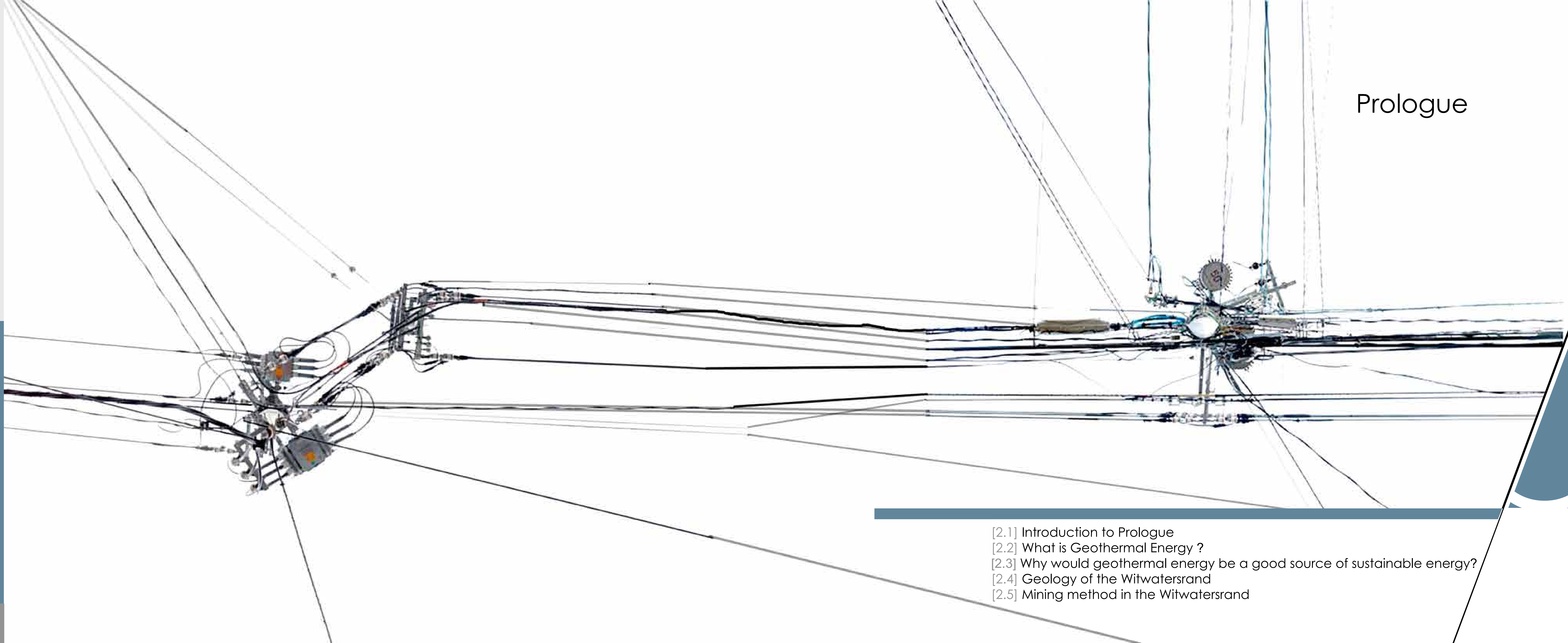
- Literature studies.
- Interviews with mine engineers, geologists, engineers of HRP Geothermal Power, and the technical department of the Johannesburg Fresh Produce Market.
- An interview with thermal engineers from Protherm Systems.
- Visits to the mine planning office in Johannesburg.
- Correspondence with Village Main.
- A visit to Hotel Verde in Cape Town.
- Visits to the site.

By using the above-mentioned, the author gained knowledge on the following aspects which have an impact on the project:

- How geothermal energy can be utilised in South Africa.
- The financial benefit and impact of geothermal energy on the economy.
- The sustainability and environmental effects of geothermal energy usage.

Through the information the author will then:

- incorporate different clients, their interests and aims in the project;
- interpret the character of the surrounding area and the specific site;
- determine how architecture can –
    - o revive history to be part of the future;
    - o transform a void into a place;
- compare these ideas with precedents; and
- conceptualise a unique design that unites the existing abandoned mining infrastructure with future users of the building, the society and the environment.



Prologue

02

This chapter is a study of the operational system of a geothermal plant. An inside-outside design method was followed so that space utilisation can be linked to the functionality of a geothermal plant and how the occupants of the building utilise its space. Being the first geothermal research centre in South Africa, all three systems used to extract geothermal energy from the earth's crust should be explored.

2.1 Introduction to Prologue

Introduction to Prologue

The geology of the Witwatersrand mine reef and the mining method in the Witwatersrand have an influence on the building of a geothermal plant. One way of making use of low-intensity geothermal energy is to convert mine shafts into geothermal boilers, which could provide heating and cooling, as well as hot water. Two Spanish engineers, Rafael Rodriguez and Maria Belarmina Diaz, are of the opinion that when a mine is still active one can access the tunnels easily in order to gather data about ventilation and the properties of the rocks, as well as take samples and design better circuits (The Green Optimistic, 2009: online). This is a very interesting point that can be explored in South Africa. According to the article "Depth of the Deepest Mine", the deepest mine in the Witwatersrand region is currently the Western Deep Mine with a network of tunnels which penetrates 3.5km into the crust of the earth (Cavalier, 2003: online). Although there are no rifts in the tectonic plates in South Africa, the country has enough deep-level mines and hot rocks to generate geothermal energy - even if drilling needs to be to a depth of 6000m, we are halfway there (Smit, 2014: online).

Exploration of geology and the mining method has a direct impact on the design of the geothermal plant. There is work to be done underground on pipes and reservoirs; therefore the geology of the area is an important consideration from a practical point of view. The industrial construction with its coarse textures, tunnels, underground operations, and the operation of the shaft play an important role in telling an architectural story of industrial development.

2.2 What is Geothermal Energy?

What is Geothermal Energy?

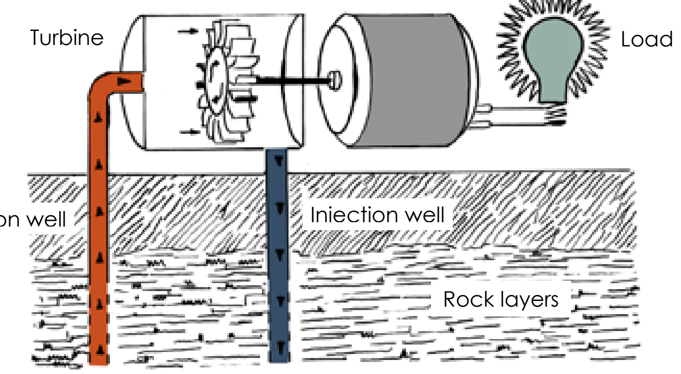
Geothermal energy has been used for bathing in hot springs since Paleolithic times and the ancient Romans used it for space heating (Cataldi, 1992). In 2012 24 countries made use of 11 400 megawatts of geothermal power (BP, 2014: online). In comparison, Eskom generates 40 000 megawatts of power (Gross, 2012) and the world total generation is 20 000 terawatts (International Energy Agency, 2012). Geothermal power is thus in its infancy, however the amount of heat within 10 000 meters of the surface of the earth contains 50 000 times more energy than all the oil and natural gas resources in the world (BP, 2014: online).

Historically the use of geothermal energy has been limited to areas near tectonic plate boundaries, but with recent technological developments drastic expansion is experienced in the scope and size of viable resources – especially for applications such as heating and cooling, where a potential for widespread exploitation has been identified.

There are three designs for geothermal power plants relating to the accessibility of natural steam, natural warm water in a well, or water artificially channelled through a geothermal system in a well. Steam, the gaseous phase of water, can be used directly as a vapour denominated system (also called a dry steam system). Hot water of a high enough temperature can be utilised through a liquid-dominated flash system. Alternatively, water is required to be channelled through a heat exchanger, called an enhanced geothermal system (also called hot dry rock geothermal energy or a binary system). The choice of which design to use is determined by the resource (Union of Concerned Scientists, 2009: online).

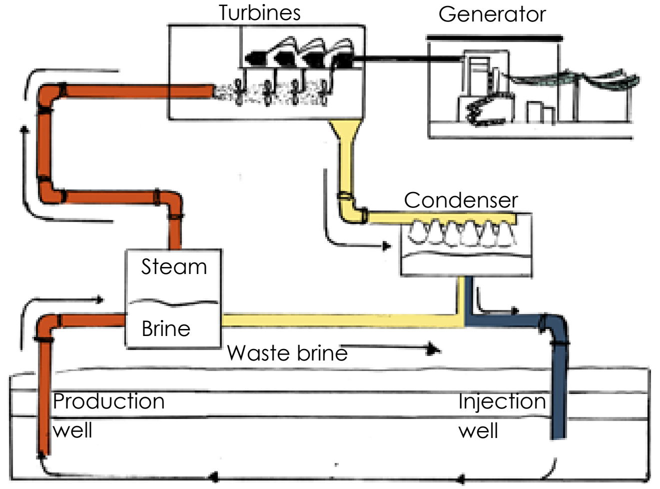
1. Dry Steam

In the vapour-dominated design the steam goes directly through the turbine and then into a condenser where the steam is condensed into water. Larderello, situated in Tuscany in central Italy is vapour-dominated. The Geysers, the largest geothermal field in the world in the Mayacamas Mountains ±116km north of San Francisco, contains a complex of 22 geothermal power plants and is also vapour-dominated. Vapour-dominated sites offer temperatures from 200-300°C that produce superheated steam. The plants at The Geysers use an evaporative water-cooling process to create a vacuum that pulls the steam through the turbine, producing power more efficiently. But this process loses 60 to 80 percent of the steam to the air, without re-injecting it underground (Union of Concerned Scientists, 2009: online).



2. Flash Steam

In a second method very hot water is depressurised or "flashed" into steam which can then be used to drive the turbine. Liquid-dominated reservoirs are more common with temperatures greater than 250°C. They are found near volcanoes surrounding the Pacific Ocean and in rift zones and hot spots. The largest liquid system is Cerro Prieto in Mexico, which generates 750 MW electricity from temperatures reaching 350°C. Flash plants are the most common way to generate electricity from liquid-dominated sources. Pumps are generally not required in high temperatures reaching 350°C. Instead it is powered when the water turns to steam. With lower temperatures the hot water is pumped under great pressure to the surface. When it reaches the surface the pressure is reduced and as a result some of the water changes to steam. This produces 'blasts' of steam. The cooled water is returned to the reservoir to be heated by geothermal rocks again (Union of Concerned Scientists, 2009: online).



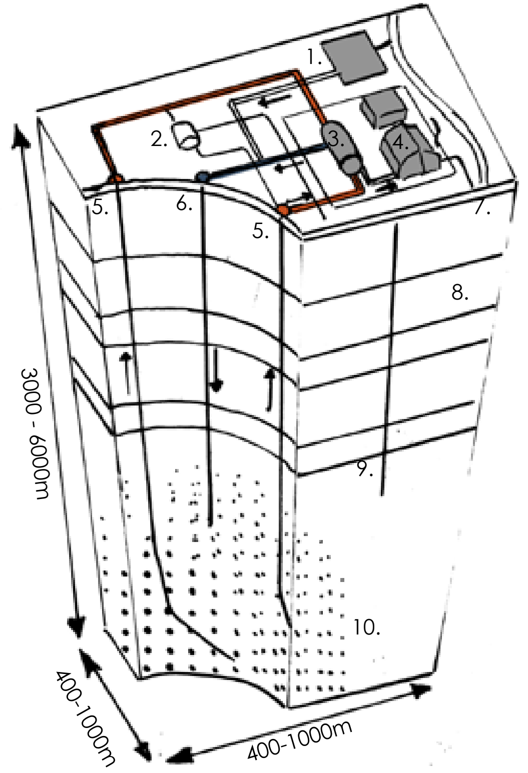
3. Binary cycle

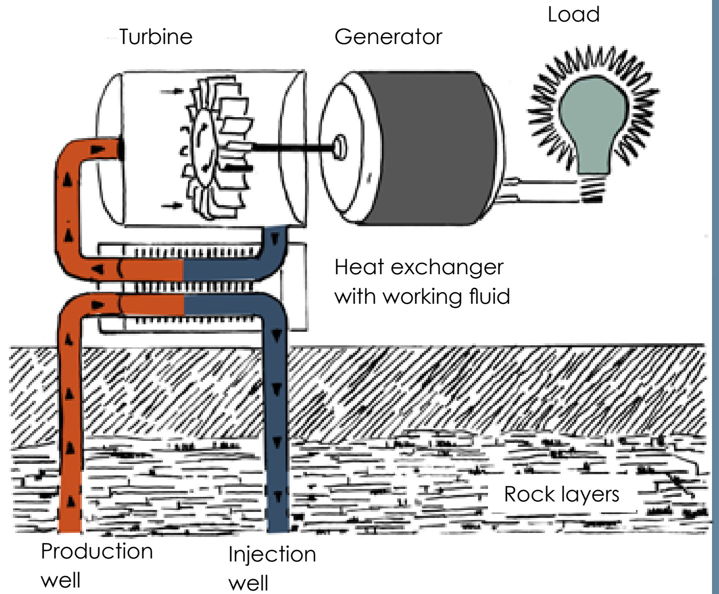
The third technique is very useful where more demanding electricity applications are found. Here the greatest benefit comes from a high natural heat flux, ideally from using a hot spring. The next best option is to drill a well into a hot aquifer. If no aquifer is available, an artificial one may be built by injecting water to hydraulically fracture the bedrock. This is called an enhanced geothermal system, hot dry rock geothermal energy or binary system. With this third system, water is injected under high pressure to expand existing cracks in rocks to enable the water to freely flow in and out. This technique was adapted from oil and gas extraction techniques. With enhanced geothermal systems the geologic formations are deeper. Different from hydraulic fracturing, no toxic chemicals are used, reducing the possibility of environmental damage. Directional drilling can also expand the size of the reservoir. Enhanced geothermal systems have been used in Insheim in Germany and at Soultz-sous-Forêts in France. Much greater potential may be available from this approach than from conventional tapping of natural aquifers (Union of Concerned Scientists, 2009: online).

In the third approach the hot water is passed through a heat exchanger, where a second liquid can be heated in a closed loop system – such as isobutene. The latter boils at a lower temperature than water, so it is more easily converted into steam to run the turbine. One cause for careful consideration with Enhanced Geothermal Systems is the possibility of induced seismic activity that might occur as a result of hot dry rock drilling and development. This risk is similar to that associated with hydraulic fracturing, although at a much smaller scale, because the bore-hole is stationary (Union of Concerned Scientists, 2009: online).

Sources with temperatures from 30-150°C are used without conversion to generate electricity for using as heating at greenhouses, fisheries, mineral recovery, industrial process heating, and bathing. Hotel Verde in Cape Town and My Pond Hotel in Port Alfred use the constant underground temperature of 19°C for cooling purposes and overall air-conditioning. Heat pumps extract energy from these shallow sources (Harms, 2013).

1. Reservoir
2. Pump house
3. Heat exchanger
4. Turbine hall
5. Production well
6. Injection well
7. Hot water to district heating
8. Porous sediments
9. Observation well
10. Crystalline bedrock



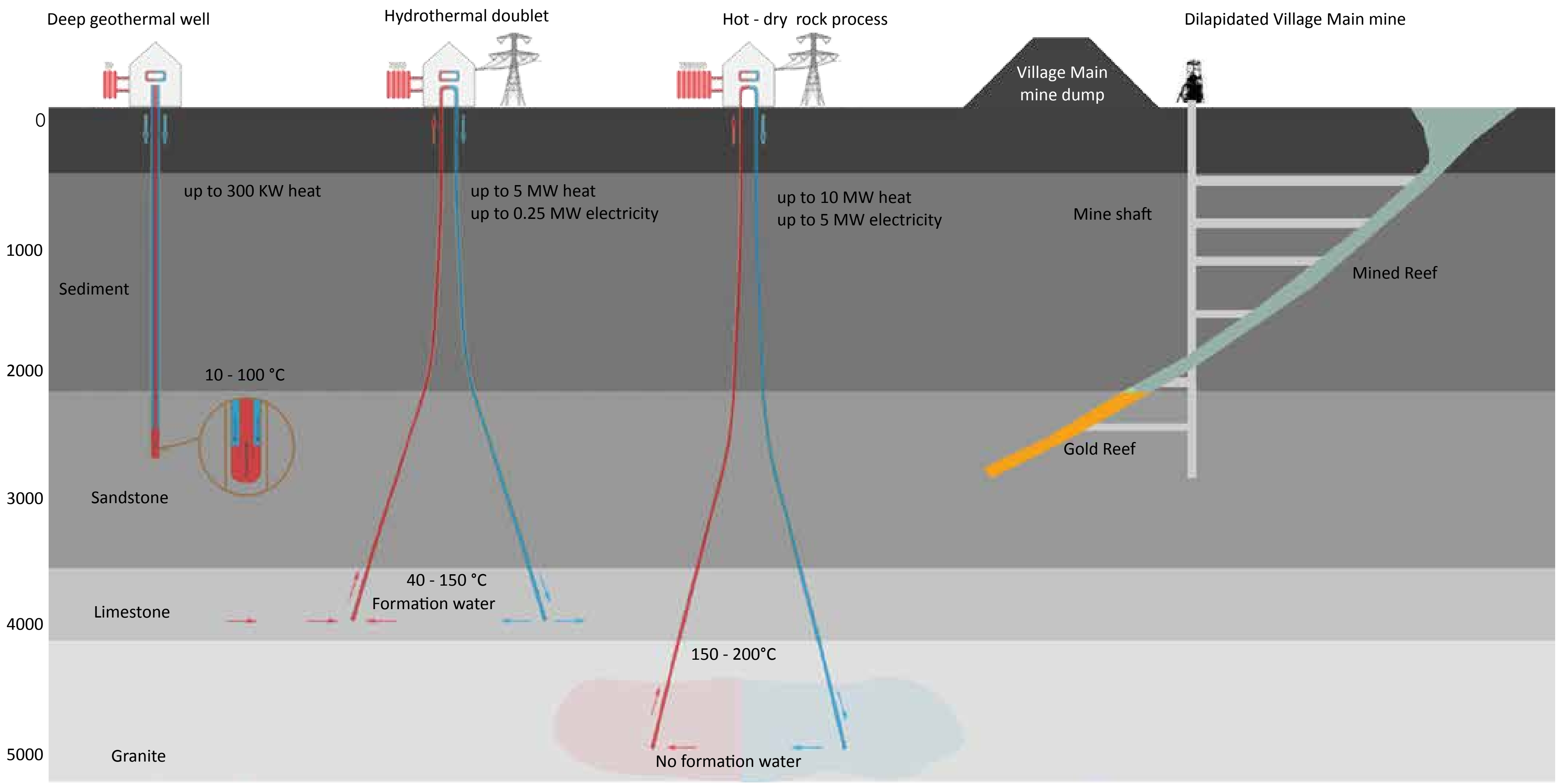


A much more conventional way to tap geothermal energy is by using geothermal heat pumps to provide heat and cooling to buildings. Also called ground-source heat pumps, they take advantage of the constant year-round temperature just below the surface of the ground. Either air or antifreeze liquid is pumped through pipes that are buried underground, and re-circulated into the building. In the summer, the liquid moves heat from the building into the ground. In the winter, it does the opposite, providing pre-warmed air and water to the heating system of the building (Harms, 2013).

4. Ground-source heat pump

In the simplest use of ground-source heating and cooling, a tube runs from the outside air, under the ground, and into the ventilation system of a building. More complicated, but more effective systems use compressors and pumps – as in electric air conditioning systems – to maximise the heat transfer (Harms, 2013).

In regions with extreme temperatures, ground-source heat pumps are the most energy-efficient and environmentally clean. Far more efficient than electric heating and cooling, these systems can move as much as 3 to 5 times the energy they use in the process (Union of Concerned Scientists, 2009: online). In rural areas without access to electricity, heat pumps are much less expensive to operate and as buildings are widely spread out, installing underground loops is not an issue. Underground loops can be easily installed during the construction of new buildings as well, resulting in savings for the life of the building (Honiball, 2014).



The power generation solutions company, HRP Geothermal Power, is of the opinion that an Organic Rankine Cycle (ORC) power plant is the preferred technology to use in South Africa, as it allows for lower-temperature heat sources – 100°C to 150°C temperature range. The Rankine system is based on the fact that the compression of a liquid consumes much less energy than that of a gas. The ORC is named for its use of an organic, high molecular mass fluid with a liquid-vapour phase change at its boiling point that occurs at a lower temperature than that of water or steam. The conventional Rankine Cycle uses water or steam, which then has a higher boiling point, as a working fluid. This allows the cycle to generate high-pressure steam from lower-quality heat to drive its turbine and generate power. This also means that ORCs can operate between smaller temperature differentials than traditional Rankine Cycles (The Green Optimistic, 2009: online).

Research will be done in different artificial boilers on different depths and all systems can be investigated if drilling takes place on different levels. The design allows for research at all levels. Therefore, at commencement of the design, space provision is of great importance.

2.3 Why would geothermal energy be a good source of sustainable energy ?

Why would geothermal energy be a good source of sustainable energy?

A point to be stressed is that the slow pace of cleaning up South Africa's 5906 abandoned mines is leading to an ecological and environmental disaster. The article "Abandoned mines poison SA water" says progress is too slow and if rehabilitation is not moving faster sinkholes and contaminated water will occur (Fin24, 2010: online). On-going monitoring and remediating should be done at abandoned mines. This perpetual process can be very costly. Geothermal use of derelict mines will offset these costs and help the mining industry to become more sustainable.

Previously with low Eskom tariffs this was not feasible, owing to the cost of drilling, but now finance could become available. With the current energy shortages and increased electricity costs, HRP Geothermal Power found that capital costs for each megawatt from coal-fired power plants equal the cost of geothermal extraction, but with the advantage that the heat source is free once you get to it (South Africa Clean Tech, 2011).

The land and freshwater requirements of geothermal energy is minimal. In chapter 10 of this thesis specific statistics will be discussed.

Most obvious is the reliable availability of geothermal energy. Other clean energy sources, such as solar or wind, are only available when the weather cooperates (Smit, 2014: online).

(Artunite.com, 2014)

2.4 Geology of the Witwatersrand

Geology of the Witwatersrand

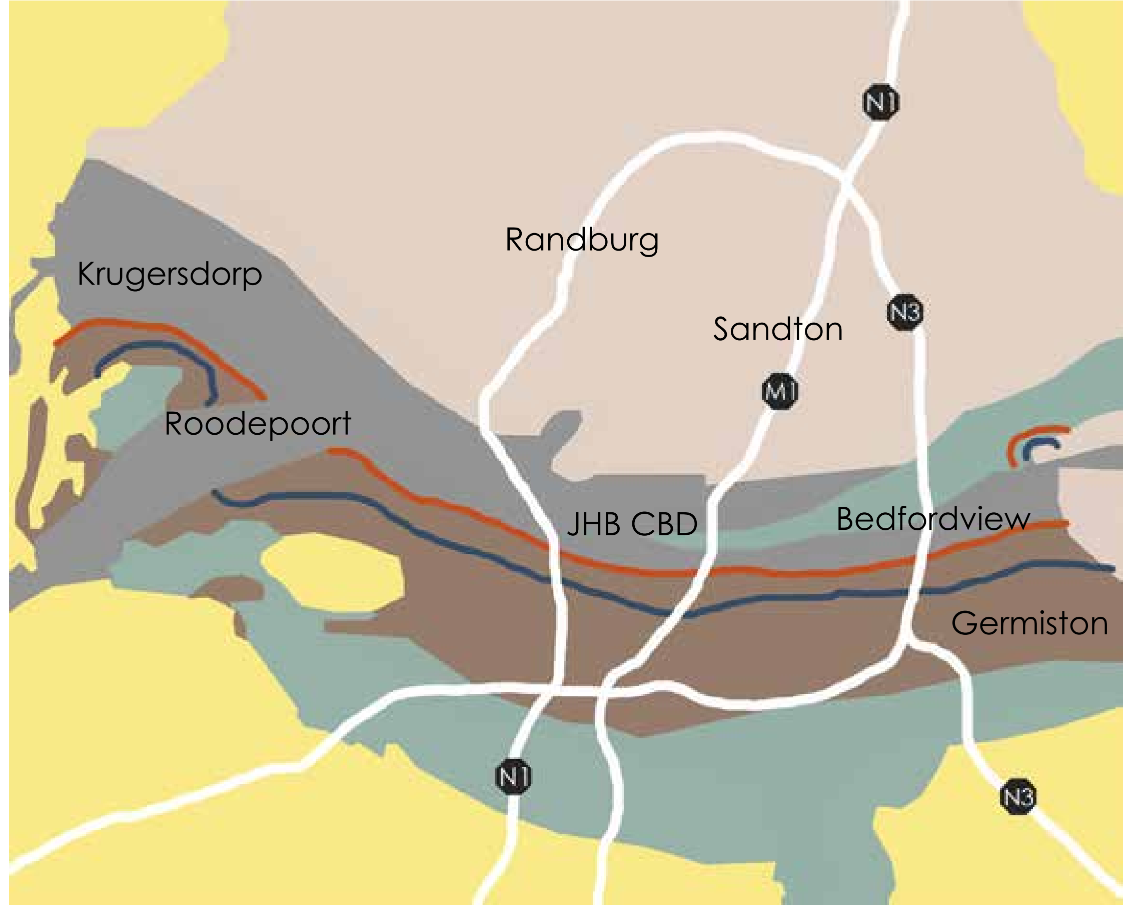
Witwatersrand, meaning "ridge of white waters", got its name from the many waterfalls that once cascaded off the scarps. When the organisation of sedimentary rocks that hosts the gold was recognised as a series, it was called the Witwatersrand Series (later it was called a System and now a Supergroup). The name of South African currency is due to the discovery of gold on the Witwatersrand (Norman & Whitfield, 2006: 38).

The Witwatersrand ridge consists of sedimentary rock layers of conglomerate, quartzite and shale. The gold occurs in layers of pebbled rock called conglomerate that were deposited as river gravel about 2 800 million years ago. The conglomerate layers are separated by layers of a rock called quartzite, which were originally deposited as layers of sand. Cementation and heating of the sand over millions of years converted it into hard, quartzite rock. In addition, layers of shale (formerly silt and mud layers) were also laid down between the layers of sand. These various sedimentary rocks were deposited on a floor of rock consisting mainly of granite. The combined thickness of the quartzite, shale and conglomerate layers is approximately 7km (Trustwell, 1977:.31-37).

The gold-bearing conglomerate reefs occur mostly in the upper 2km portion of the compilation. The sedimentary layers were buried by lava that rose up from deep in the earth along cracks known as dykes about 2 700 million years ago. The lava-formed dykes ended the gold-forming event. The layers of rock later became tilted and were partly eroded. They now dip horizontally towards the south at angles varying from 20° to about 80° and extend from Randfontein in the west to Boksburg in the east (McCarthy, 2010: 5).

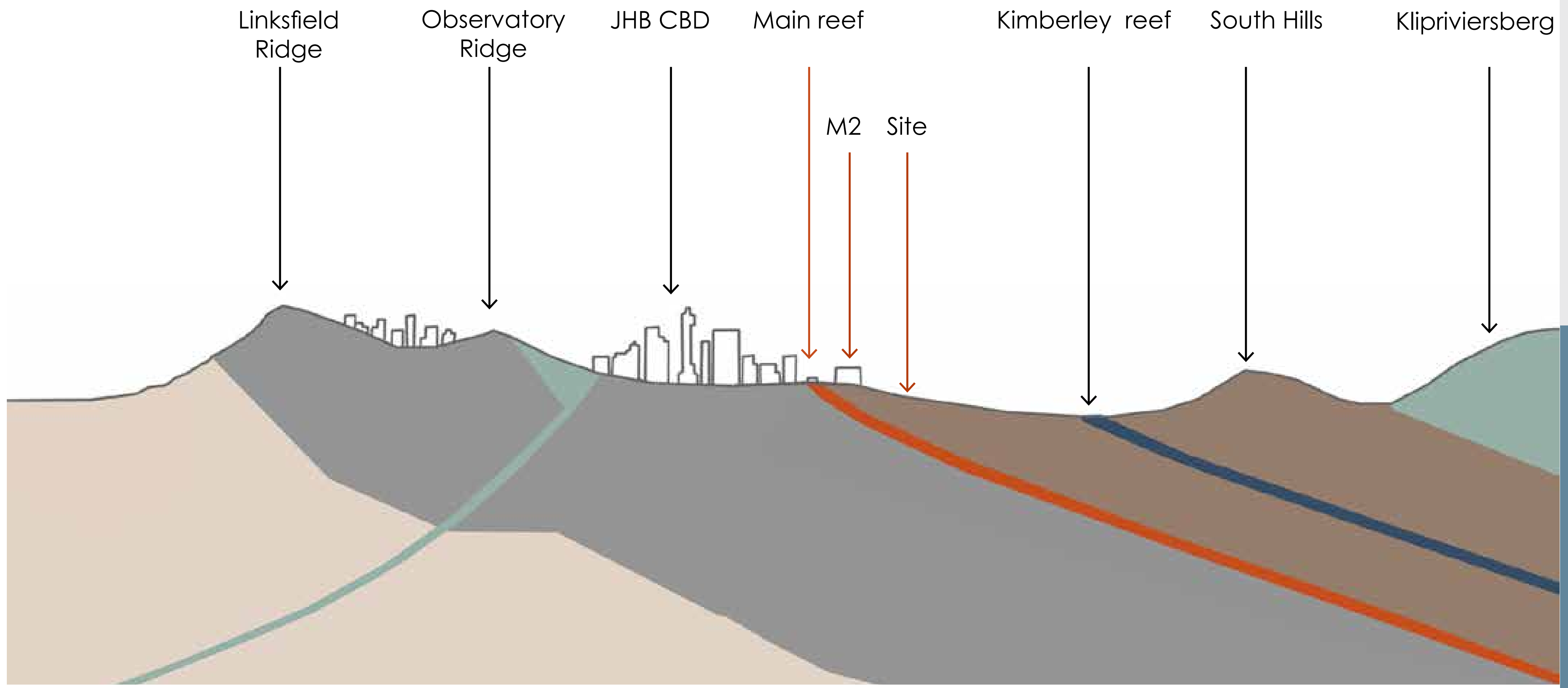
Not all of the conglomerate layers or reefs carry economic concentrations of gold. On the Witwatersrand, only three or four of the reefs contained significant gold. The important gold-bearing reefs were the Main Reef, Main Reef Leader, South Reef and the Kimberley Reef (Coetzee, 1976).

A simplified geological map that shows the distribution of the main rock types of the Witwatersrand. Reefs are indicated with blue and red lines (McCarthy, 2010: 5).



- Main reef
- Kimberley reef
- Dolomite and settled rocks
- Granite and related rocks
- Quartzite and shale
- Quartzite and conglomerate
- Lava

A geological cross-section in a north-south direction showing the dip of layers of sedimentary rock in the south. Most of the mining was on the Main Reef with limited mining on the Kimberley Reef (McCarthy, 2010: 6).



- Main reef
- Kimberley reef
- Dolomite and settled rocks
- Granite and related rocks
- Quartzite and shale
- Quartzite and conglomerate
- Lava

2.5 Mining method in the Witwatersrand

Mining method in the Witwatersrand

Prof. Terence McCarthy (2010) of the University of the Witwatersrand described the mining methods used in the early days of gold mining on the Witwatersrand in his analysis of the acid water problem in the Gauteng area. He explained that it is actually a simple procedure.

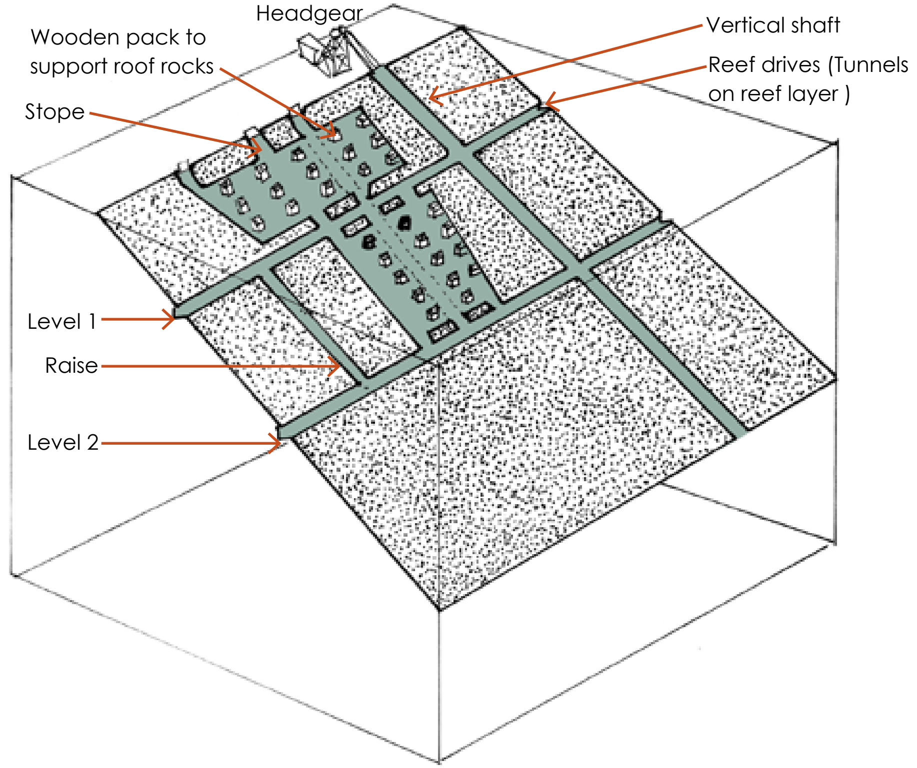
A tunnel (called an inclined shaft) was dug down from the flat surface of the reef. At certain intervals horizontal tunnels were dug. These were called levels. The bottom levels were connected with the top levels with yet more tunnels that were called raises. These raises were widened sideways to create stopes where the actual mining took place. Reef drives or more horizontal tunnels were dug perpendicular onto the shaft. The ore was then moved down to the reef drive below where it was loaded on wagons or cocopans to transport it to the shaft for removal to the surface. The roof was supported by columns that were left next to the reef drive. In the stopes the roof was also supported by wooden support packs. The minimum width of the mine opening was 1 metre – even when the conglomerate layers were less than one metre, because movement in a smaller area became too problematic for working. Where the conglomerate was thicker, the entire layer was usually mined.

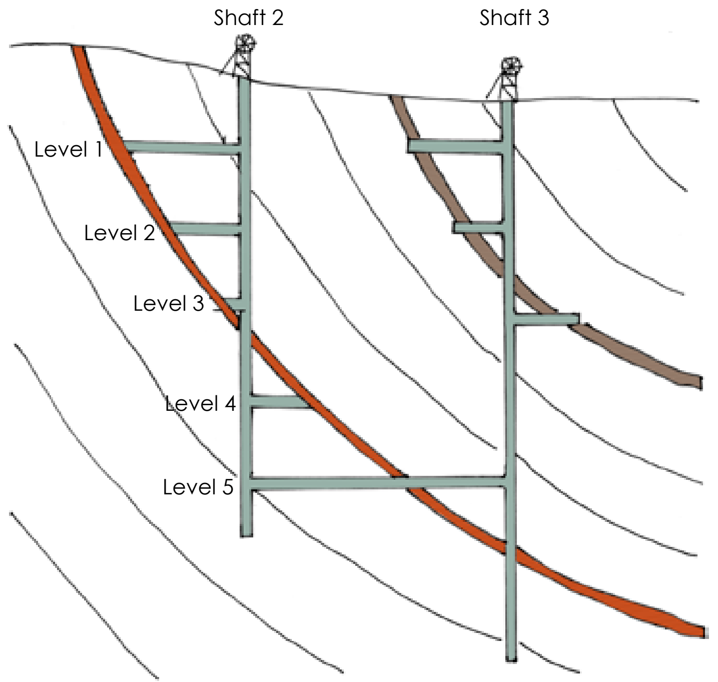
As a mine became deeper, different tunnels were dug. The incline shaft became inefficient and was replaced by a vertical shaft. More horizontal tunnels were dug from the shaft to the reef. They were called crosscut drives, from where the reef drives were dug as before. For safety reasons reef drives were eventually abandoned and tunnels were dug below and parallel to the reef. As mining progressed even deeper to depths of ± 3000m more shafts were sunk. They were called subvertical or sub-incline shafts.

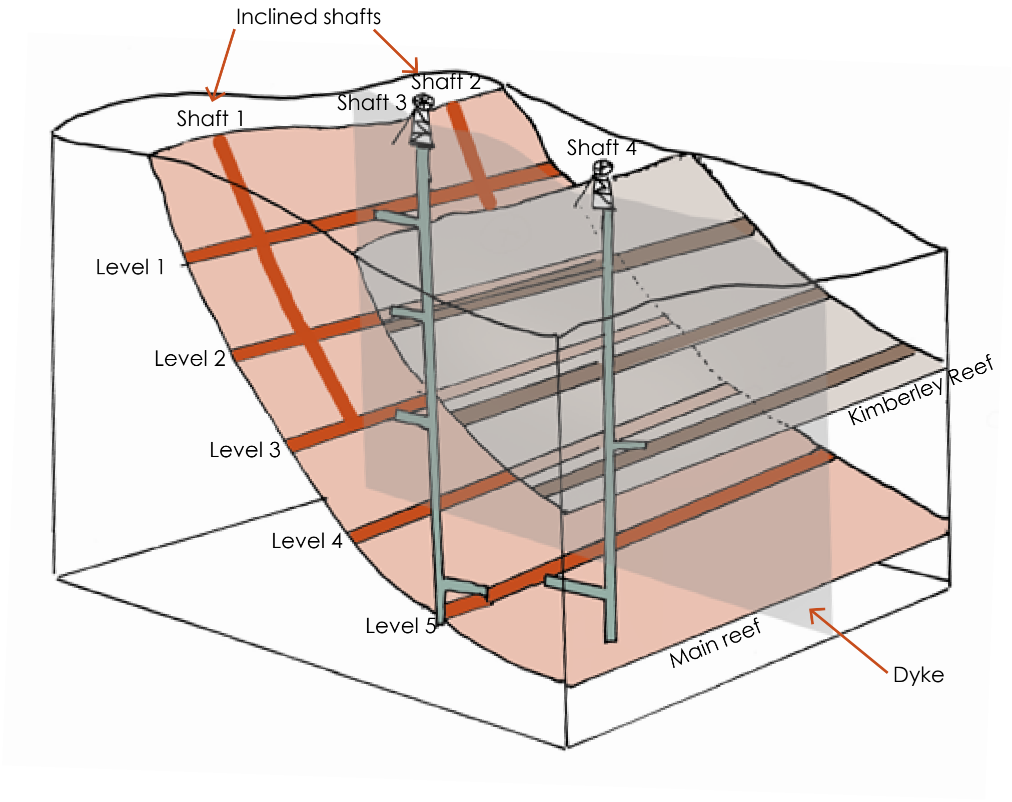
The supply of fresh air and the removing of stale, dusty air became of the utmost importance. To control airflow underground barricades were erected in the older areas and some parts of the underground void were used to remove stale air. Other parts of the void were again used to channel fresh air to the workers. To keep up with the mining progress these paths were constantly changing. Along the Witwatersrand more than one reef was mined simultaneously – some had lots of gold bearing ore and others less. The Main Reef Leader was particularly extensively mined. Dykes that cut across the reef layers were not mined as they contained no gold.

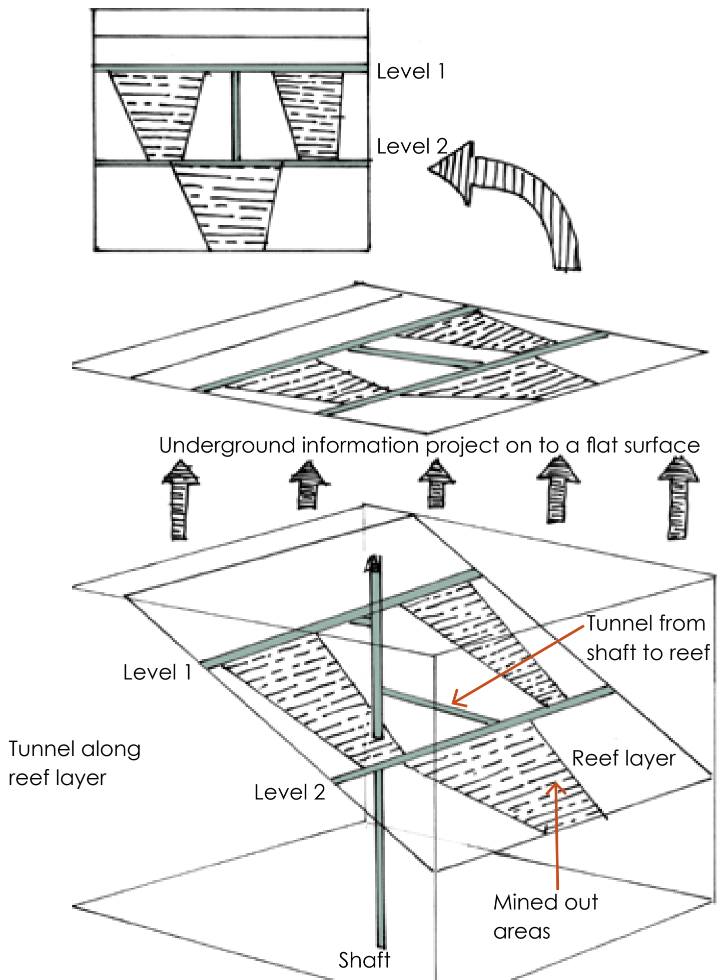
Prof. McCarthy mentions that it was theoretically possible in the past to walk underground all the way from Roodepoort to Boksburg, because adjacent mines generally interconnected their workings. In practice, however, this was not possible because reef drives and other tunnels that were no longer needed were blocked off with brick walls or wooded barricades. These barricades were erected to prevent workers from straying into old and dangerous areas and also to control the air-flow to the active working areas.

In order to keep track of the mining, plans of the mine workings were kept by mine surveyors. Prof. McCarthy explains that a mine plan is a projection of the underground excavations onto a horizontal surface. (McCarthy, 2010: 5).









Historic overview

03

3.1 History of Gold Mining on the Witwatersrand

Historic overview

This project starts with a journey into the past to get a better understanding of what the author intends to do and to get guidance on how to travel forward. What better guidance could we get than the words of President Paul Kruger of the Zuid-Afrikaansche Republiek (ZAR)? "Neem uit die verlede wat goed is en bou daarop u toekoms" (Olivier, [s.a.]: online).

This chapter starts with a timeline of gold mining in the ZAR where different reefs were mined. It is then narrowed down to the Main Reef on which Village Main Reef Gold Mining Company is located.

From a historical perspective, a picture is painted of the development of Johannesburg that was mining based. With earlier developments, sustainability was not valued as an important factor for improvement. The presentation of this project is based on the scars of earlier developments to reshape a neglected space into a place of importance. The word void is being used in this thesis to describe the condition of the existing mine site. To clarify the idea of a void one can refer to the arguments of Lebbeus Woods. Woods argues that these zones were places at some time or other, where the status quo has been disrupted – places where the sense of community, livelihood, social and personal relationship and meaning has been lost. These voids are spaces of discomfort and places in crisis. (Woods, L.1956: 199). The Phenomenon of Place of Norberg-Shultz is a continuation of Heidegger's philosophies regarding building and dwelling. Norberg-Schultz defines a place as an area with boundaries where one can identify and orient oneself. The genius loci or the essence of a place therefore becomes more than a built form (Norberg, S. 1976: 419).

History of Gold Mining on the Witwatersrand

1853: Pieter Jacobs Marais reports his discovery of alluvial gold (deposited by water movement) in the Jukskei River on B.J. Liebenberg's farm, Bultfontein. The site was just north of the present Sandton. Though Marais thought that he was the first person to discover gold in this area, history proved him wrong. Allegedly Carel Kruger, a hunter in the area, had discovered gold in 1834. Another report of gold findings came from John Henry Davis, an English geologist, who prospected around Krugersdorp in 1852.

1874: Australian prospector, Henry Lewis, discovered alluvial gold at Blaauwbank west of Krugersdorp – nearby Magaliesberg village of today.

1877: The British annexed Transvaal. The British wished to bring Transvaal into a union by force. This angered the Boers, which furthered chances of war. The same year the Pedi attacked the Boers of Transvaal and Boers claimed the British had not adequately assisted them.

1880: The First Anglo-Boer War (December 1880 to March 1881). The South African Republic was victorious.

1881: Stephanus Minnaar found gold at Kromdraai, 10km north of Krugersdorp – part of the Cradle of Humankind.

1884: The first recorded discovery of gold in the Witwatersrand rocks was made by Jan Gerrit Bantjes in June 1884, on the farm Vogelstruisfontein. On Wilgespruit, now part of the Kloofendal nature reserve just north of Roodepoort, the brothers Fred and Harry Struben found high-grade, gold-bearing quartz veins. It was called the "Confidence Reef". Ironically they did not have much success in the Confidence Reef, but it sparked off a flood of prospectors to the Witwatersrand and eventually resulted in the discovery of the Main Reef in 1886.

1885: A public digging was proclaimed on the farm Kromdraai. The Struben brothers erected a 5-stamp mill in Confidence Reef with the help of George Walker. They crusted conglomerated bands from Roodepoort, but did not have much success.

1886: Previous discoveries were of minor reefs and the credit for discovering the main gold reef goes to George Harrison. On a Sunday morning George Harrison (probably accompanied by George Walker) discovered the Main Reef outcrop on Langlaagte. Harrison reported this finding at Langlaagte formally and the Gold Rush started. Mining magnates from Kimberley, namely JB Robinson, Dr Hans Sauer, Cecil John Rhodes and Charles Rudd, arrived at Langlaagte and proclaimed prospective ground. On the 20th of September President Paul Kruger issued a proclamation, declaring nine Witwatersrand farms public digging. With this event the official founding of the Witwatersrand Gold Field was established. The Government of the Zuid-Afrikaansche Republiek surveyed on a triangle of vacant land, called Randjieslaagte. These surveyed plots at Randjieslaagte were sold, thereby establishing the town soon to be known as Johannesburg.

1887: Charles Rudd was sent to London by Cecil John Rhodes to register "The Gold Fields of South Africa" with a capital of £250 000, and the first mining house of South Africa was established. Charles' brother, Thomas, was the first chairman. More stamp mills were erected and that gave the indication of the richness of the Witwatersrand.

1888: From small surface diggings a production of over 120 000 ounces (about 4 tons) were reported. Within a few years more than a hundred small mines came into being along the whole Witwatersrand, stretching from what is now known as Randfontein in the west to Springs and Nigel in the east. As workings became deeper, the mines had to amalgamate to form economic units and the era of the Randlords had begun. Alfred Beit, Hermann Eckstein and Lionel Phillips laid the foundation of the company later known as Rand Mines Limited.

1889: Problems started – mines ran into unweathered conglomerated ground at around 30m. It not only made mining more expensive, but gold grades were declining and the fresh ore did not easily release gold in the extraction process that was used. The Barnato brothers arrived and set up the Johannesburg Consolidated Investment Company (JCI).

1890: Hopes are high again with the historic technology breakthrough – with the new McArthur Forrest cyanidation process gold was extracted from fresh ore with much higher recovery than before and the gold industry was saved. Geologist Joseph Curtis drilled the first core borehole of 152m to the south of Johannesburg and found the gold bearing South Reef and Main Reef conglomerates.

1895 - 1896: 29 December to 2 January – with the Jameson Raid from old Rhodesia, support was given to the Uitlanders with the goal of taking control. The raid was ineffective and no uprising took place, but it was an inciting factor in the Second Boer War.

1899 - 1902: The Anglo Boer War affected the whole country. Gold mines closed down. The war ended with the Treaty of Vereeniging signed on 31 May 1902. The Boers were given £3 million for reconstruction and were promised eventual limited self-government, which was granted in 1906 and 1907. The colonies of the Zuid-Afrikaansche Republiek and Orange Free State later formed part of the Union of South Africa. The war left a large proportion of the population homeless and destitute, which resulted in ideal conditions for rapid urbanisation, cheap labour and extensive mining rights for the foreigners.

1902 - 1910: During this period administrative structures were created and a relationship developed between Afrikaner politicians and mining capitalists. The new constitution excluded blacks from political power. Racial segregation was further developed through policies proposed during reconstruction and solidified after 1910. The way for Apartheid was beginning to take shape. The Union of South Africa was established as a member of the Commonwealth. In the same year the Land Alienation Act was instituted by Lord Milner. Black people left the rural areas and moved into the mining hub in search of employment.

1917: Sir Ernest Oppenheimer, along with the American bank J.P. Morgan & Co., founded the Anglo American Corporation. £1 million raised from United Kingdom and United States sources was ultimately responsible for the name of the company. Twelve years later, in 1957, Sir Ernest died in Johannesburg and was succeeded by his son, Harry Oppenheimer, who also became chairman of De Beers. In the late 1940s and 1950s, the Anglo American Corporation focused on the development of the Free State goldfields and the Vaal Reef mines. The success of the mines enabled the company to become the world's largest gold mining group.

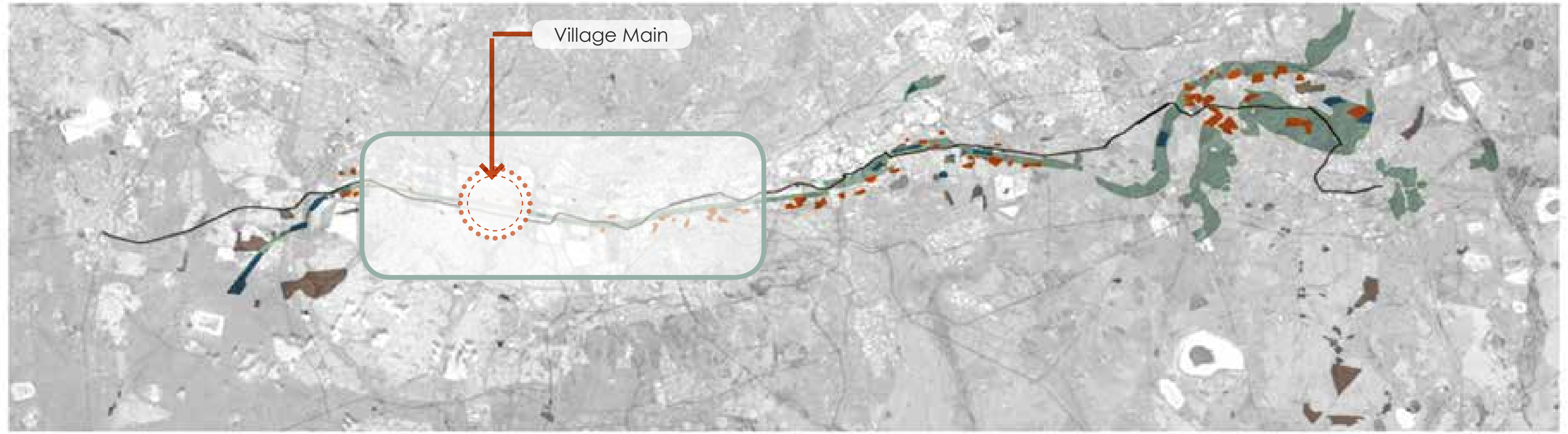
1930 - 1940: Major building developments took place after South Africa went off the gold standard. The growth of manufacturing brought an even greater influx of blacks into the city, especially during World War II (1939-1945), when many white workers were serving in the military. The city's black population doubled, with many of the new arrivals crowded into squatter camps.

1948: The National Party gained power and implemented the Group Areas Act which again forced the black population out of the inner city and into the specified areas or townships. One of these townships was the South Western Townships (SoWeTo).

2007: Gold mining in SA employed over 240 000 people and accounted for R49 billion in foreign currency earnings. New mines, such as the Burnstone Mine with an estimated value of R 3,5 billion, continue to open. The opening of other gold mining projects, such as Doornkop South Reef Mine – expected to deliver 82,8 tonnes of gold within a 20 year period – adds to the idea that gold mining in South Africa is still a viable and lucrative industry.

| Historic overview

3.2 Main reef and its history

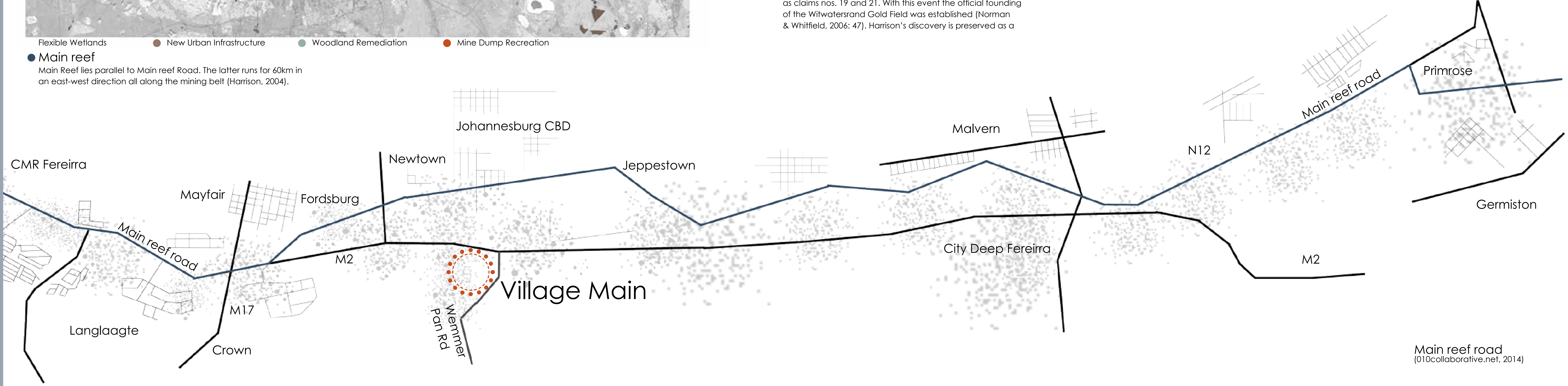


Flexible Wetlands
New Urban Infrastructure
Woodland Remediation
Mine Dump Recreation

Main reef
Main Reef lies parallel to Main reef Road. The latter runs for 60km in an east-west direction all along the mining belt (Harrison, 2004).

Main reef and its history

Gerhardus Cornelis Oosthuizen bought a section of the farm Langlaagte in 1874. Langlaagte lies 11km from the centre of Johannesburg. The Main Reef Group of Conglomerates was discovered in 1886 by George Harrison (and perhaps George Walker) on a portion of the farm Langlaagte. Both men had their own version of how they found the gold reef, but it was only Harrison's version that was supported by evidence. (South African History Online, [s.a.]: online). On the 20th of September 1886 President Paul Kruger of the Zuid-Afrikaansche Republijk issued a proclamation, declaring nine Witwatersrand farms public diggings. Langlaagte was incorporated into the group as claims nos. 19 and 21. With this event the official founding of the Witwatersrand Gold Field was established (Norman & Whitfield, 2006: 47). Harrison's discovery is preserved as a national monument in 1944, where the original gold outcrop is believed to be located. A park was named in his honour and is known today as George Harrison Park (Johannesburg Hotel Guide, [s.a.]: online) (The Heritage Portal, 2013: online). From 1874 to 1885 activity increased, with the result that eventually there was prospecting and mining on 19 farms to the north of the Main Reef. On 9 June 1886, J. G. Bantjes discovered the Main Reef independently on the farm Vogelstruisfontein. On 9 July 1886 the Reef was opened to prospecting along a distance of 29km and active prospecting took place over the whole area from Roodepoort to Driefontein (South African History Online, [s.a.]: online).
The first stamp battery was erected in April 1887 on the Main Reef. The capital for the development of the Witwatersrand goldfields mainly came from Kimberley, but also from the Paarl and Pietermaritzburg. The most important mining properties were purchased in the second half of 1886 and the first half of 1887 (South African Heritage Resources Agency, 2012: online).



Main reef road
(010collaborative.net, 2014)

3.3 History on Village Main Gold Mining Company

History on Village Main Gold Mining Company

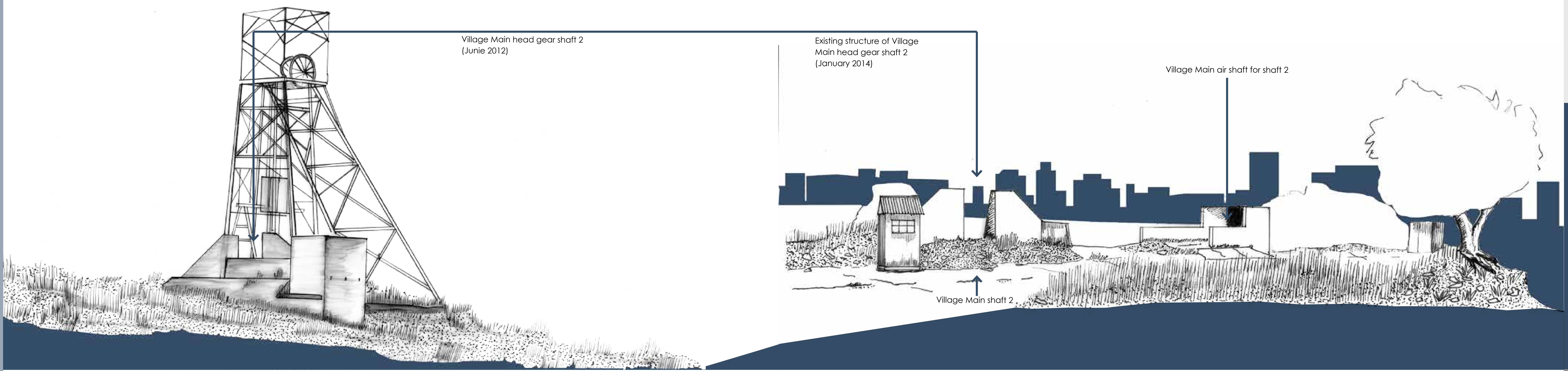
The original Village Main Gold Mining Company (today known as "Village") was incorporated in 1889. This company's mining operations ceased in 1921 when an earth tremor caused the collapse of the 15th level. No effort was made to reopen the mine, as it was believed to have been virtually worked out. At that stage the mine had mined 7,9 million tonnes of ore, producing 3,56 million ounces of gold. However, when South Africa abandoned the gold standard in 1993, it became obvious that reopening derelict mines was an attractive possibility.

The present company, Village, was formed in June 1934. It had an ore reserve of 3 293 000 tonnes with an average of 4 g/t, giving a life expectancy of 17 years at a monthly mining rate of 15 000 tonnes. In following years it obtained the New Robinson, Meyer and Charlton and New Wolhuter properties. In 1976 underground operations were halted, but the mine continued treating sand dumps and calcines for their gold content. The calcines lasted until 1980 and the company continued treating sand dumps until 1995 when these operations became unprofitable. Since then the mine has not been in operation and has been effectively dormant. Though it is engaged in various rehabilitation and closure activities.

In terms of the Mineral and Petroleum Resources Development Act, 2004, all mining rights held by the company have ceased to exist. Village did not reapply for these rights and they either reverted back to the state or were applied for by other companies. In 2008, the company To the Point Growth Specialists (Pty) Limited acquired a 48 percent stake in Village, with the hope of transforming Village into a diversified, resource company (Village Main Reef, 2014: online).

Village successfully acquired the Lesego Platinum project in 2010 which was the first significant step to rebuild Village into a self-sustaining mining company. By the end of the financial year 2010 this procurement transformed Village into one of the top performing shares on the Johannesburg Stock Exchange (JSE) – a reversal of its previous curtailed operations. Current on-going exploration and evaluation of the Village flagship project demonstrates significant potential for shareholder growth.

Village prides itself on creating self-sustaining, socially responsible mining entities through the continuation of identifying and acquiring undervalued assets and the impacts on these assets in a way which realises and unlocks their potential value (Village Main Reef, 2014: online).



Context

(Maharishiinstitute.org, 2014)

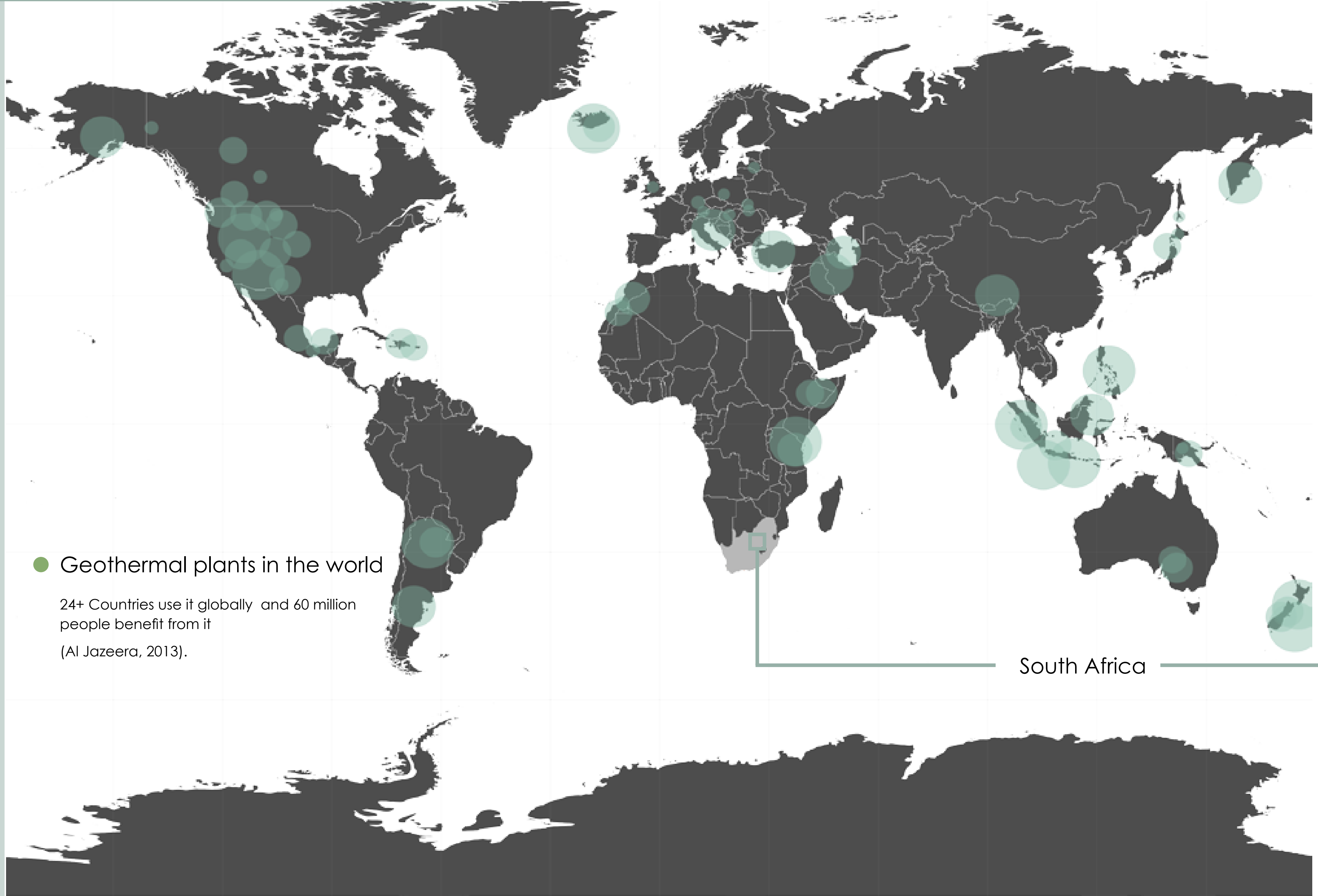
04

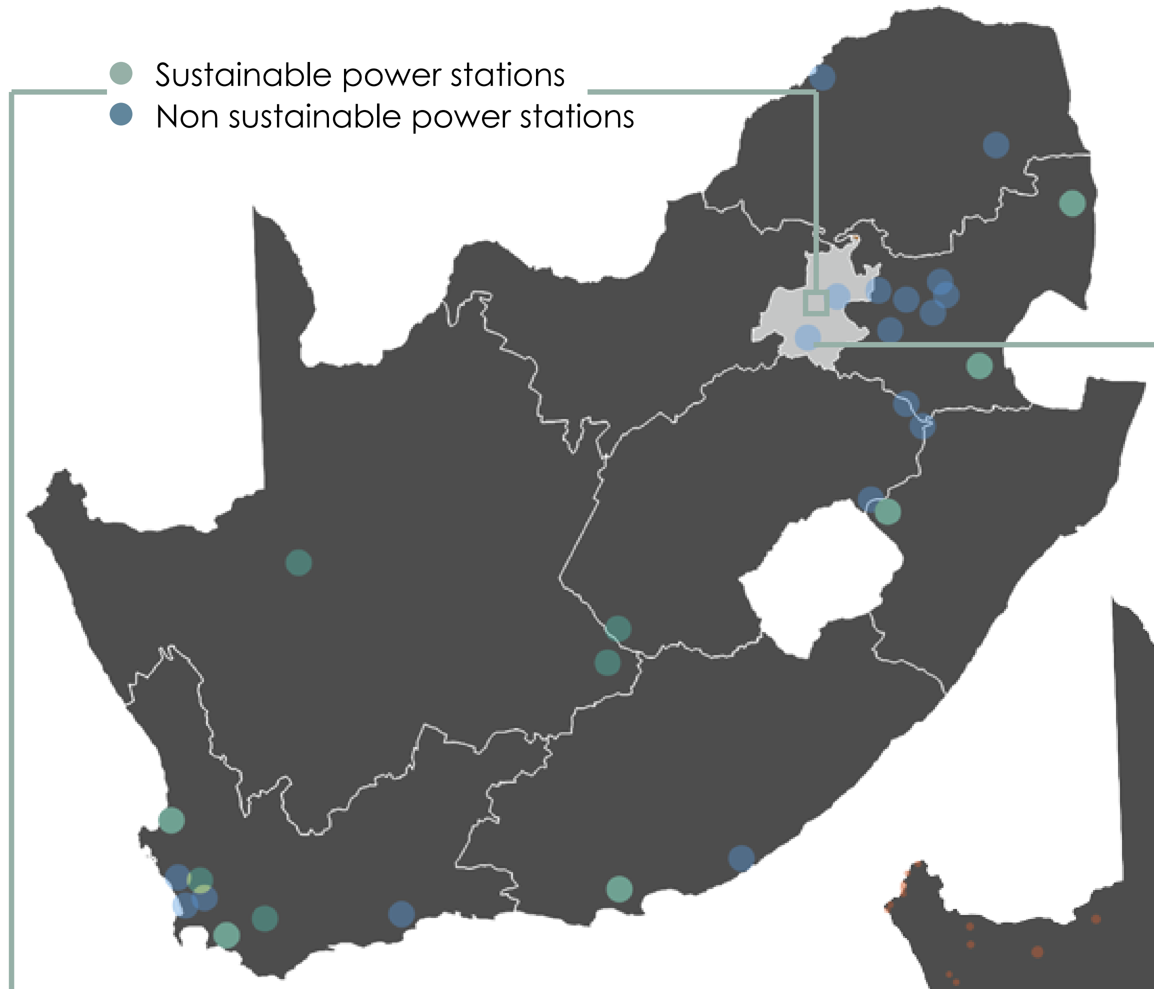
4.1 Macro context

A rational approach to the context of the site lies in a carefully considered site analysis. It not only forms the basis of a cost-effective programme and a sensitivity towards the design and the environment, but it identifies an understanding of building site considerations, the time factor of the project and the impacts that the project has on the community.

[4.1.1] South Africa - Gauteng

An investigation is launched to locate the best area in South Africa for this project. Gauteng and its surroundings have the most mines and is the most densely populated region in South Africa.



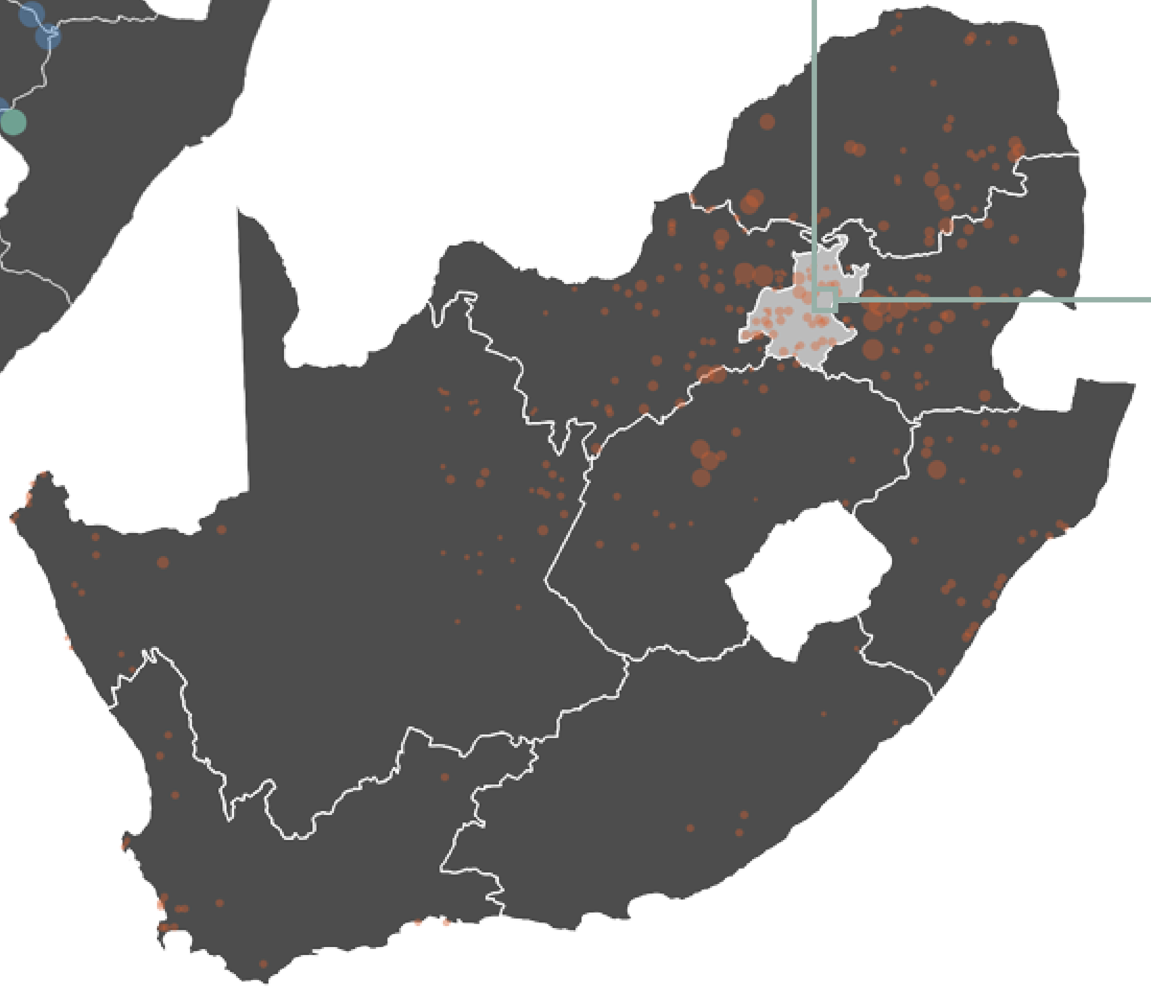


South Africa:

Electricity :	75.2%
Gas:	3.3%
Paraffin:	7.8%
Wood:	11.6%
Coal:	0.8%
Other:	1.3%

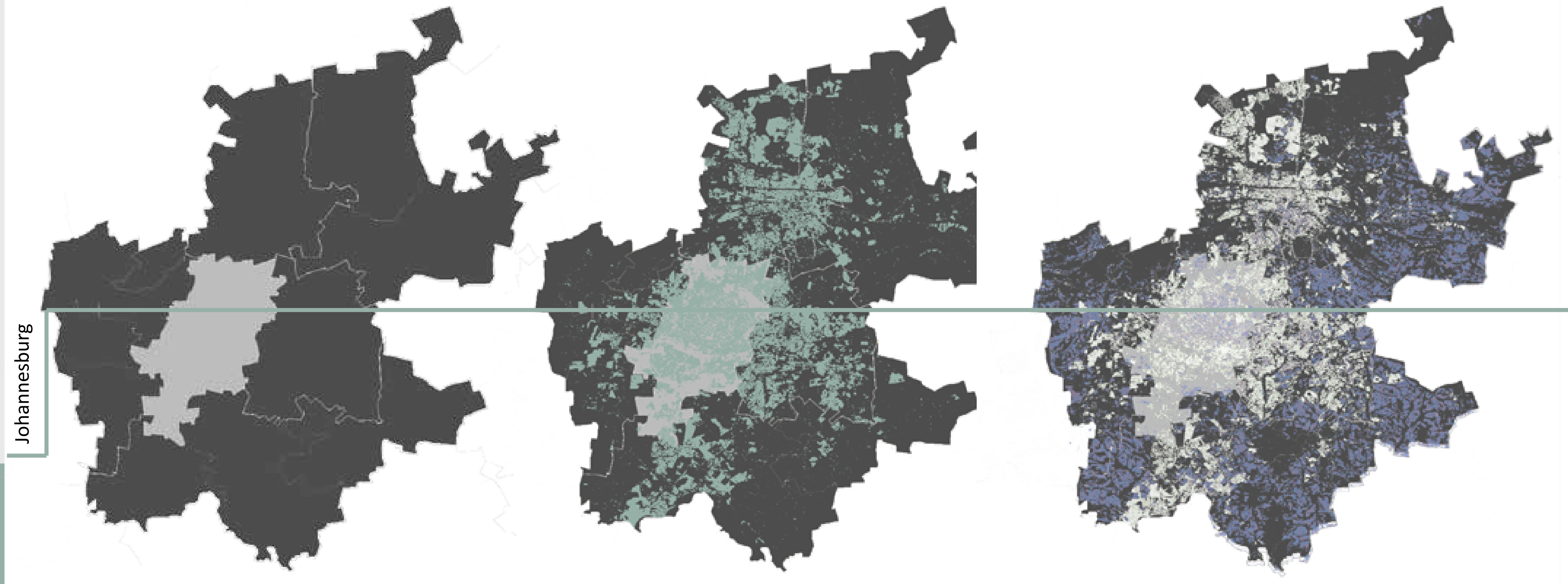
Energy usage excluding transport
(Gcro.ac.za, 2014)

South Africa:
Estimated 6153 ownerless and derelict mines in S.A. with an estimated rehabilitation cost of R30 billion.
(Gcro.ac.za, 2014)



[4.1.2] Statistics

All statistics indicate that the Gauteng region will be the designated place for building a geothermal plant.



Energy usage:

Electricity :	82.2%
Gas:	3.1%
Paraffin:	10.9%
Wood:	0.9%
Coal:	0.5%
Other:	2.4%

Gauteng
(Africa, 2014)

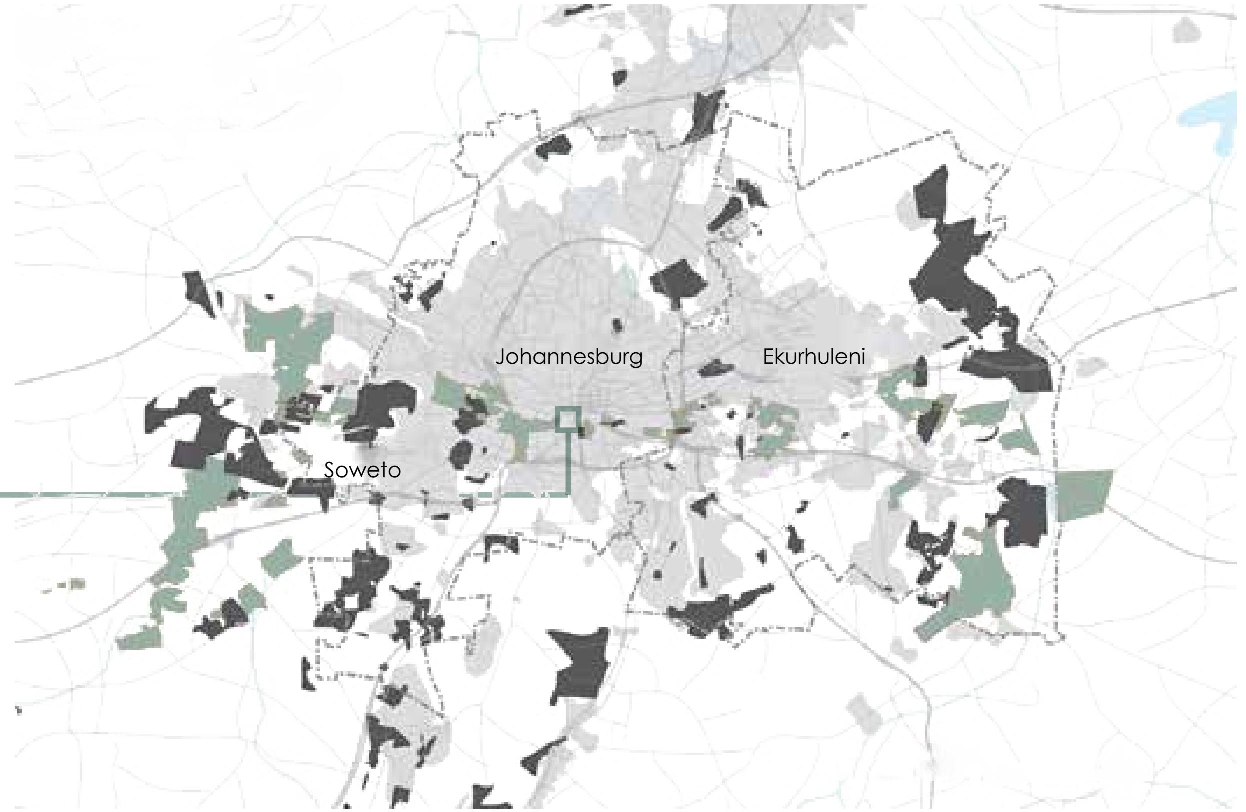
Urban:
Buildings, Industrial, Residential, New Development, Streets, Roads

Gauteng
(Gcro.ac.za, 2014)

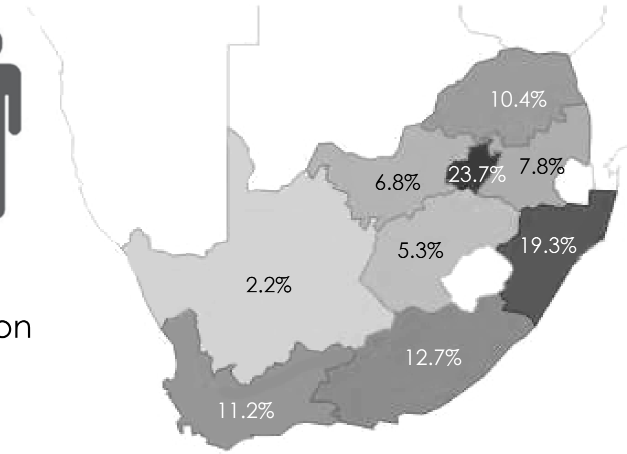
Man - made Green Space:
School grounds, Sports and Recreation, Trees(non-natural), Cultivated land

Natural green space:
Bushland, indigenous forest, Shrub-lands, Degraded natural vegetation, Natural land Surface

Gauteng
(Gcro.ac.za, 2014)



Zoning of Gold Mines ● Gold mines ● Informal settlements ● Urbanized areas ○ Municipal boundaries
(Ceroi.net, 2014)



12.3million
Gauteng
51.8million
South Africa

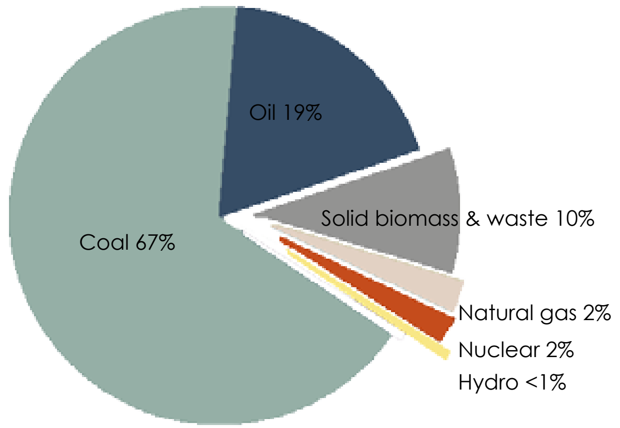
Population
(Africa, 2014)

Johannesburg statistics

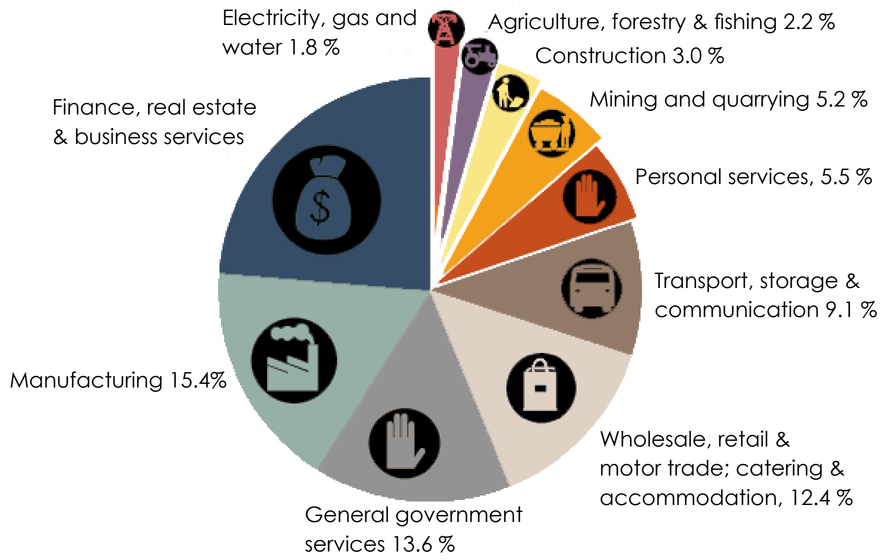
Total population	4 434 827
Young (0-14)	23.2%
Working Age (15-64)	72.7%
Elderly (65+)	4.1%
Dependency ratio	37.6%
Sex ratio	M 107 - F 100
Growth rate	3.18%
Population density	2696 Persons/km ²
Unemployment rate	25%
Youth unemployment rate	31.5%
No Schooling aged 20+	2.9%
Higher education aged 20+	19.2%
Matric aged 20+	34.7%
Number of households	1 434 856
Average household size	2.8
Female headed households	36.2%
Formal dwellings	81.4%
Housing owned / paying off	40.2%
Flush toilet connected to sewerage	87.1%
Weekly refuse removal	95.3%
Piped water inside dwelling	64.7%
Electricity for lighting	90.8%

(Africa, 2014)

Division of mine land ownership
(Centralrandgold.com, 2014)



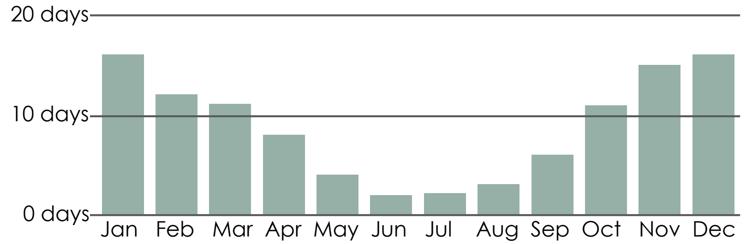
Total primary energy supply in South Africa, 2011
(Africa, 2014)



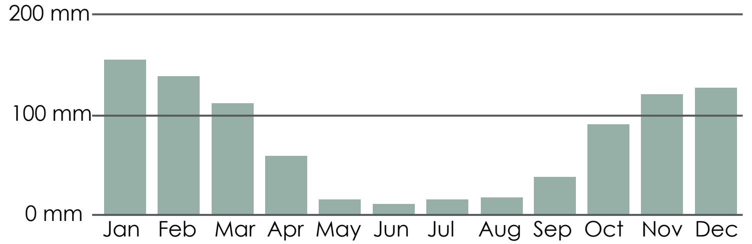
Contributions to GDP - Annual
(Africa, 2014)

[4.1.3] Climate

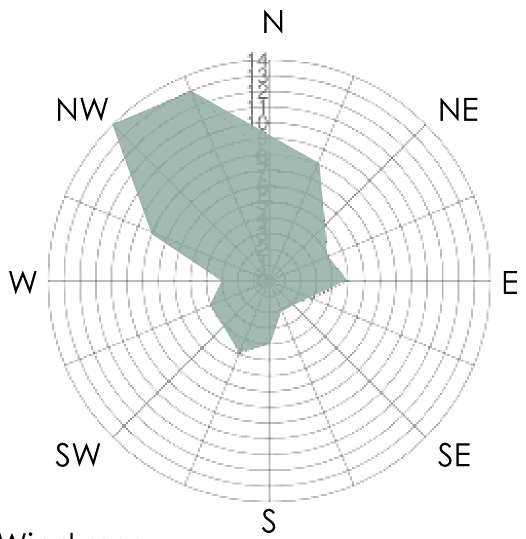
Analysing the surrounding environment and the climate of a place will help clarify the reason for the orientation of the structure and the effect the climate will have on the structure and the materials used.



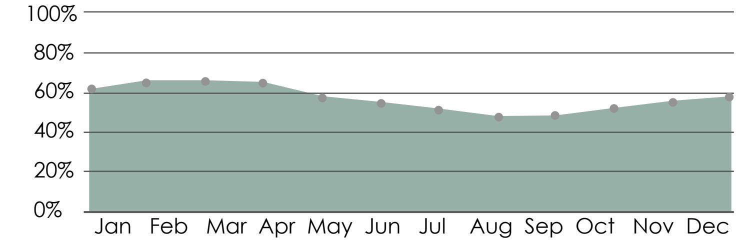
Rainy days
(Weather-and-climate.com, 2014)



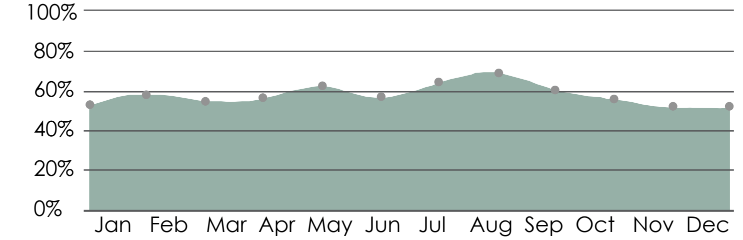
Precipitation
(Weather-and-climate.com, 2014)



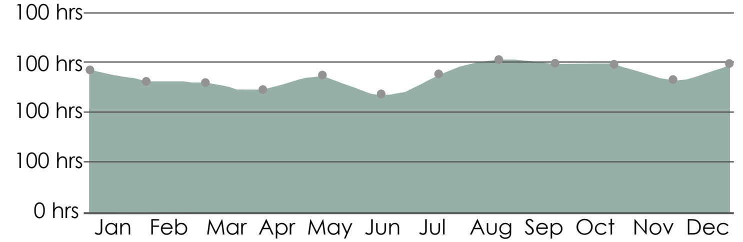
Wind rose
(Windfinder.com, 2014)



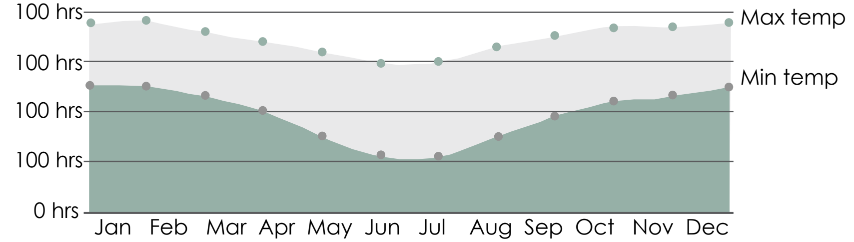
Relative humidity
(Weather-and-climate.com, 2014)



Sunshine percent
(Weather-and-climate.com, 2014)



Sun hours
(Weather-and-climate.com, 2014)

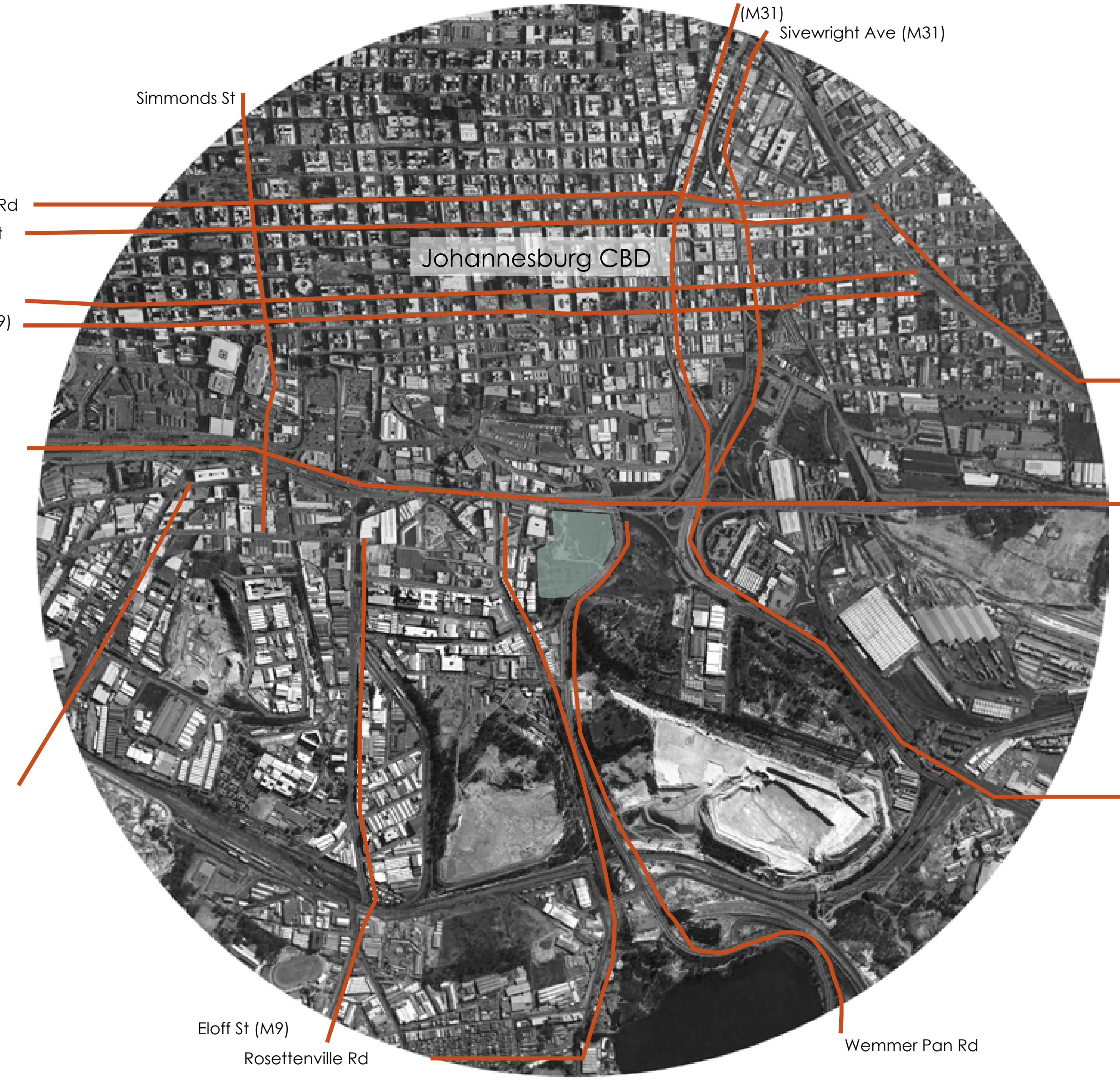


Temperature
(Weather-and-climate.com, 2014)

4.2 Meso context

[4.2.1] Horizontal Analysis

Sensitive architecture should take into consideration the unique qualities and character of the surrounding area. A horizontal analysis is initiated to encourage creative design that is responsive to the local and regional context and contributes to the aesthetic identity of the community.



- Site
- Wemmer Pan dam
- Industrial area
- Residential
- Business area
- Mine dump

- Site
- Gold reef
- Parks and recreation

- Site
- Population per dot (100)
- Movement

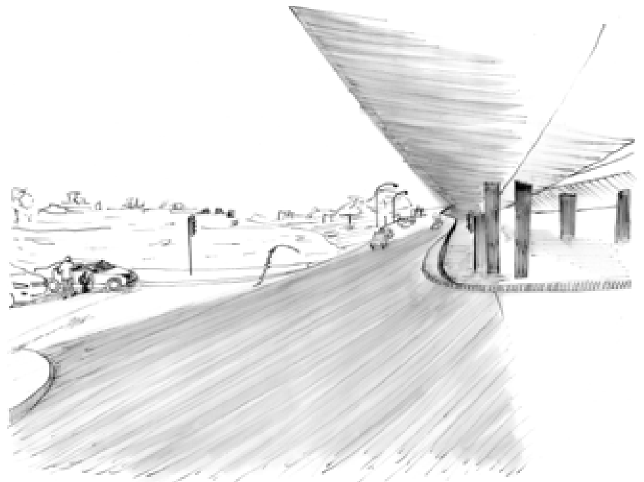
- Site
- Active space

- Site
- High interactive social space
- Low interactive social space

- Site
- CBD grid layout
- Primary Industrial area grid layout
- Secondary Industrial area grid layout

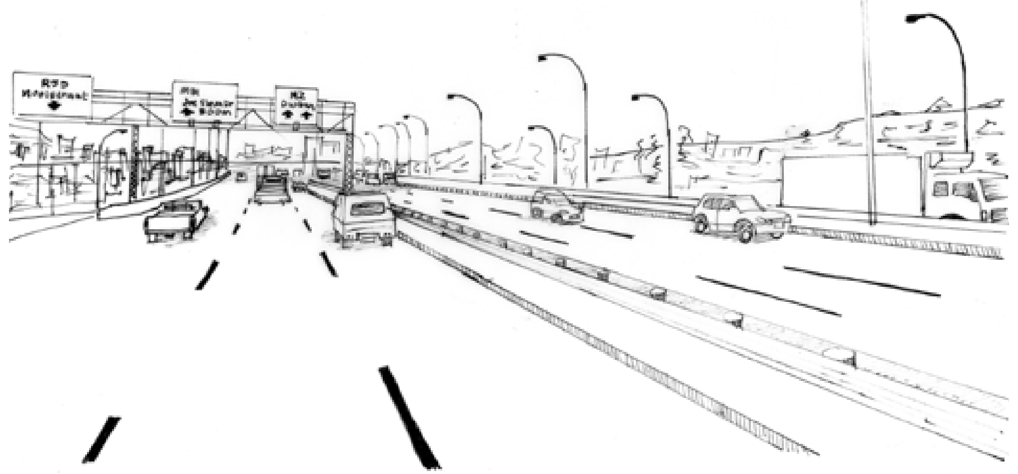
Open area beneath Francois Oberholzer Freeway (M2) which taxi's use.

Street view of Anderson Street (R29).



Junction at Wemmerpan Road with M2.

Street view of Marshall Street (also known as R29).

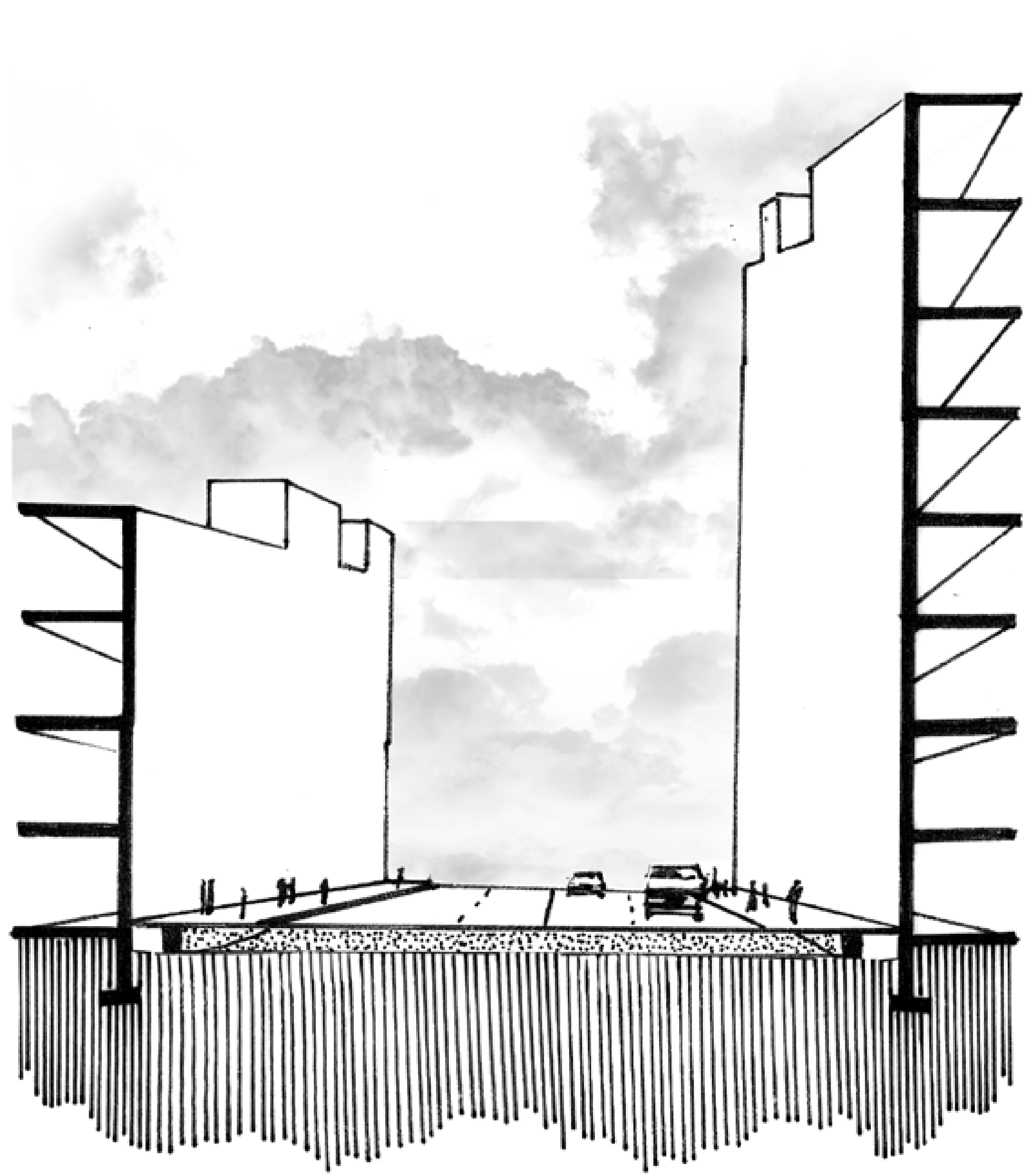


Street view of Francois Oberholzer Freeway.

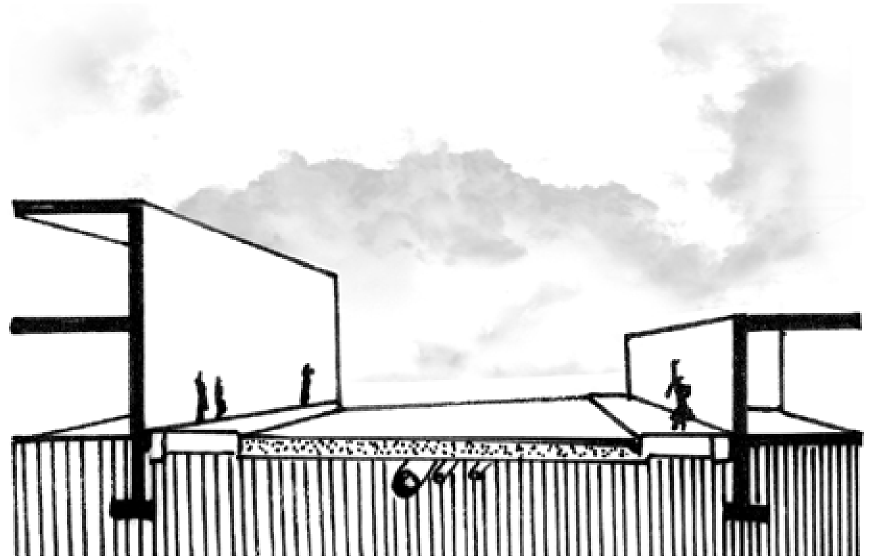
| Context

[4.2.2] Vertical Analysis

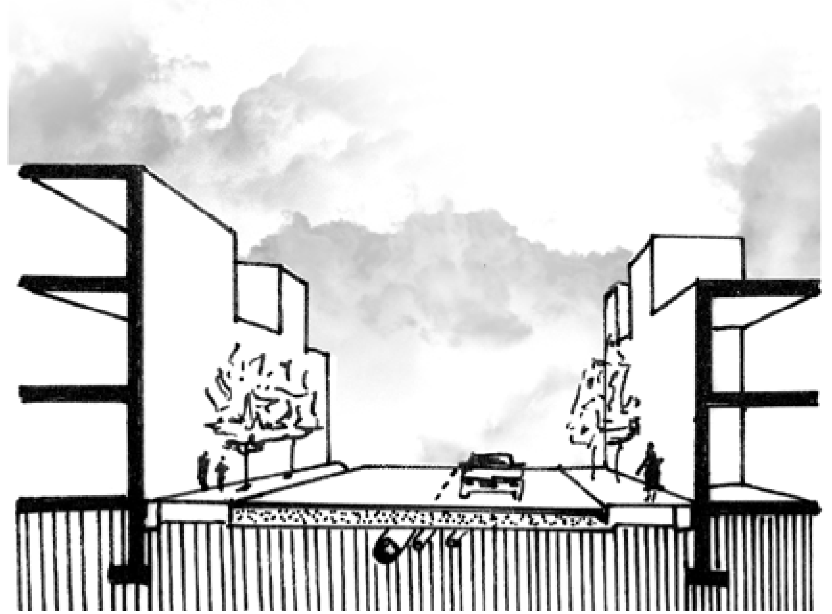
An analysis of the Johannesburg skyline – vertical nodes are distinctive landmarks that provide way-finding for people in the area and which also define the character of a neighbourhood.



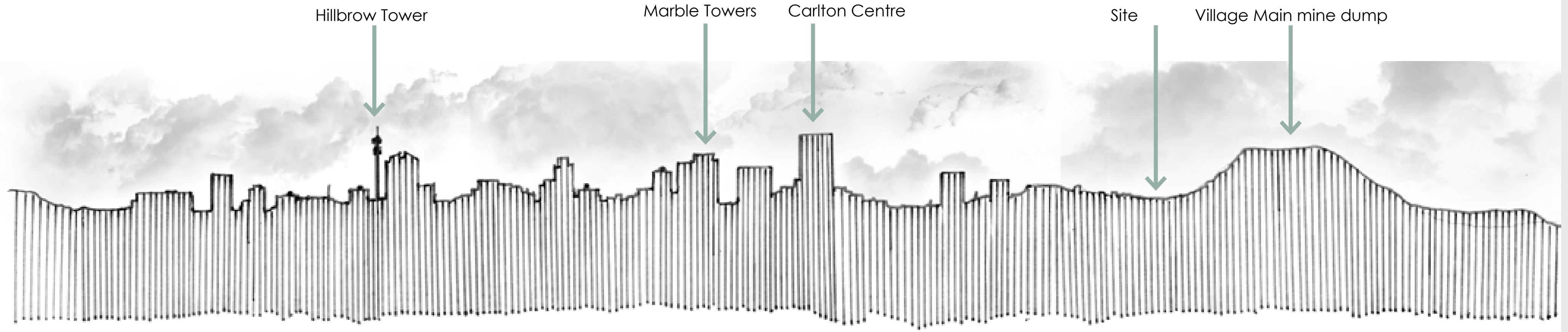
Section through Johannesburg CBD (Market Street)



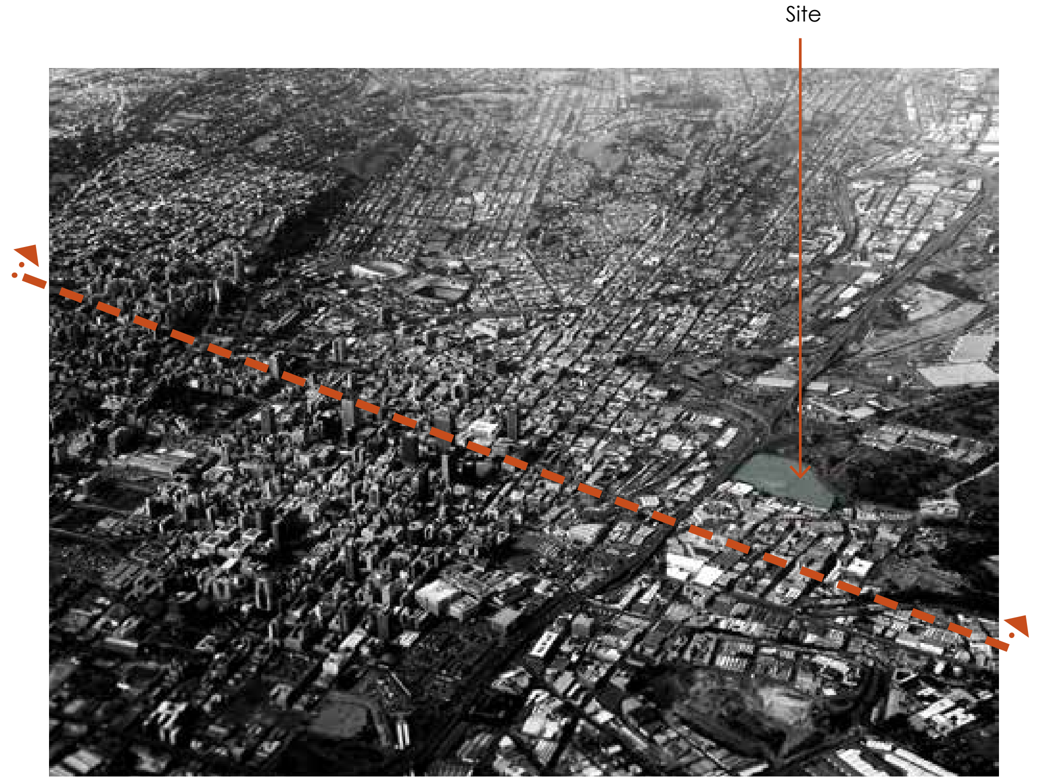
Section through Industrial area (Newton Street)



Section through liminal space (Durban Street)



Section through Johannesburg CBD



Johannesburg aerial view
(Travelblog.org, 2014)

Johannesburg urban development

Although Johannesburg is a young city by historical standards, change and adaptation have always been central to the history of Johannesburg. In planning creatively for the future one needs to understand the historic impact, schools of thought and movements of the past within urban development.

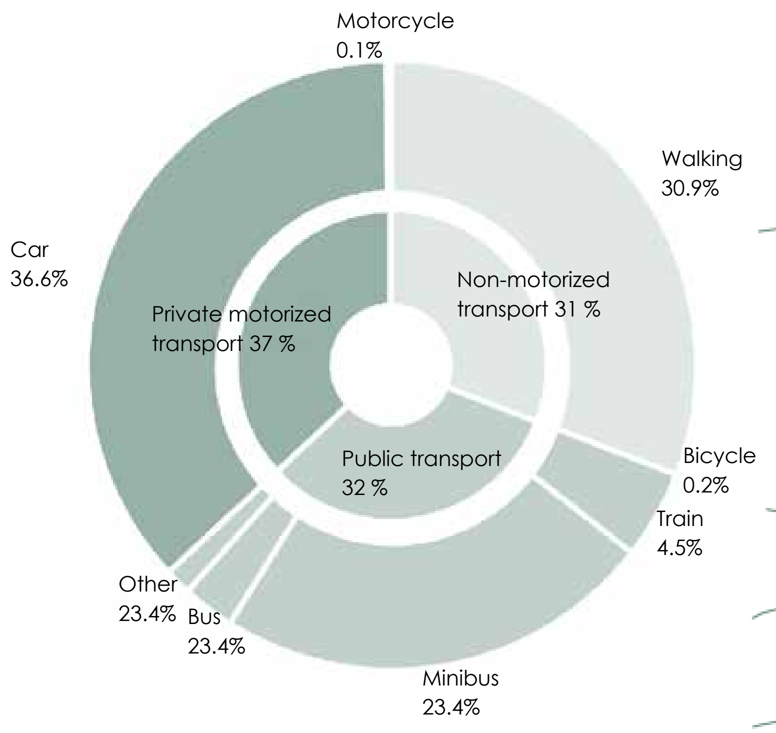
Major building developments took place in the 1930s. In the late 1940s and early 1950s Hillbrow densified into a high-rise built area. In the 1950s and early 1960s, the Apartheid Government constructed the massive agglomeration of townships that became known as Soweto. New freeways encouraged a massive suburban sprawl to the north of the city. In the late 1960s and early 1970s, tower blocks were constructed. The Sentech Tower's construction (originally called the Brixton Tower or the Hertzog Tower) commenced in 1961 and was completed in 1962. The Sentech Tower is a concrete television tower standing 237m tall. The Standard Bank Centre was built in 1968 and is 139m tall. The building was built from the top down, meaning that after the central core was built, the floors were suspended from cantilevered arms with the top floors added first, followed by each lower floor. The Strijdom Tower (now known as the Hillbrow Tower) was constructed for Telkom. Construction was completed in April 1971. It was the tallest structure and tower in Africa for 40 years. The Southern Life Centre filled the skyline of the central business district. It was built in 1973 to a height of 138m. The Carlton Centre (a skyscraper of 50 floors) was financed by Anglo American Properties. Construction began in the late 1960s by demolishing the old Carlton Hotel and closing roads to form a city superblock. Construction was completed in 1974 (Jones, 2003: online).

The central area of the city underwent something of a decline in the 1980s and 1990s, due to the high crime rate and after property speculators directed large amounts of capital into suburban shopping malls, decentralised office parks and entertainment centres. Sandton City was opened in 1973 (Sandton City, [s.a.]: online), followed by Rosebank Mall in 1976 (Rosebank Management District, [s.a.]: online) and Eastgate in 1979 (ShowMe South Africa, 2012: online). The construction of Melrose Arch started in 2007 (Murray & Roberts Construction, 2007: online).

Although the Johannesburg CBD has one of the densest collections of skyscrapers in Africa, many of the buildings are unoccupied as tenants have left for more secure locations in the Northern Suburbs, in particular Sandton and Rosebank. In recent years there have been significant movements to redevelop the city centre. This process of gentrification and redevelopment started in 2005 (MobilyTrip, [s.a.]: online).

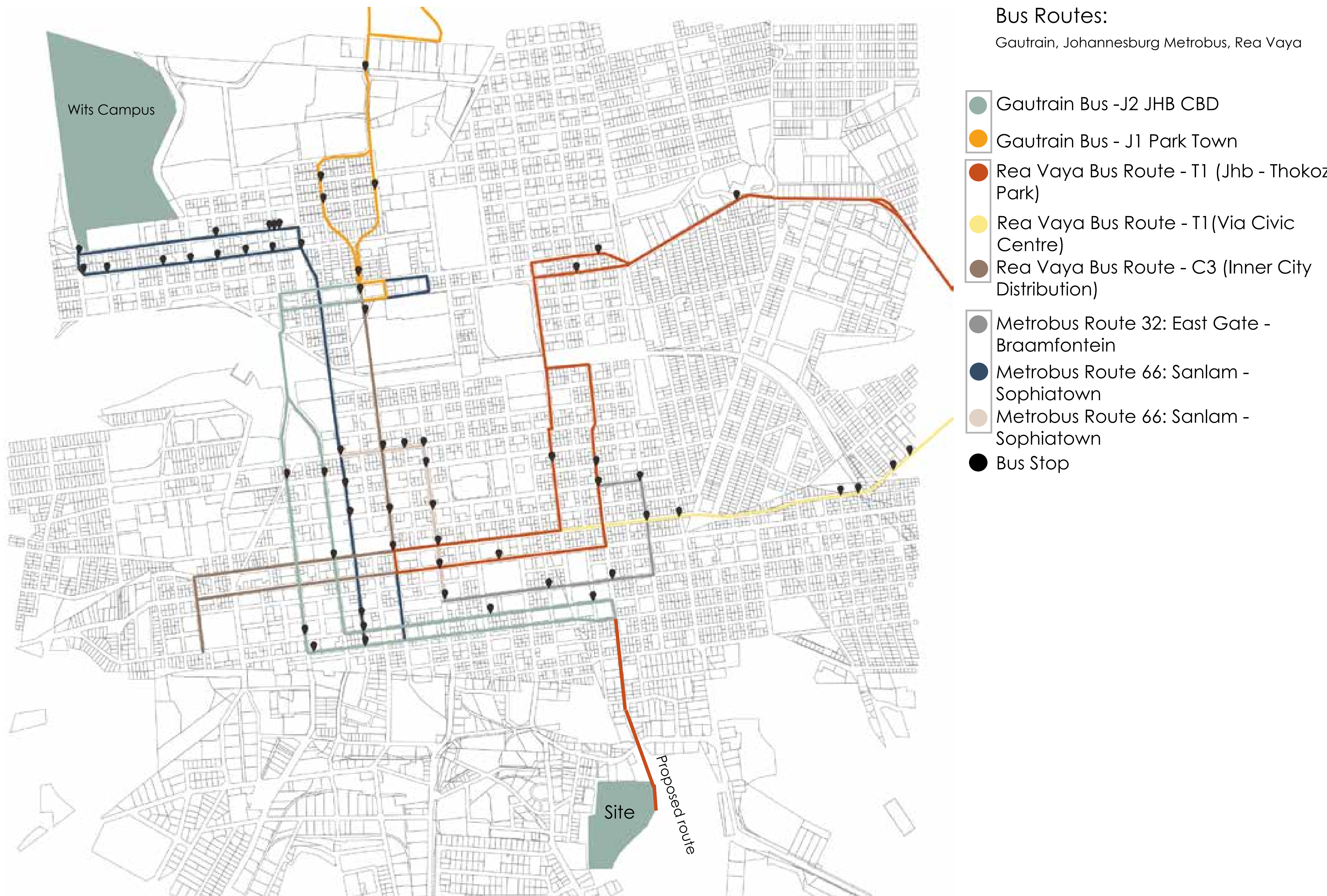
[4.2.3] Transport Analysis

Transportation planning generally involves access and circulation qualities, but as a project theoretically based on a sustainable journey it goes beyond the above factors. In this case a multi-disciplinary approach of public and employment access, environmental awareness and cost-effectiveness is need and also viable, because at the moment no public transport feeds the last kilometre to the site. To introduce the municipality of Johannesburg's environmental awareness to tourists and the media, a proposal regarding bus routes from the Wits Campus is suggested.



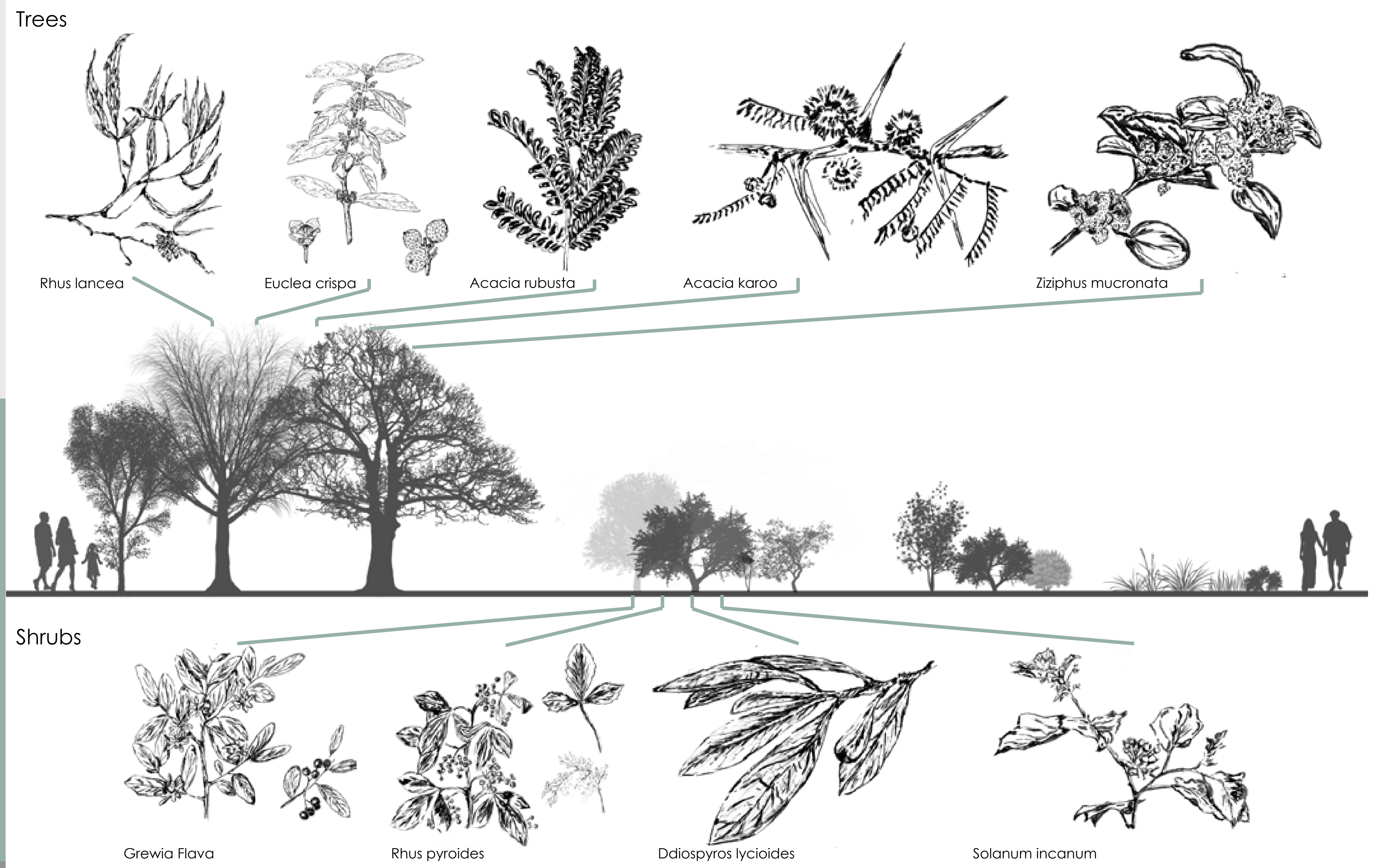
Johannesburg Transport
(Africa, 2014)

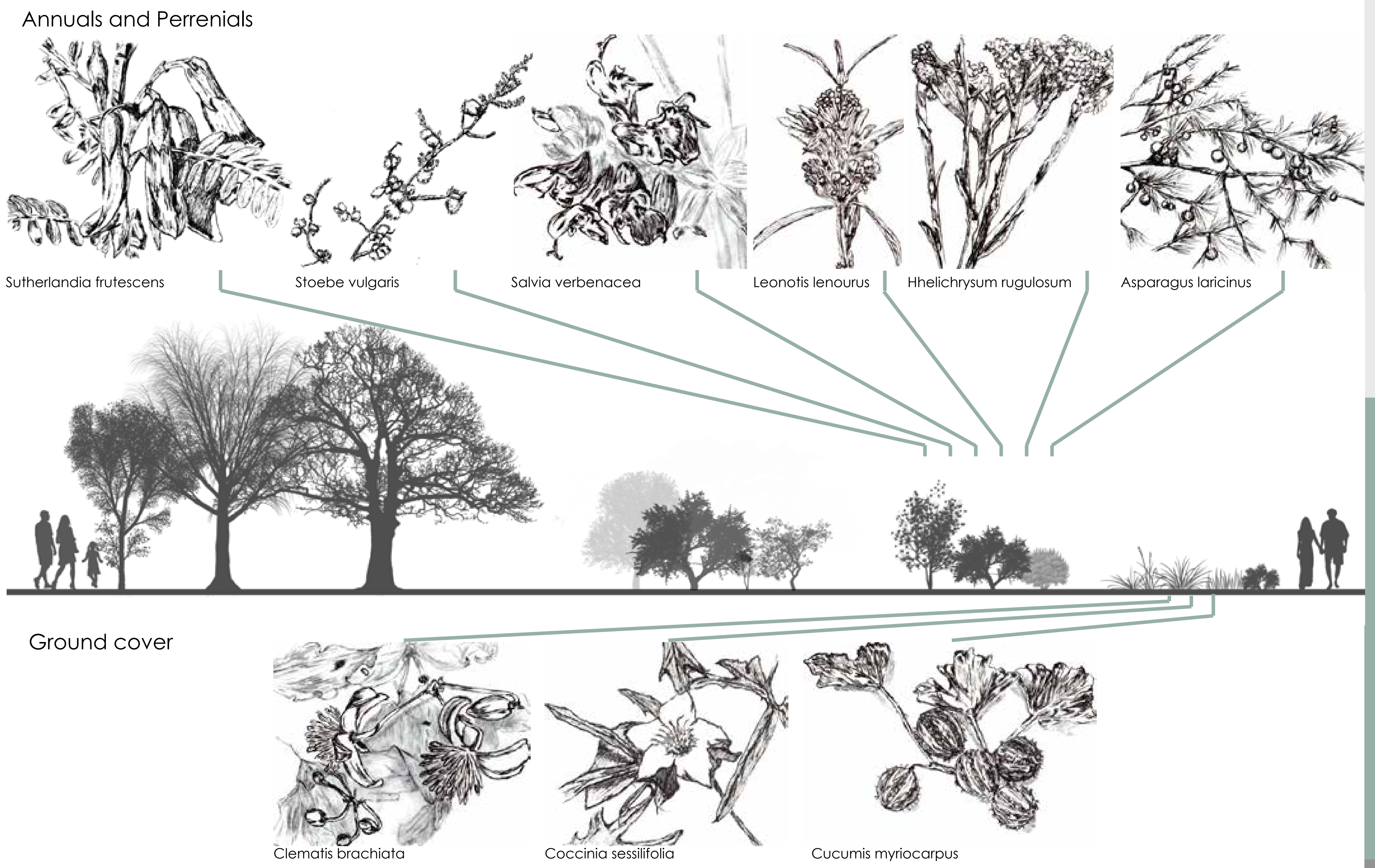
Grid indicating roads of Johannesburg



[4.2.4] Flora of the region

The built environment and infrastructure interact with the natural surroundings.
Indigenous landscaping can be used as a tool for sustainable urban development – it can be seen as reintroducing the natural heritage of an area.





[4.3.1] Texture on Site

When evaluating the suitability of a building site, soil texture is an important physical factor to consider. It can be a tool in achieving the feeling of the site and can thus be applied as a clue to the potential of the site.

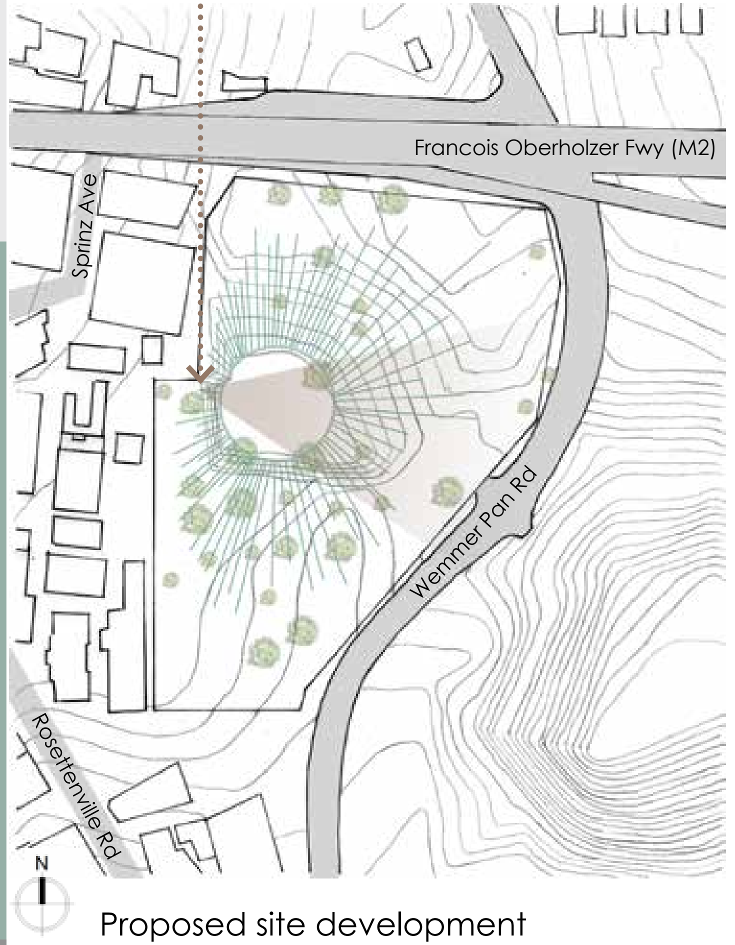
Hard	Medium	Soft
		
		
		

[4.3.2] Site Analysis

An in depth study of the site is a necessity to explore the full potential of the site. The structure and the site must form a unit to serve humans and to preserve the environment. To achieve this unity good building design responds to the inherent qualities that the site has to offer. It involves the views from and onto the site, the grid layout of the surrounding buildings, the contours of the site, wind direction over the site, the sun pattern on the site and the physical mine underneath.

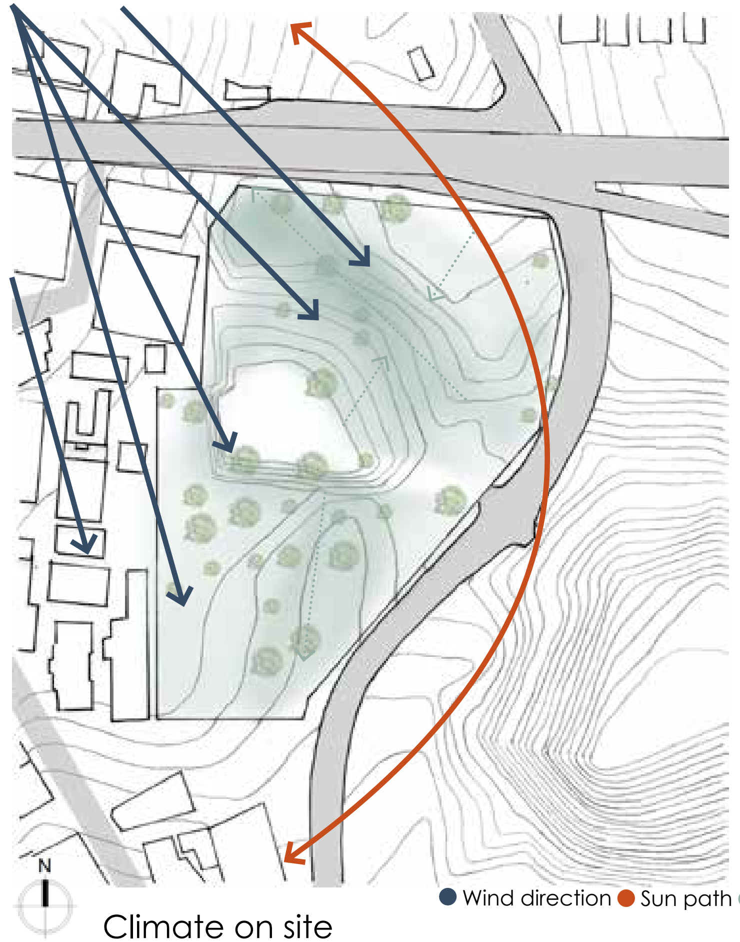
View on to site

Panorama on site



Proposed site development

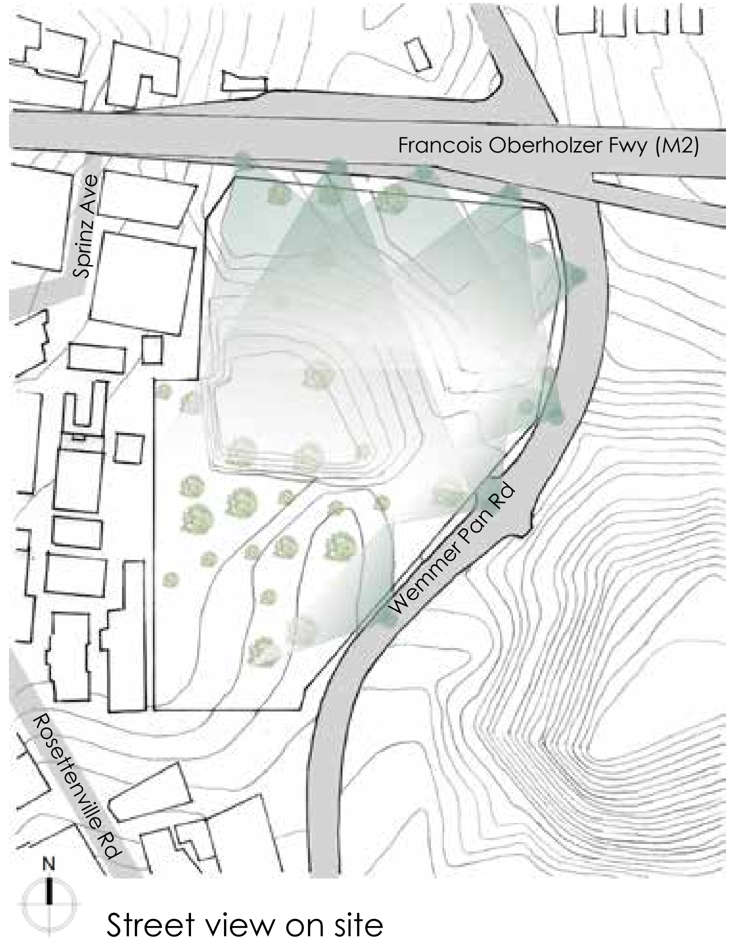
This proposed project forms a halfway house between an industrial area to the west and businesses to the north of the site, the CBD of Johannesburg, about 1.5km north west of the site, the Johannesburg Fresh Produce Market on the east (1.3 km from the site) and Wemmer Pan lying 2km in a southern direction from the site. Johannesburg's Turffontein Racecourse is west of Wemmer Pan. All these surroundings – as well as the sensory stimuli coming from the noise from the traffic – will have to be considered in forming an inclusive understanding to link the built fibre of all areal functions.



Climate on site

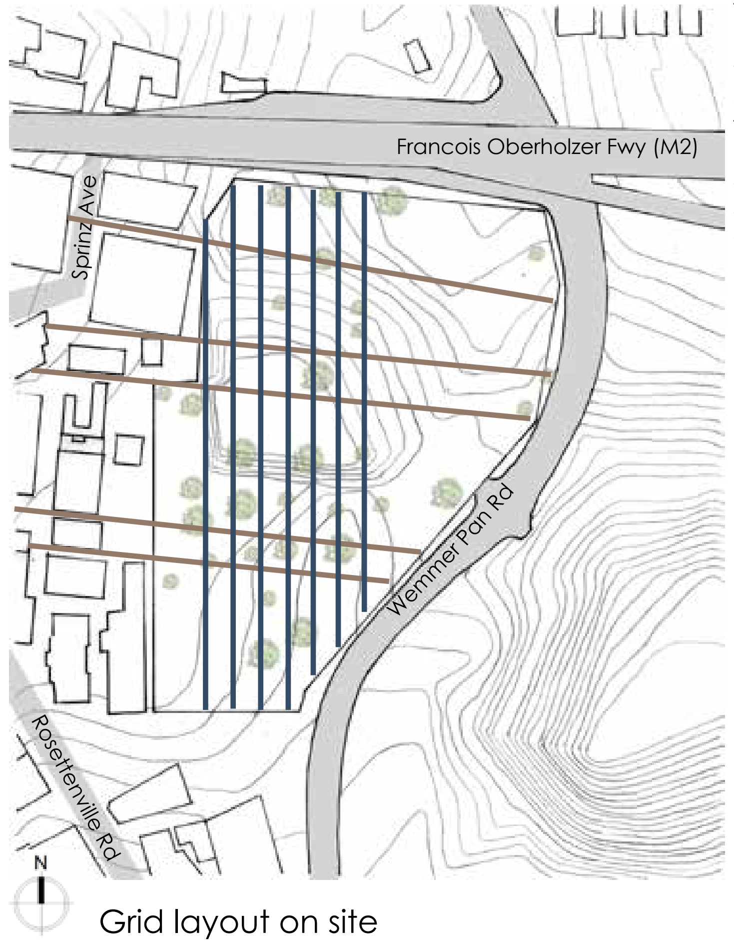
● Wind direction ● Sun path ● Drainage

The site is on a slight hill, therefore the natural drainage slopes towards the all sides. The site is 1753m above sea-level with a subtropical Highveld climate. The temperature ranges from 15 - 26°C in summer and 4 - 15°C in winter. Wind speeds vary from 3.2km/h to 27.3km/h on the site. The wind direction was measured on the site as mostly north to north west.



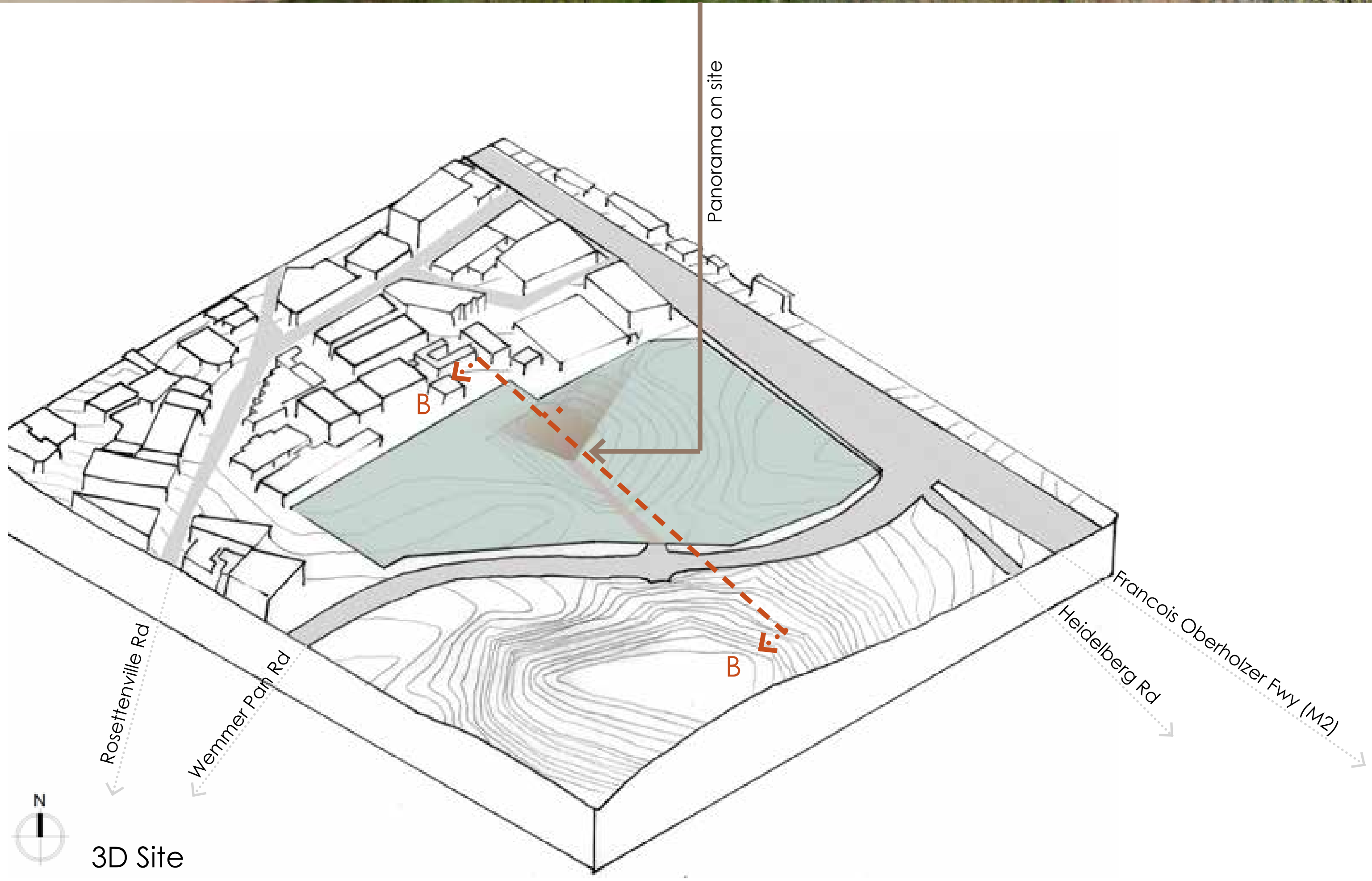
Street view on site

It is a very visible site where the M2 crosses the Wemmer Pan Road running north to south. The topography of Village Main allows for different visual experiences. The site falls about 10m towards the east and has a view over Wemmer Pan Road. It falls about 20m to the north, but the Francois Oberholzer Freeway (M2) is elevated and thus has a very good view onto the site.

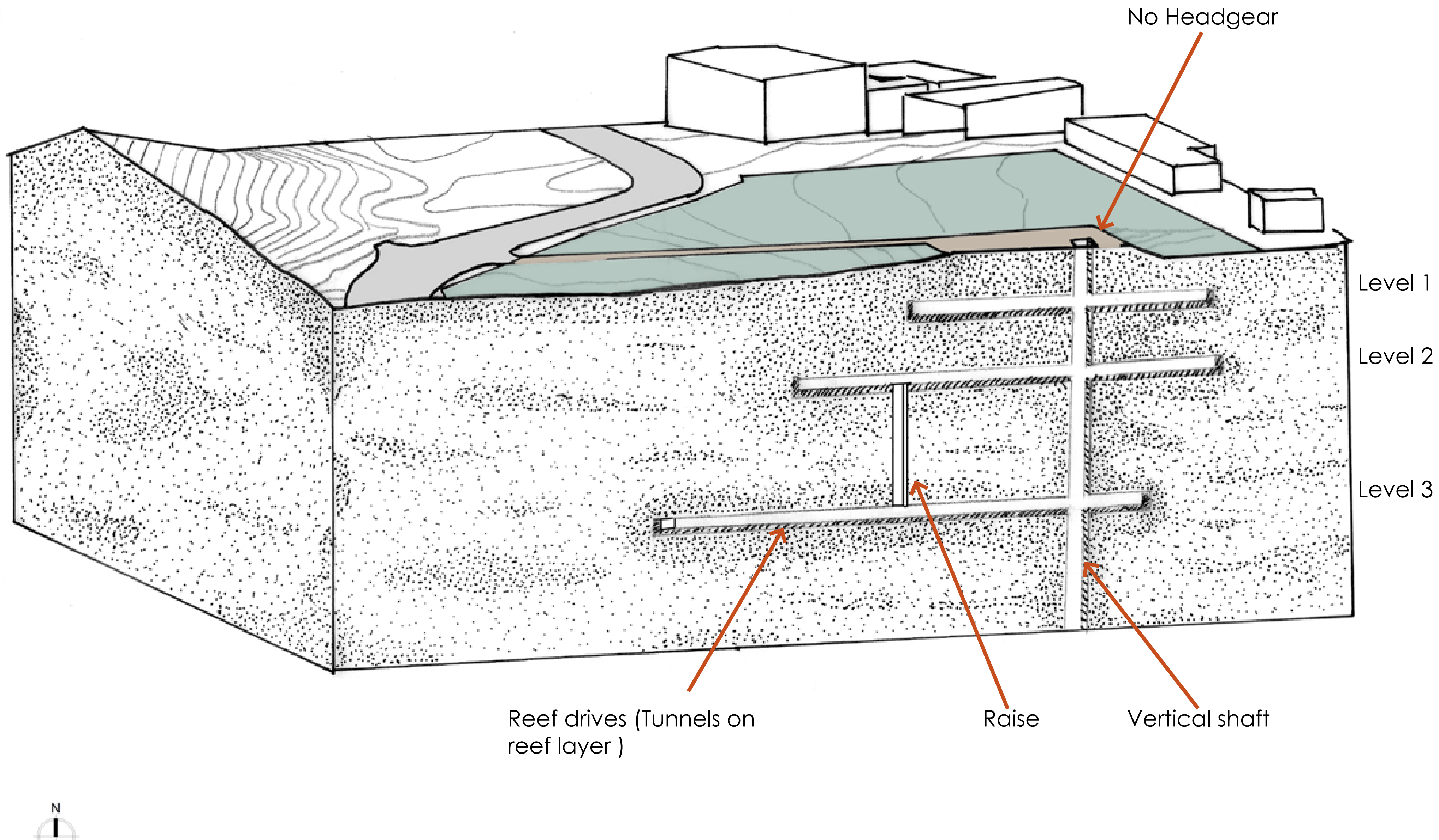


Grid layout on site

The CBD from the north and the industrial area from the west form a grid layout on the site. The blue lines follow the CBD grid layout and the brown lines follow the grid layout of the industrial area.



3D Site



Section BB

| Context

Precedents

05

[5.1] Analysed projects

[5.1.1] C-Mine Expeditie (NU architectuuratelier)
[5.1.2] La Tourette (Le Corbusier)
[5.1.3] Apartheid museum (Mashabane Rose Architects I GAPP Architects and Urban Designers et al.)

[5.2] Inspirational projects

[5.2.1] T Bailey Office (Tom Kundig)
[5.2.2] Castelvecchio (Carlo Scarpa)

Through the study of existing projects, building techniques, form, the use of materials and the innovative solution for design, structure and site problems can be studied.

[5.1.1] C-Mine Expeditie by NU architectuuratelier

Revitalisation of a depleted mine. Construction year 2012 in Genk, Belgium.

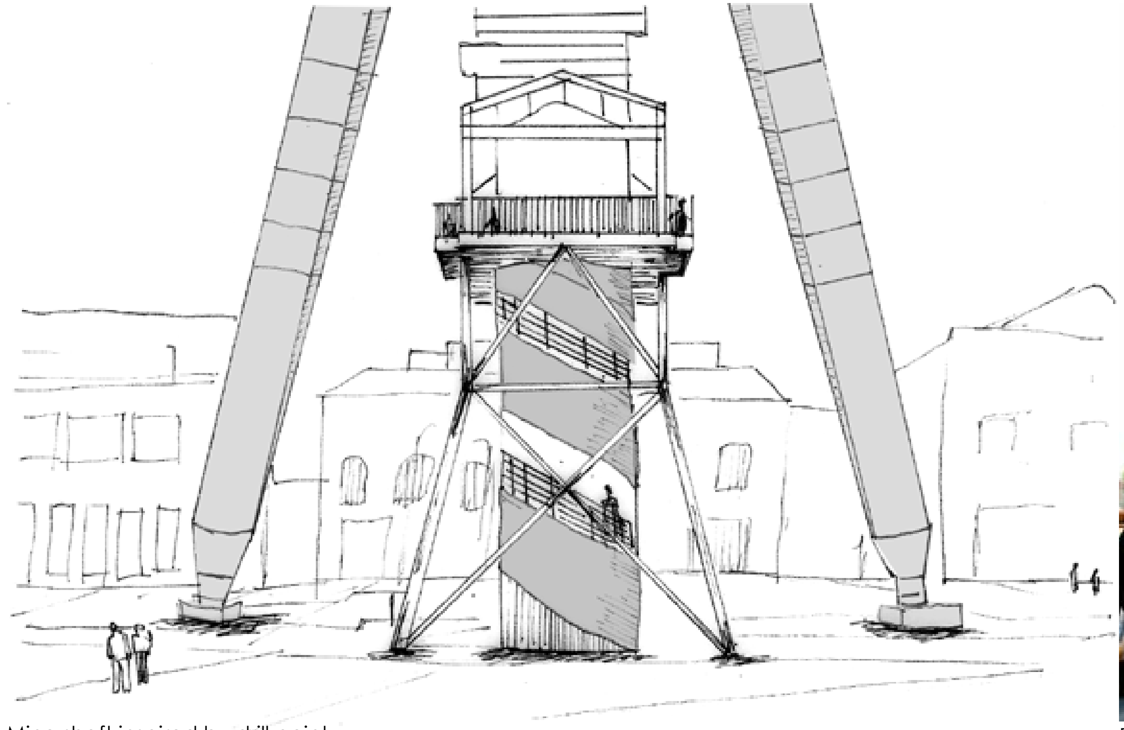
C-tour is the winning project of a competition for the design of an underground tourist attraction within an old mine-complex of Winterslag in Genk, Belgium. C-tour forms a tour under as well as above the ground. The focal point of this project is on the experience, made by linking some existing subterranean mine-industry constructions with new structures and tunnels.

The old ventilation shaft is the start of C-tour. In this shaft some new elements are implemented and organised in order to create new relations with the public square above the ground. These new elements also introduce the idea of creativity mixed into rough and functional spaces.

C-tour takes the visitors through a range of different disorienting spaces. It starts with a museum that carries out the memory of the mine-industry, continues to an art gallery and finally ends in a monumental staircase (ArchDaily, 2013: online).

(ArchDaily, 2013: online)

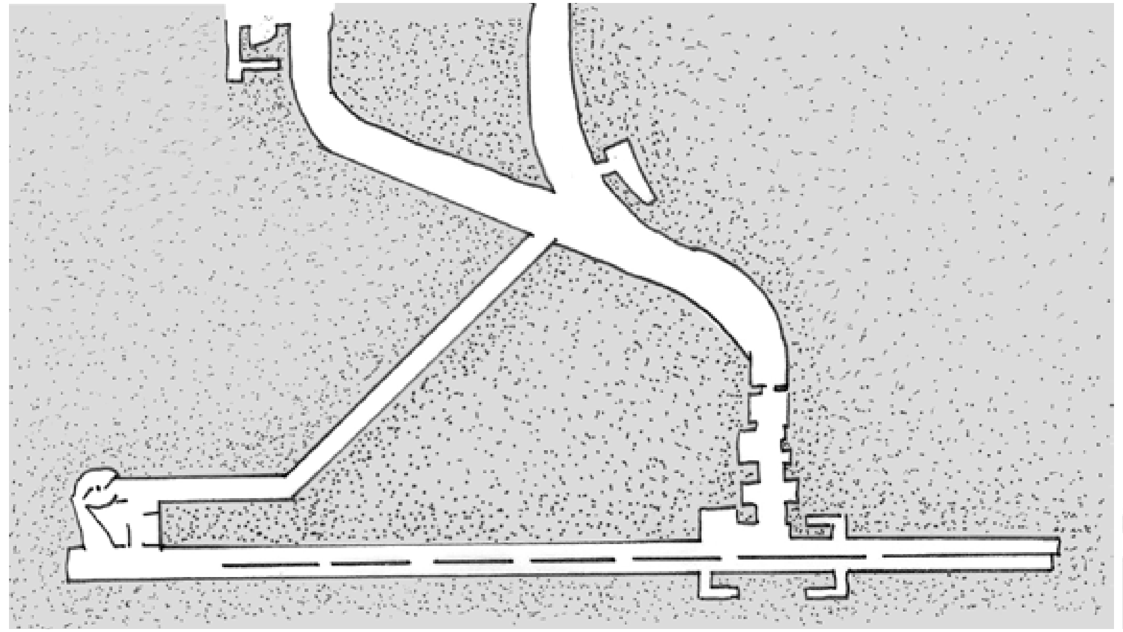
(ArchDaily, 2013: online)



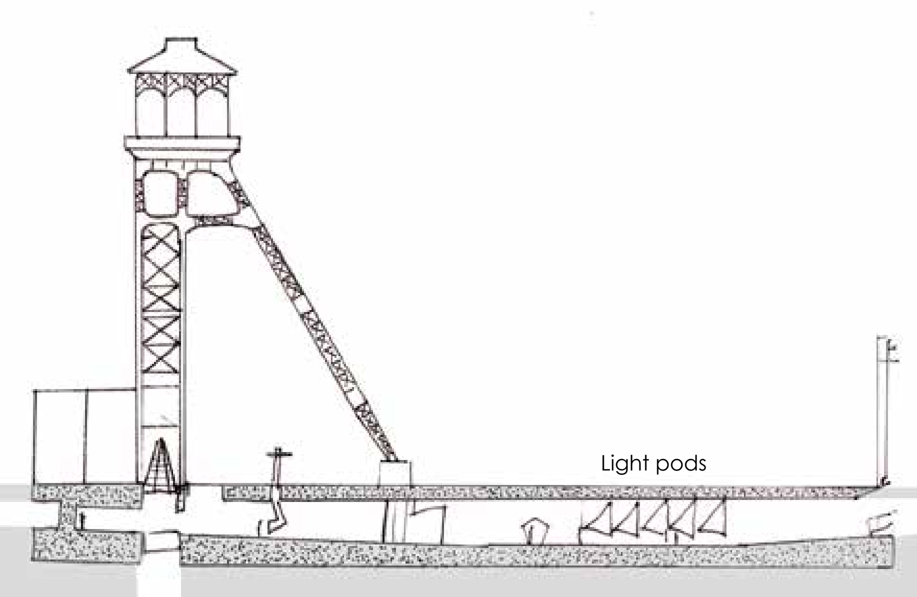
Mine shaft inspired by drill point.

(ArchDaily, 2013: online)

Restaurant at C-Mine Expedite.



Underground plan of tunnels.



Section through C-Mine Expedite.

[5.1.2] La Tourette by Le Corbusier

Natural light is a dynamic tool for expressing the quality of space. Construction took place from 1957 to 1960 in Eveux-sur-Arbresle, near Lyon, France.

The Convent of La Tourette is Le Corbusier's last building completed in Europe. The one request from Father Marie-Alain Couturier to Le Corbusier was that he must "create a silent dwelling for one hundred bodies and one hundred hearts." Le Corbusier chose this site to create an introvert building style which still connects with the environment with maximum views of the steep sloping bank (Sveiven, 2010).

The five key elements of Le Corbusier are present in the Convent of La Tourette (Glynn, 2004: online):

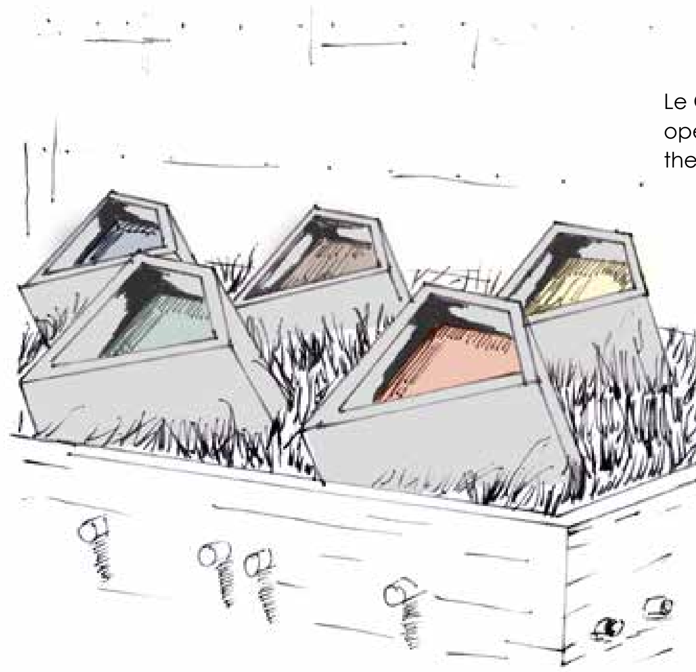
- The pilotis inside the walls freeing the façade of the walls
- Long strip windows.
- A plan around a courtyard.
- A free façade. As the walls were deprived of the usual constructional role, their design became free as well.
- The grassed rooftop.

La Tourette – built as a chapel, a residence for a hundred souls and a place of learning – groups around a central courtyard. The court is closed off by the chapel at the end. The main entrance is on the eastern elevation on the upper slope and leads to the U-shaped residence. The circulation connects all the parts from the residence on the top two floors down to the atrium. A ramp, a concrete corridor with uneven yet rhythmic glazing, leads down to a metal wall that rotates to enter the church.

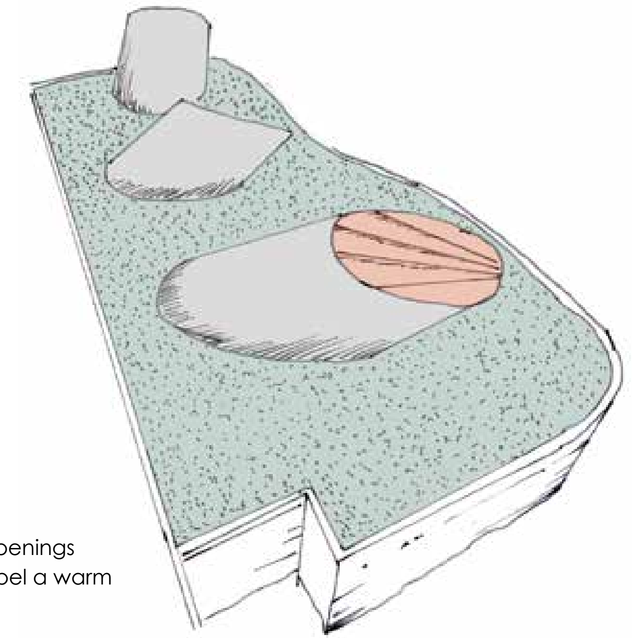
The structural frame is of rough reinforced concrete. Panes of glass cover three of the exterior faces with a flowing glass surface (Henze & Moosbrugger, 1966: 11-14).

(Glynn, 2004: online)

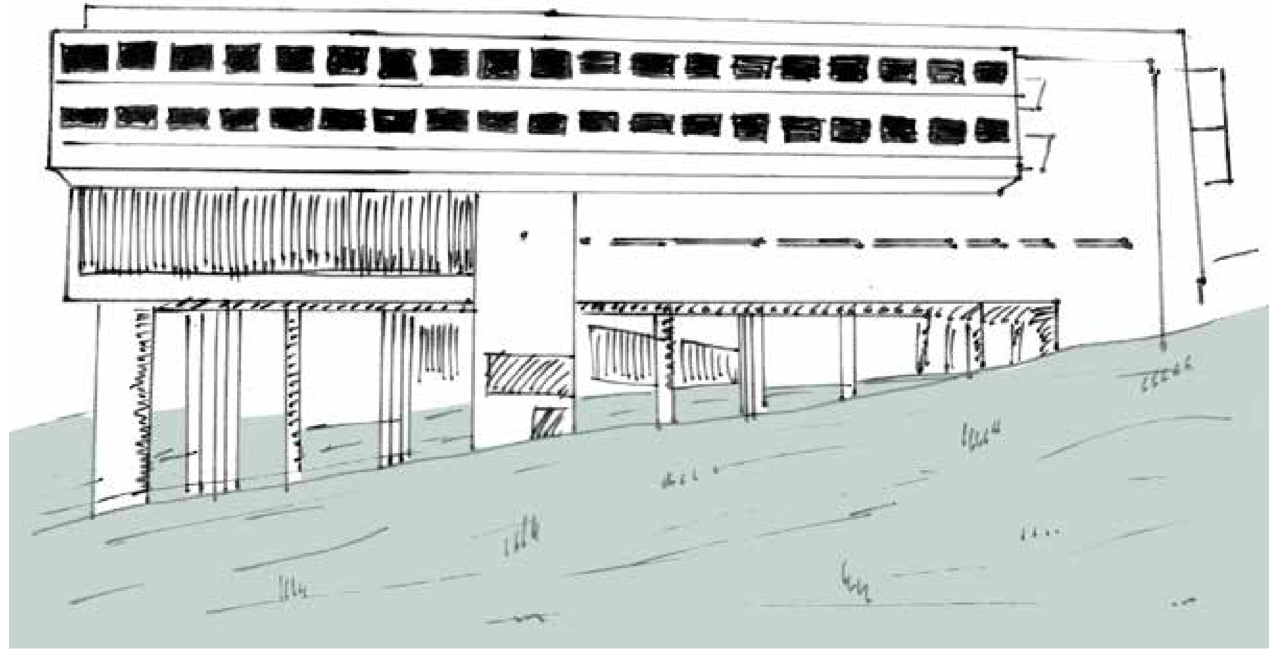
(Glynn, 2004: online)



Le Corbusier used different shaped openings to regulate light falling into the chapel of La Tourette.



Different colours in these openings give the interior of the chapel a warm and lively atmosphere.



Northern elevation of La Tourette.

[5.1.3]Apartheid museum (Mashabane Rose Architects I GAPP Architects and Urban Designers I Britz Roodt Association I Linda Mvusi Architecture and Design

The Apartheid Museum is approximately 2km from the geothermal centre. Completed in 2001 in Johannesburg.

An architectural consortium, comprising GAPP Architects and Urban Designers, Britz Roodt Association, and Linda Mvusi Architecture and Design, conceptualised the design of the building (Mashabane Rose Associates, [s.a.]: online).

The site is located in an industrial and mining zone south-west of the CBD of Gauteng and to the east of Soweto, adjacent to the Gold Reef City theme park and the Casino. The complex connects with its context. The strange juxtaposition reinforces the notion of segregation of the Apartheid system. The landscape, dotted with mining structures, is harsh and gives the impression of devastation due to neglected industrial usage.

The landscape has been shaped with earthworks, some to a height of twelve meters above the ground level of the building. The site was shaped to form a gulley from which the building emerges and the adjacent landscape is formed by a stylised recreation of the typical landscape.

Materials are used honestly and form part of the voyage – off shutter concrete, rough plastered walls, red brick walls, exposed concrete ceilings, gabion baskets with rusting frames, and floor finishes of raw screed were used (GAPP Architects and Urban Designers, 2014: online).

The reception area provides a guide to the museum. Adjacent is a large auditorium with a continuous 15 minute documentary. An exhibition hall with displays of international occurrences of discrimination can be visited. This is also a turning point from which the full length of the museum is viewed down an internal walkway back to the point of previous arrival. The services are also channelled along this route forming a spine that leads the eye down a series of platforms (Mashabane Rose Associates, [s.a.]: online).

The shared techniques of an understanding of form, space and light remind visitors that while they can see the landscape, it deliberately remains out of reach all along the journey.

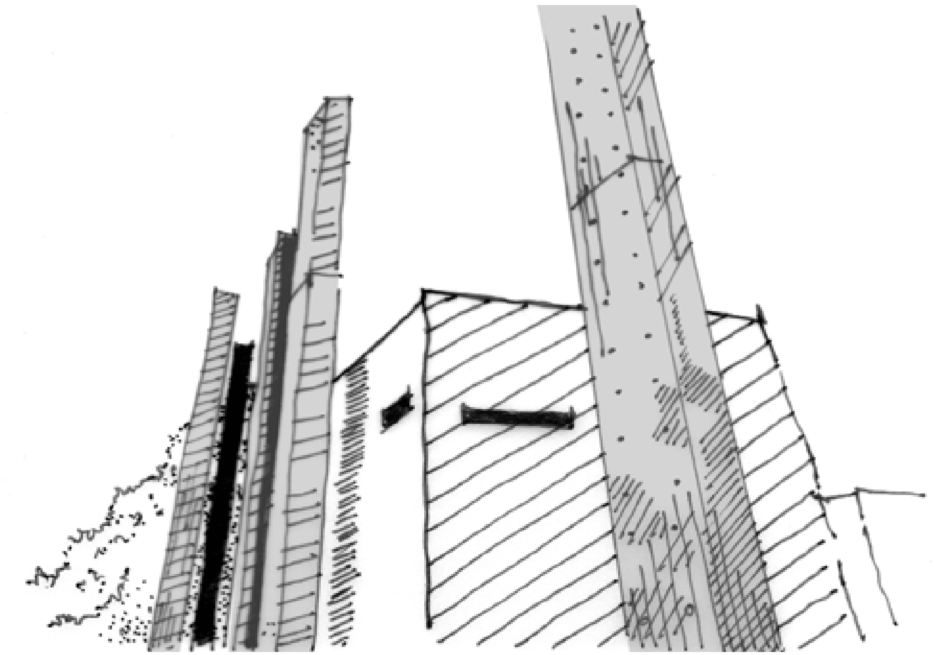
Visitors, randomly classified as "white" or "non-white", start their journey through a heavy galvanised steel, industrial turnstile.

(Mashabane Rose Associates, [s.a.]: online)


(Mashabane Rose Associates, [s.a.]: online)


(Mashabane Rose Associates, [s.a.]: online)


A 120m ramp with a gabion wall: As visitors walk up the ramp, posters of indigenous people are placed in such a way that the feeling of making this voyage along with them, is conveyed. The high gabion wall creates the illusion of closure and restraint.


The seven 15 metre columns in off shutter concrete represent the seven pillars of the constitution.

5.2 Inspirational projects

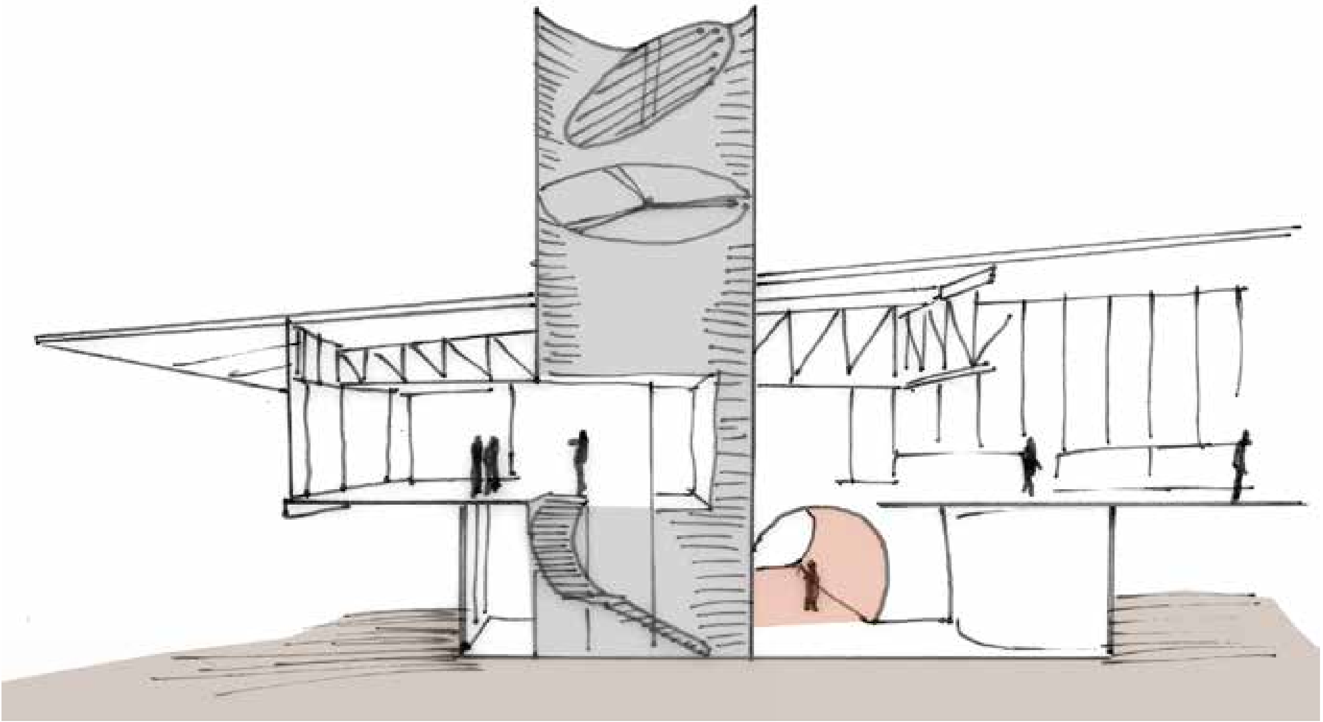
[5.2.1] T Bailey Office Tom Kundig

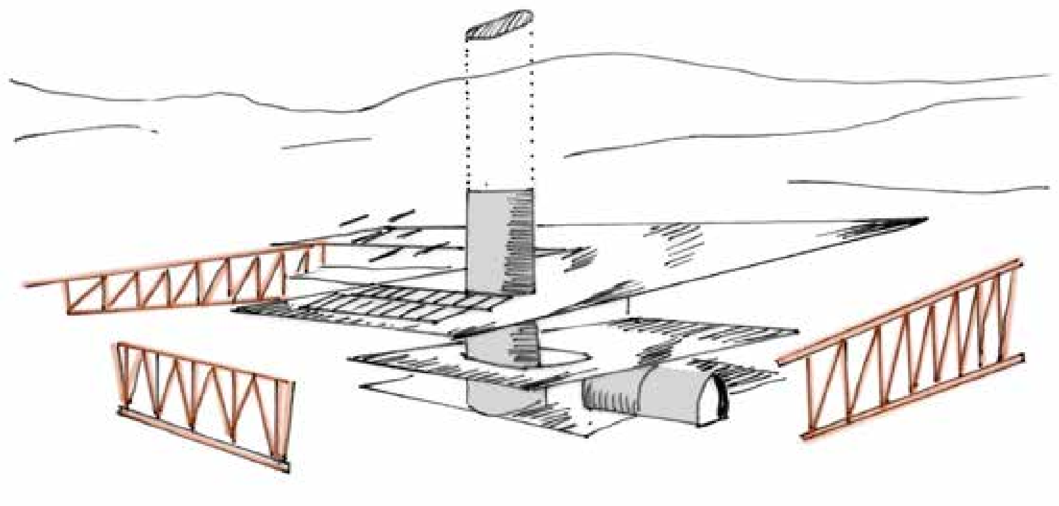
In Kundig's buildings a fusion of industrial harshness and an aesthetic balance can be experienced. Construction year 2011 in Anacortes, Washington State

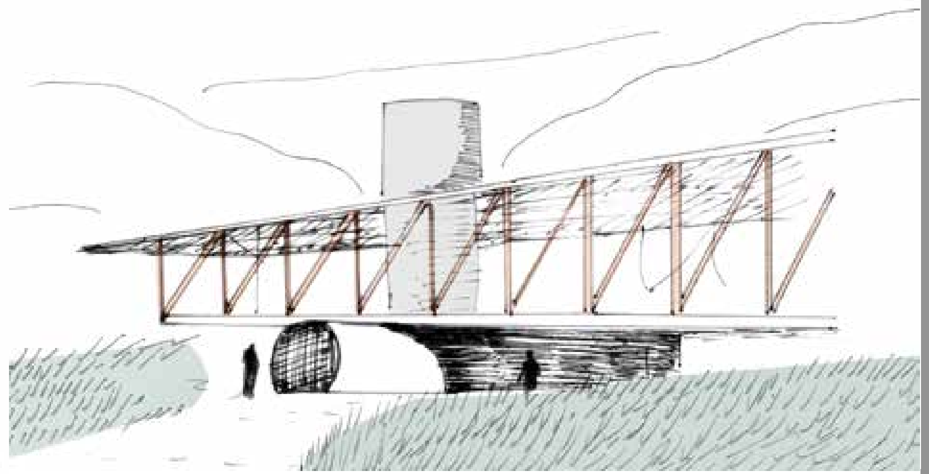
Tom Kundig of Seattle studio Olson Sundberg Kundig Allen Architects has designed an extension to the headquarters of a steel pipe factory; T Bailey Inc. Kundig uses the giant pipes of the client as architectural elements. These pipes are made at the facility and are usually used to make wind turbine towers.

Materials are unfinished – concrete floors, unfinished steel and an exposed structure – which give the space a raw yet aesthetic character. With this design of Kundig construction becomes architecture (Olson Kundig Architects, 2014: online).


(Olson Kundig Architects, 2014: online).


A pipe functions as a chimney for ventilation.


Exploded view of the structure.


The structure is exposed to become architecture.

[5.2.2] Castelvecchio by Carlo Scarpa

Scarpa's buildings are an inspiration where complexity and detail is concerned. Construction started in 1354 in Verona, Italy with Forlati renovations in 1923. Scarpa's reconstruction period: 1959-73

An inspiring example of preservation.

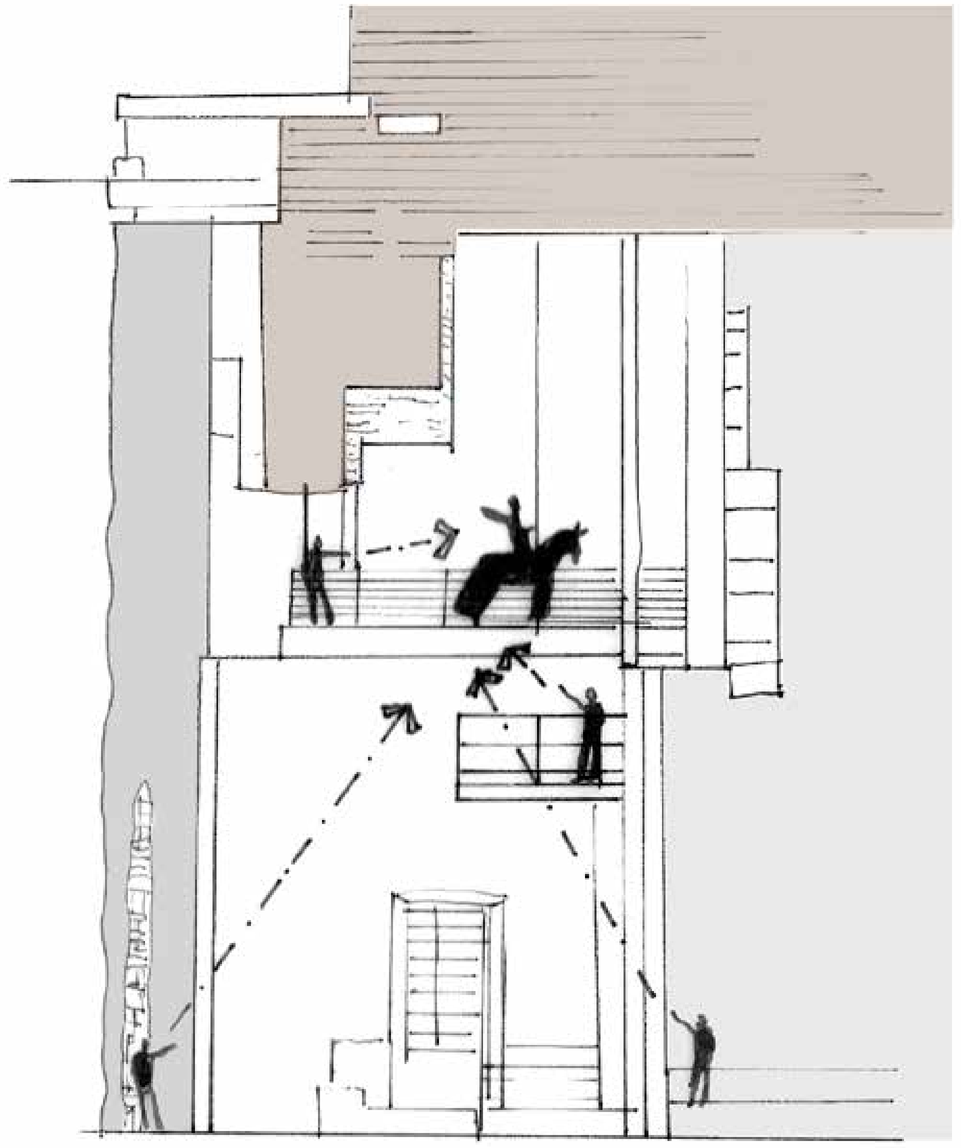
Castelvecchio is a medieval fort in Verona. It was constructed as military housing for the lords of Verona in the 14th century. Later in the 18th century Napoleon demolished portions of it and had a wing added to it for his troops. It was changed to a museum in 1923 and the design was done by the architect Forlati. His idea was to make it a place of culture that it never was by adding fake beams, making fountains, and turning the barracks facade into a late Gothic style façade. The authentic frame has been preserved, but the architecture now told a false story.

In 1958 the museum underwent a total restoration with the idea to restore its authentic history. Scarpa wanted to tell the true story of Castelvecchio – without nostalgia or exaggeration. He saw that the history of Castelvechio was more important than the forms of the architecture, but he realised that these histories are revealed through its architecture.

Scarpa exposes the decorations that Forlati added like a theatre stage set by pulling doors and windows back from the Gothic facade. He also heightens this awareness by moving the entry from the formal centre to the end. The museum art objects are taken out of context by placing them on floating planes to indicate that the building forms a backdrop to the artefacts. Thus the architecture becomes part of the exhibition (Buxton, 2013: online).

(Buxton, 2013: online)

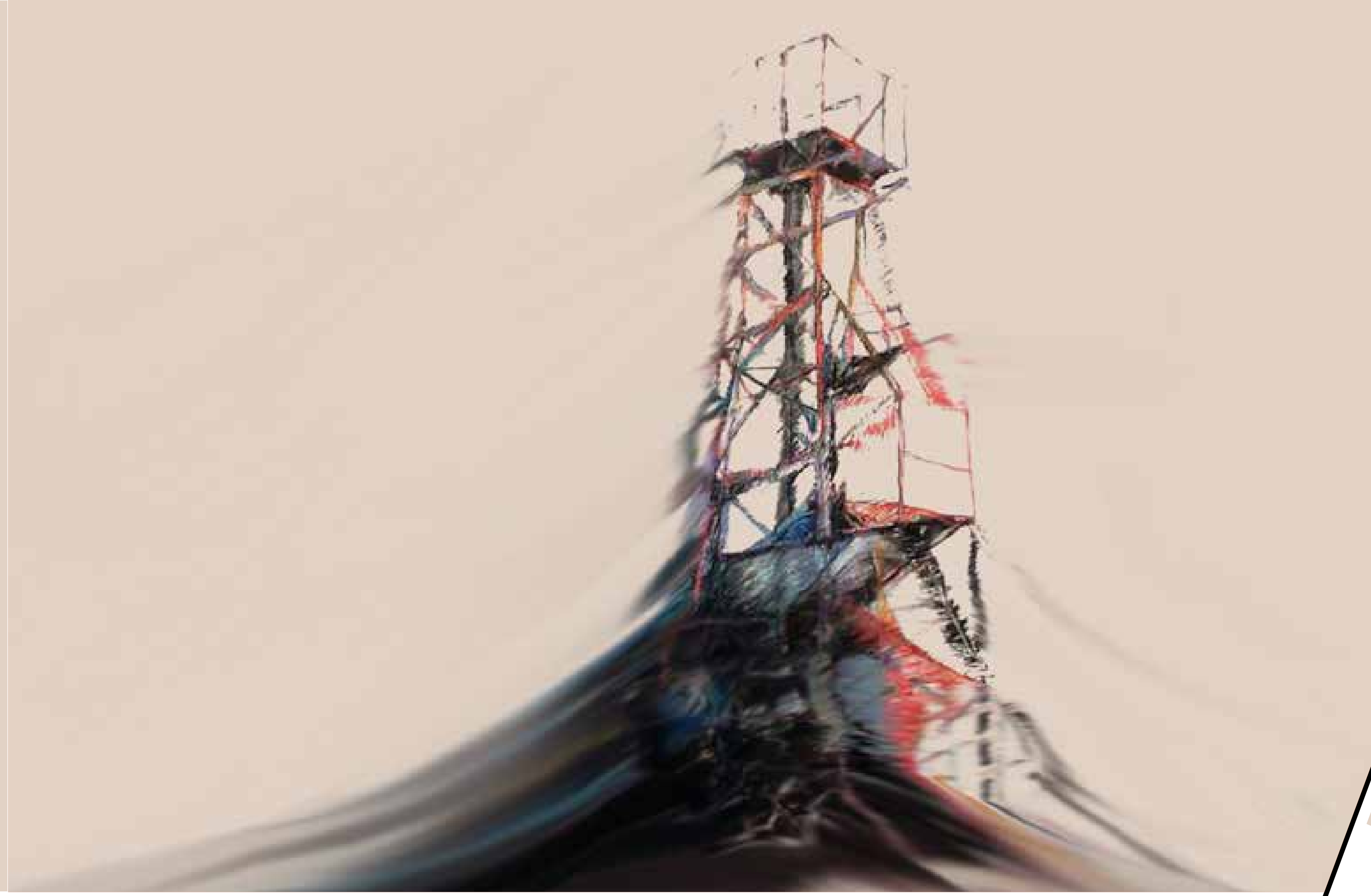
Castelvecchio shows how Scarpa's architecture is based on juxtaposition and the reconnection of spaces by the deliberate exposure of Forlati's renovations. His architecture tells a story of the different layers of history.



(Buxton, 2013: online)

Scarpa frames the Equestrian Statue of Cangrande in the courtyard from different views. Scarpa preformed select demolitions and peeled back roofs to reveal layers of history in dialogue. He used modern materials in expressive ways to mediate between different eras. The point at which two points meet can often be perceived as a problem. Scarpa addressed this problem as an opportunity of providing detail as this joint.

Accommodation



06

6.1 Facilities

Public Spaces:

Reception:	Foyer of building where visitors receive information.
Kitchen: Lounge: Outside Lounge:	Cafeteria for visitors and staff where refreshments can be bought. Kitchen supplies the cafeteria. The outside lounge is a smoker's area.
Rest room:	Each level has a rest room. The rest room at subfloor level contains lockers for staff members.
Information Centre:	All information of the geothermal process and the energy it provides.
Auditorium:	160 seater that can accommodate lectures, meetings and conferences.
Foyer to auditorium:	Waiting Area.

Semi-public Spaces:

Computer room:	For the use of students for designing, research and computer software purposes.
Library:	Research purposes.
Offices:	Three offices and one open plan office proving working space for 6 people. One head office adjoining a secretary office.

Private Spaces:

Laboratory:	Research and water test centre.
Medical facility:	Base for medical officer.
IT room:	Two IT rooms necessary for operation of geothermal plant.
Mine Shaft:	Restored mineshaft. It is not open to the public. All the mechanical controls of the lifts and pipelines run in the shaft.
Head gear:	The tower is necessary to operate the mine shaft.
Workshop:	Two workshops where equipment can be checked, fixed and instruments and tools can be stored.

(On.is, 2014: online)

The Hellisheiði Power Station in southwest Iceland, only a 30 minutes' drive from Reykjavik, the capital of Iceland. It is the largest geothermal power station in Iceland. Almost 30% of the energy in Iceland is produced by geothermal power plants due to high concentration of volcanoes in Iceland. In addition, geothermal heating meets the heating and hot water requirements of approximately 87% of all buildings in Iceland (On.is, 2014: online).

6.2 Accommodation list

Site

Parking bays:	120
Disabled parking bays:	5
Bus parking bays:	2
Total Parking bays:	127
Total Parking area:	**885 m ²**

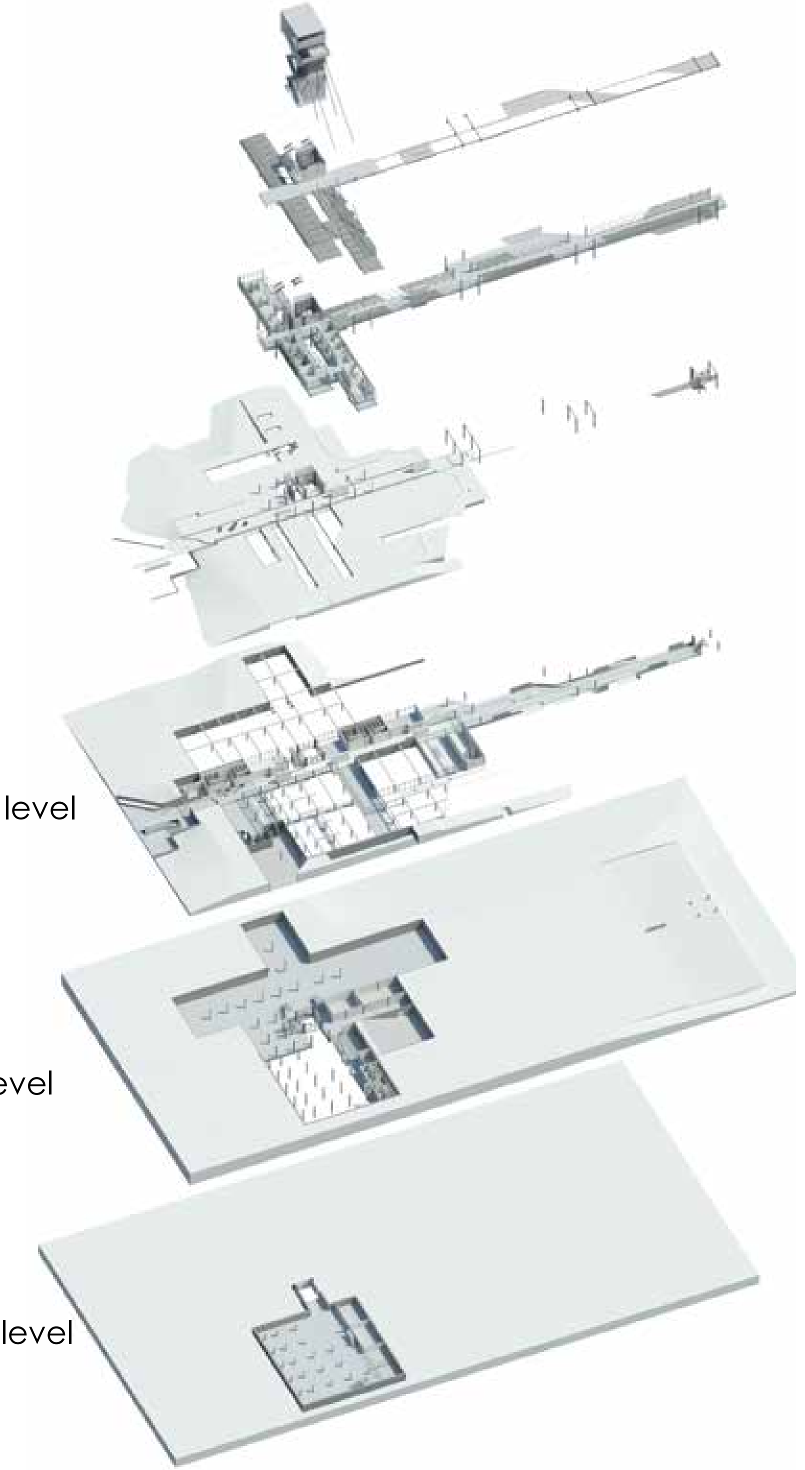
Guard Hut:	Toilet	2 m ²
	Locker	2 m ²
	offices	9 m ²
Total Guard hut :		**13 m ²**

Headgear

Head gear structure (25 m ² x 10 levels)	250 m ²
View point	25 m ²
Total	**275 m ²**

Level 2

Open office plan	25 m ²
Offices x5	61 m ²
Laboratory	119 m ²
Restroom no. 4	54 m ²
Conference room	24 m ²
Tea room	19 m ²
Mine shaft	25 m ²
Under roof Total	**327 m ²**
Walkway 100m x 4m	400 m ²
Total	**727 m ²**



Ground floor level

Reception	25 m ²
Kitchen	61 m ²
Lounge	119 m ²
Outside Lounge	54 m ²
Restroom no. 3	24 m ²
Lecture room no. 1	59 m ²
Mine Shaft	25 m ²
Information center	42 m ²
Lecture room no. 2	59 m ²
Auditorium	222 m ²
Foyer to auditorium	97 m ²
Restroom no. 2	24 m ²
Computer room	112 m ²
Library	66 m ²
Passage	361 m ²
Under roof Total	**2103 m ²**
Walk way 100m x 4m	400 m ²
Geothermal plant:	
Separators	486 m ²
Turbines	105 m ²
Transformers	102 m ²
Pressure release	82 m ²
Cooling tower	153 m ²
Out side Total	**1328 m ²**
Total	**3431 m ²**

1st Subfloor level

Medical facility	16 m ²
Restroom no.1	
Locker Room	24 m ²
Workshop	37 m ²
Machine room	50 m ²
Storage room x1	25 m ²
Mine Shaft	25 m ²
Mine winch x4	85 m ²
Total building	**262 m ²**
Geothermal plant:	
Injectors	100 m ²
Water testing	60 m ²
Pressure controllers	46 m ²
Test controllers	135 m ²
Total	**603 m ²**

2nd Subfloor level

Workshop	30 m ²
Machine room	30 m ²
Storage room x2	40 m ²
Mine Shaft	40 m ²
Total building	**140 m ²**
Geothermal plant:	
Pumps x2	143 m ²
Injectors x2	42 m ²
Total	**322 m ²**

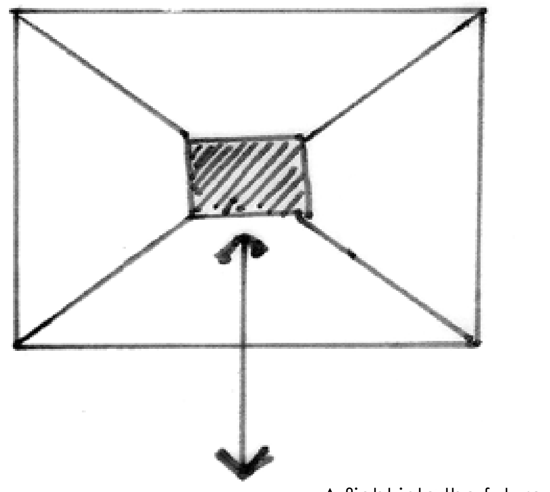
07

Theoretical Investigation

7.0 Journey

A Flight into the Future via a Sustainable Journey...

At the start of this project there was a constant negative attitude that it would not work in South Africa, and the essay "Three kinds of Historicism" from Alan Colquhoun came to mind (Colquhoun, 1996: 200). Colquhoun argued that the historian regards architecture and all human endeavours from the perspective of historicism. Historicism not only emphasised the "laws" of history and nature, but also the individuality of each historical situation. Humans and their institutions are not seen under the same category as organic studies, because human reason is not a true reflection of the absolute truth – it is a reflection from a background of traditions and customs that a period developed and is also influenced by geography.



A flight into the future.

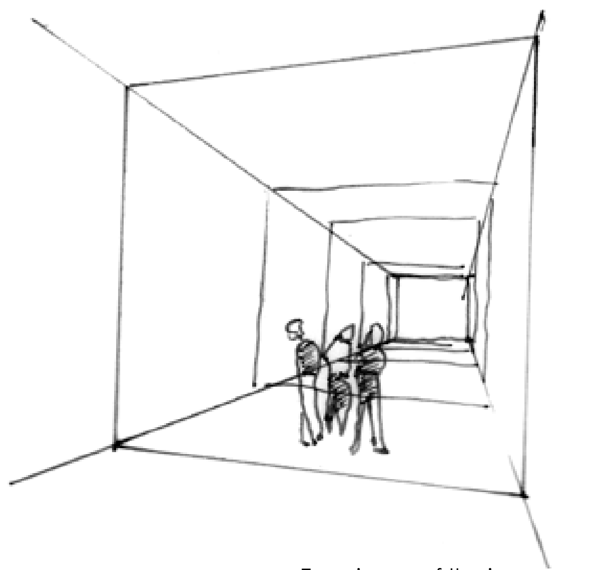
Friedrich Meinecke points out that a flight to the future is one way the historian can overcome relativism implications (Colquhoun, 1996: 203). All cultures are not just measured against themselves with a solid idea, but are also measured in terms of potential ideas, in other words: where does it lead to? For art and architecture, this flight into the future is quite a godsend way of looking at creation, because they can express their work in the spirit of the time given without looking back. C-mine Expedite of NU architectuuratelier creates a physical illustration of Meinecke's idea. The futuristic double helix staircase at the end of the tour brings the visitors to the top of the highest shaft-tower of Belgium which allows for a magnificent view of the surrounding landscape and the whole industrial site (ArchDaily, 2013: online). In architecture Meinecke's idea of a flight into the future means a constant creation of new forms of social and technological development. This is especially true in context of new developments where the overall view is that the idea would not succeed.

The question, "how can development be propelled without neglecting the past?" leads to the idea of connections and the following questions can then be asked:

- Is the past a necessity for place-making and for rebirth?
- Does dwelling on existing creations have an impact on future development?
- Will society benefit from this rebirth?
- Does revival and rebirth in this particular case make sense?

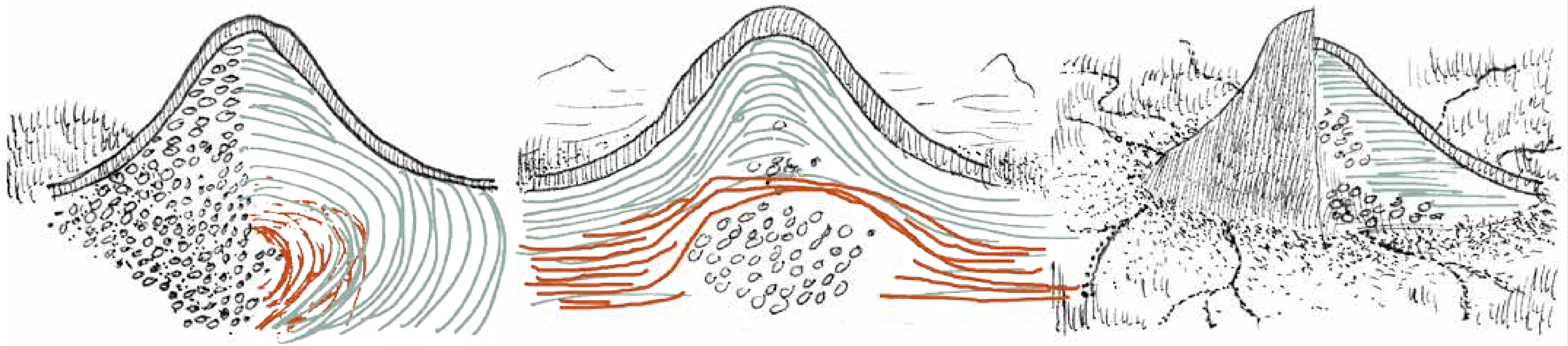
Connections defined as a relation between ideas, people or objects are necessary in joining proposed architecture to the history, typology and topology of a certain place. When looking at the essay "In case of the Tectonic" by Kenneth Frampton it could lead to answers for the previous questions. Frampton argues in his essay that Scarpa sees architecture as an art form, because the joint plays such an important role in architecture (Frampton, 1996: 516-520). He calls this connection the place where construction and a symbolic statement of architecture takes place. Scarpa's intervention at the Castelvecchio can be seen as a mediator between the past and present, between art and architecture, and also as commentary, allowing all parts their own authenticity (Buxton, 2013: online).

In the touchstone of this project this joint can be experienced on several levels: the joint between the stereotomic mass and tectonic lightness that also addresses Heidegger's fourfold of earth, air, deity and mortality (Bloomer & Moore, 1977: 78). Secondly the joint is observable in the connection between man and machine and also between a moment and on-going movement. It symbolises the question "where am I?", not only in relation to place, but also in relation to history, the present and future developments. In short, all these connections and ideas of revival give way to a journey – a journey from and through the past with extended journeys undertaken between man, his environment, science and art to culminate in a work of architecture that can carry the past and present into a sustainable future. Sustainability is the only way to undertake a flight into the future as a future-oriented travel cannot be built on a vacuum. The architecture of the Apartheid Museum offers a collective journey of memories of the rise and fall of Apartheid. This journey would not have been possible without preservation (Mashabane Rose Associates, [s.a.]: online).



Experience of the journey...

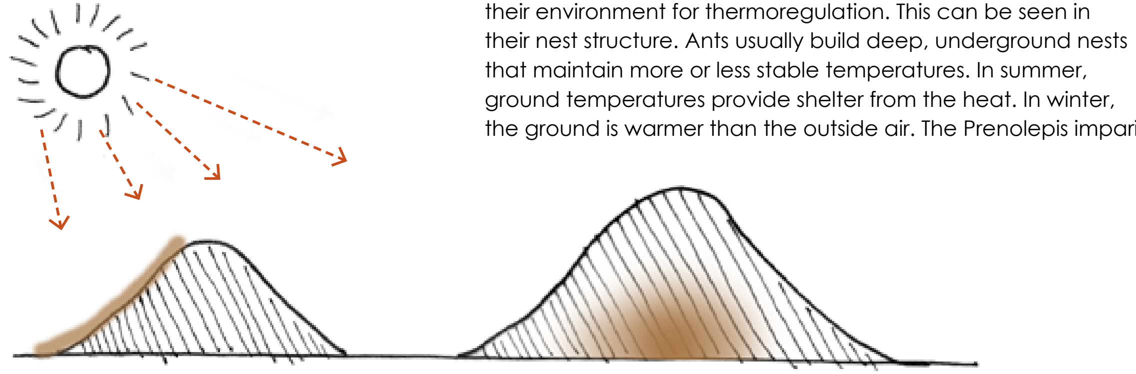
Michelangelo Pistoletto not only contributes to the idea of a connection between aesthetic and ethics, but also paves the way for the thought of man only being part of the bigger picture. In 2003 Pistoletto wrote "The Third Paradise" manifesto. The basic idea of the "The Third Paradise" is the overcoming of the current worldwide conflict between the two polarities of nature and artifice. The Third Paradise is symbolically represented by a reconfiguration of the mathematical infinity sign. In the



The constant temperature of the nest of the winter ant.

three circle "New Infinity Sign", the two outer circles represent nature and artifice and the middle one – the joint – represents the fertile connection of the Third Paradise (Digital-Life-Design, 2013: online).

In the early 1960s, while Pistoletto was painting his self-portrait, he noticed everything else that was also reflected in the mirror. He realised that his face was just a part of all the images in the mirror. He explains his work as follows: in the contemporary world Art cannot just deal with Aesthetics. It also has to take Ethics into consideration. Pistoletto used different artistic forms; painting, sculpture, installation and performances. In everything his basic idea of a socially involved art turned into that of the art as a means to actively experiment, implement and promote social responsibility (Digital-Life-Design, 2013: online).



Thermoregulation of antnests.

Baron Anthony Giddens, a British sociologist, joins Pistoletto's idea of social responsibility. Giddens takes the view that we are confronted by a universal problem – that of the survival of humanity. Giddens argues that man does not have to save the planet with little green movements, for the earth and nature will look after itself – albeit at the expense of humans. He believes that man should create a future in which the civilisation of the world is to be sustainable (IIEA1, 2010).

Maybe attention to nature to assure man's survival became necessary. Research teaches us about the sustainable journey of an ant. Ants use their internal energy to revive from the egg, the larva, and the pupa on their journey to adulthood. Ants also have the remarkable ability to dwell underground and to take to the sky to ensure reproduction (AntWeb, 2014: online).

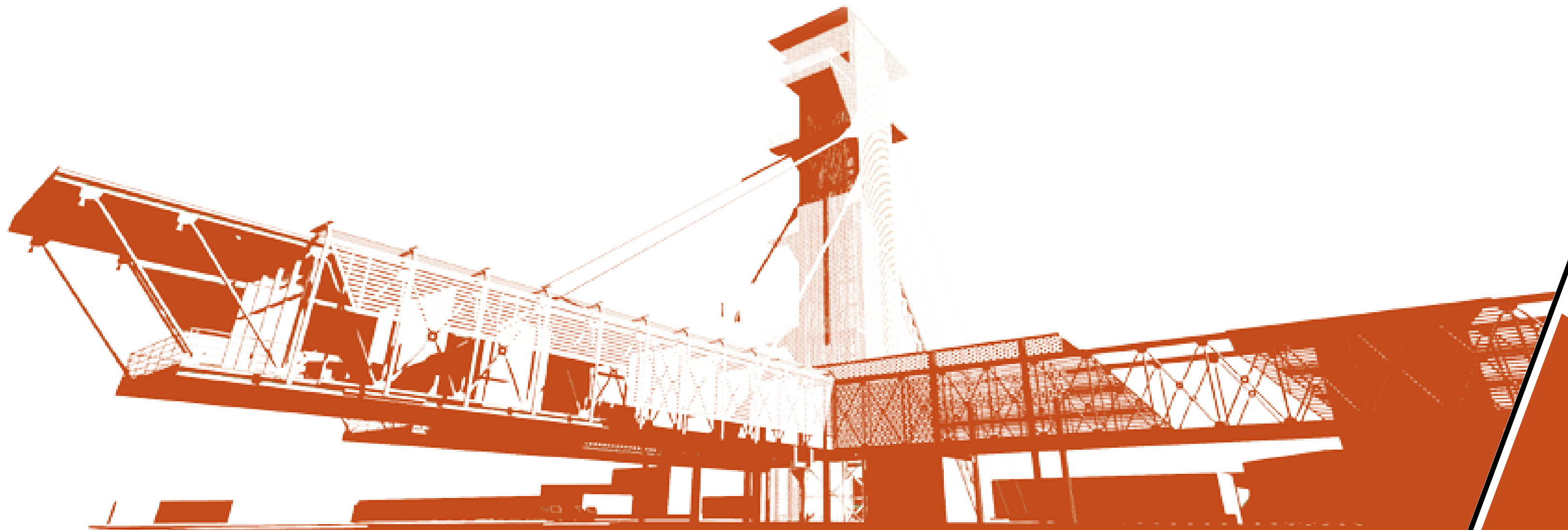
Ants are cold-blooded insects, which means that they rely on their environment for thermoregulation. This can be seen in their nest structure. Ants usually build deep, underground nests that maintain more or less stable temperatures. In summer, ground temperatures provide shelter from the heat. In winter, the ground is warmer than the outside air. The Prenolepis imparis (commonly called the winter ant) builds very deep nests (close to 3.6 meters below the surface). The winter ants retreat to the cool shelter of their nests during summer and only come to the surface during cooler months (Sandton City, [s.a.]: online). Rocks serve as solar collectors, therefore many ants build their nests under rocks. Rocks heat up faster during the day (even under shady conditions), but they also cool down faster at night (HowStuffWorks, 2014: online). In architecture thermoregulation can be experienced in Tom Kundig's T Bailey Office. Located within the vertical pipe, a skylight and a large fan ventilate the main office floor. The skylight and fan are powered by solar energy (Olson Kundig Architects, 2014: online).

Apart from thermoregulation, ants also teach man to ignore little diversions. An ant will just walk around an obstacle in its path. Unnecessary negativity and the stubbornness to cling to the past should be ignored.

Man must learn to utilise infinite energy in a sustainable way. Sustainability does not happen overnight – it means to undertake a journey. The future of all architectural convictions will be tested in the latest and most urgent global crisis – sound and sustainable conditions that will survive the future. As Jules Verne puts it in his science fiction novel of 1864, A Journey to the Centre of the Earth: "Science, my lad, is made up of mistakes, but they are mistakes which it is useful to make, because they lead little by little to the truth." (Verne & Malleson, 2008: 97).

Perhaps only then the architect can ask with Jacques Derrida: "Who ever said that one was born just once?" (Derrida & Weber, 1995: 340).

Design development



08

| Design development

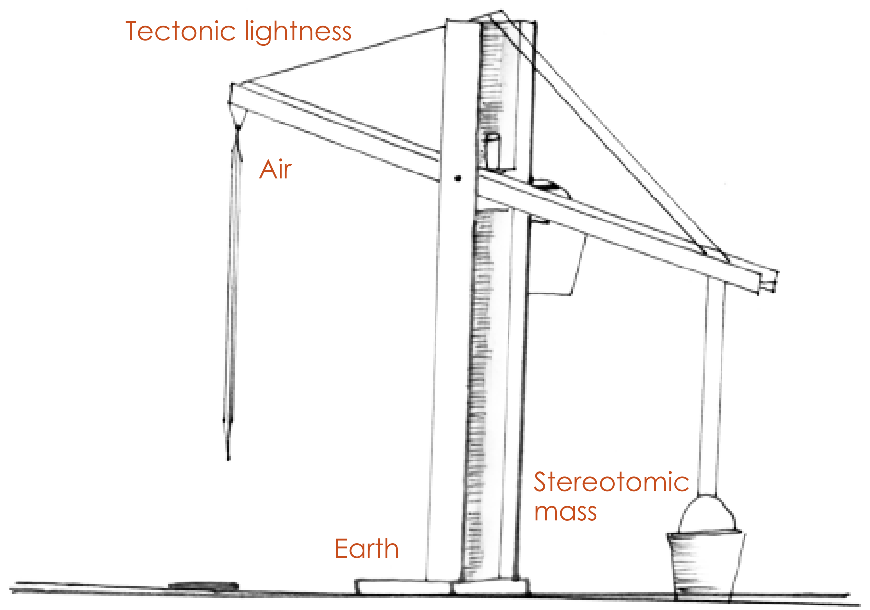
8.1 Touchstone

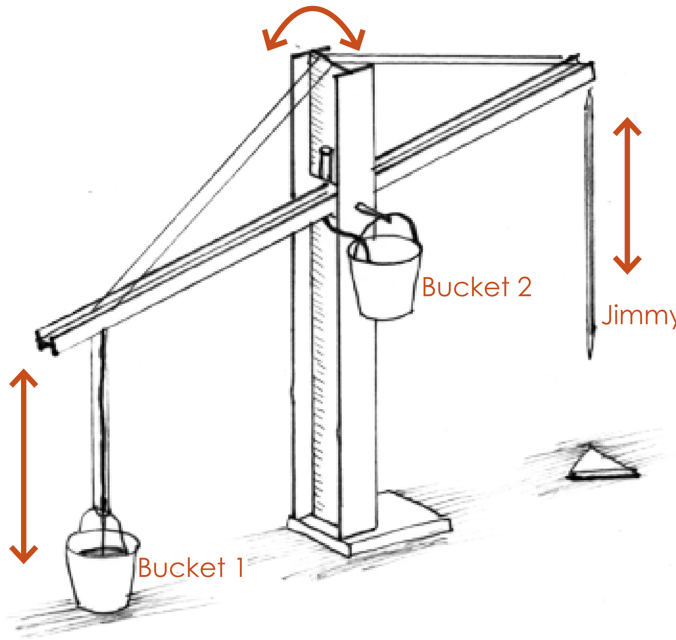
Touchstone

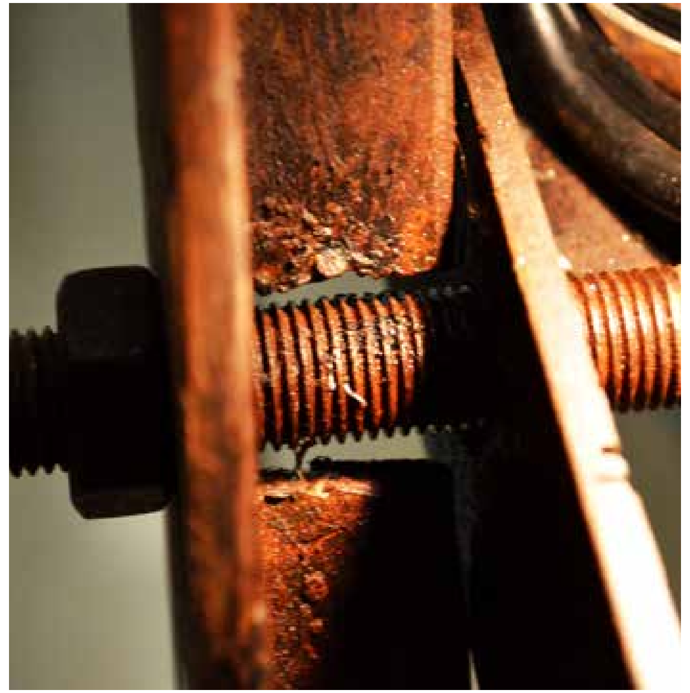
The touchstone is an example of a metaphor in which playing with initial ideas and thoughts is expressed physically. This touchstone serves as the starting point of an idea of connections between man and machine, stereotomic mass and tectonic lightness, movement and moment. With an oscillation movement of the jimmy where the latter continues to oscillate as long as it does not experience energy loss, a thought of a sustainable voyage emerges to culminate later into cement and mortar.

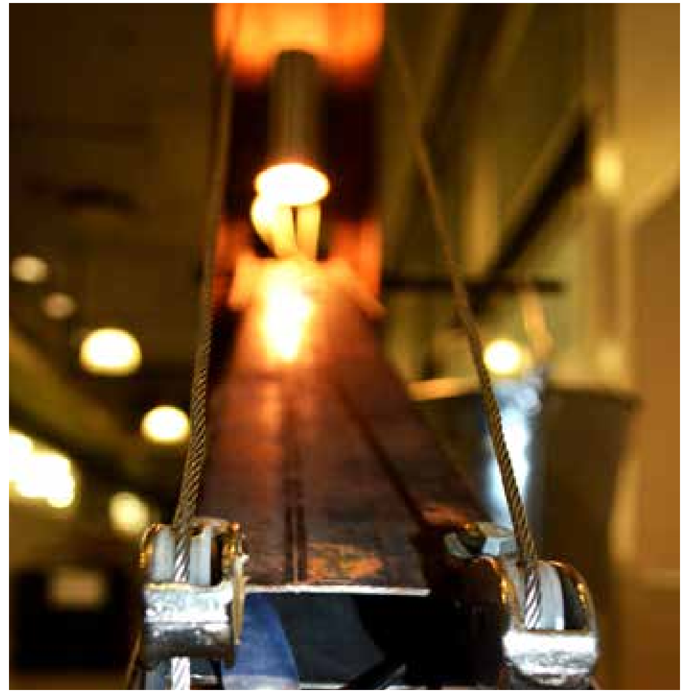
Actions of touchstone:

There are two buckets full of water. Water is pumped from bucket 1 to bucket 2. When bucket 1 is lighter than the jimmy, the jimmy drops down and bucket 1 rises, but not as high as bucket 2. As the jimmy falls down, the pump stops automatically and the water runs back from bucket 2 to bucket 1 as a result of gravitational force. As the jimmy rises, bucket 1 drops again to the original position, the pump switches on automatically and the process is repeated.

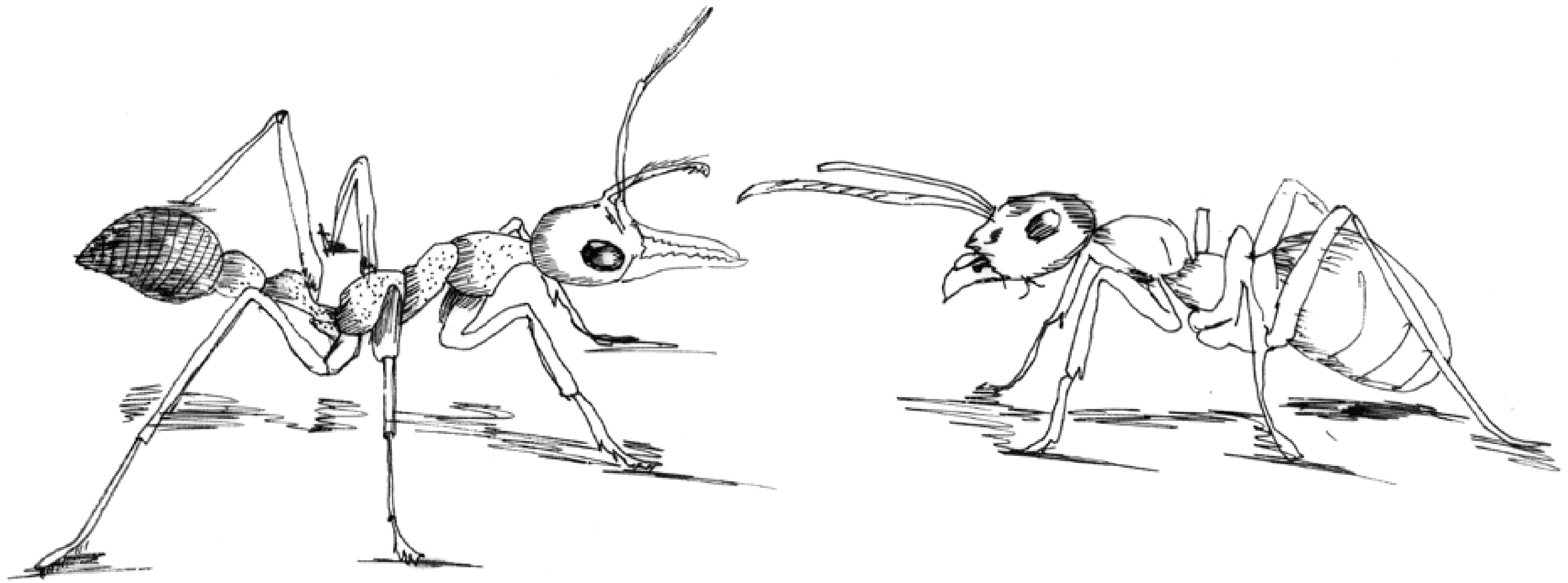








8.2 Concept



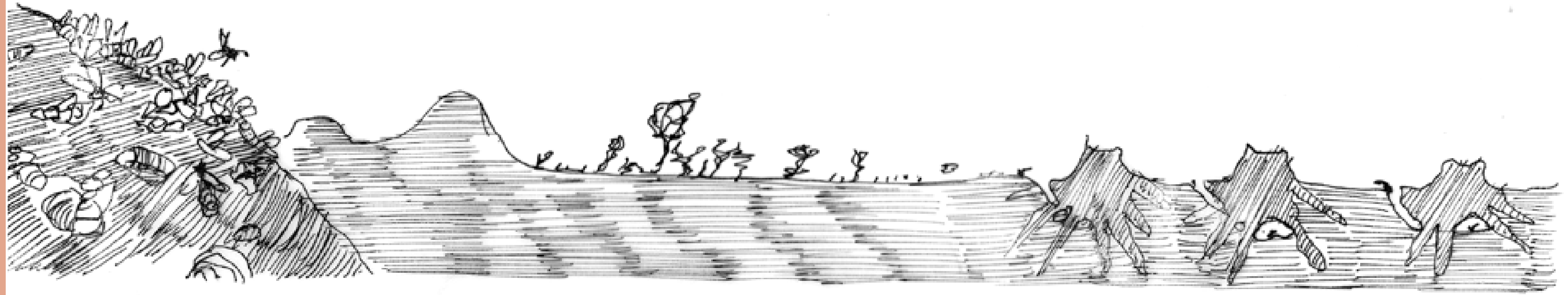
The secrets of ants

The design is driven by the concept of ant nests and the journeys undertaken by ants seeking food.

Ants never sit still. They are always on a journey – back and forth between their nest and food resources. Different ant species have different and very efficient methods to forage for food. They cover vast distances from their nests and use different methods for navigation – by using scent (Carroll and Janzen, 1973: 231-257), by keeping track of distances and direction (Wittlinger, Wehner & Wolf, 2006: 23), by using the position of the sun (Wehner, 2003: 579.) and even by using the earth's magnetic field (Banks & Srygley, 2003: 835-846).

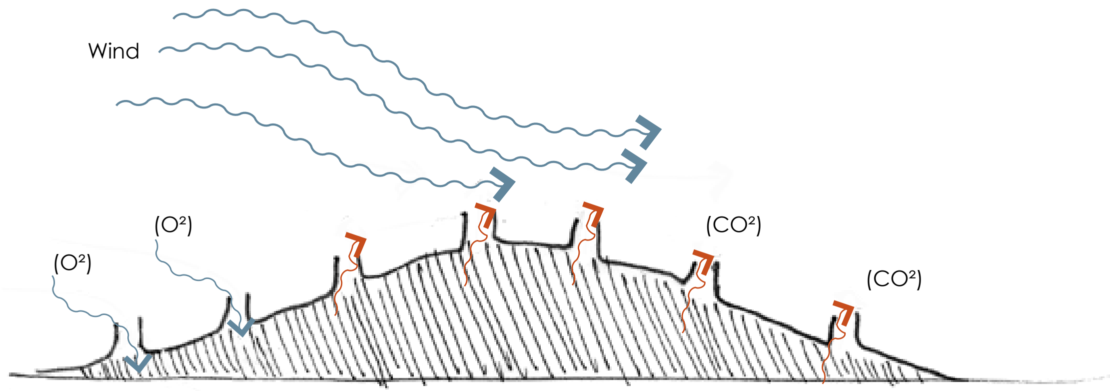
The fire ant (Solenopsis invicta) needs a constant temperature of 32 °C for their larvae. To achieve this they carry their larvae around during the course of the day – depending on the heat at the surface of the nest or the centre of the nest. Atta fungus-gardening ants have their own method to regulate their nest's temperature. The nest dome has small chimneys. As wind blows over the nest, convection over the chimneys pulls stagnant air (CO^2) out of the nest and allows fresh air (O^2) to flow back inside (AntWeb, 2014: online). Kundig's T Bailey Office works on the same principle. Warm air is sucked from the office space through the stairway pipe and evacuated out of the building. This green idea reduces the use of air-conditioning (Olson Kundig Architects, 2014: online).

Architecture of this project expresses the understanding of the survival processes of the ant.

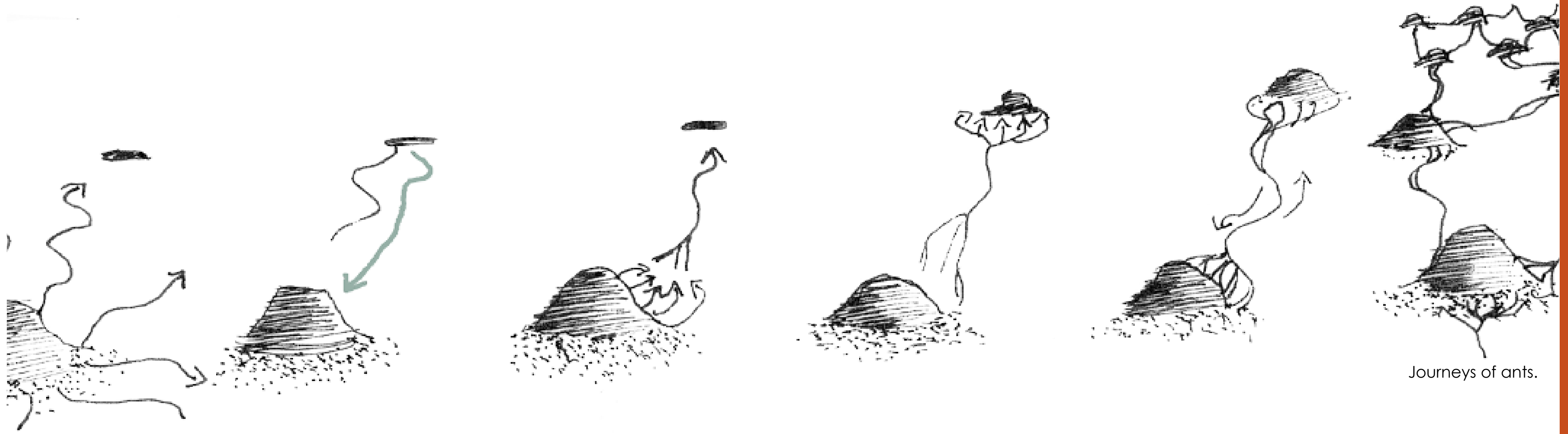


Sustainable nests of ants.

Escavation of an antheap (Antweb.org, 2014)



The thermoregulation of the Atta fungus-garden ant.

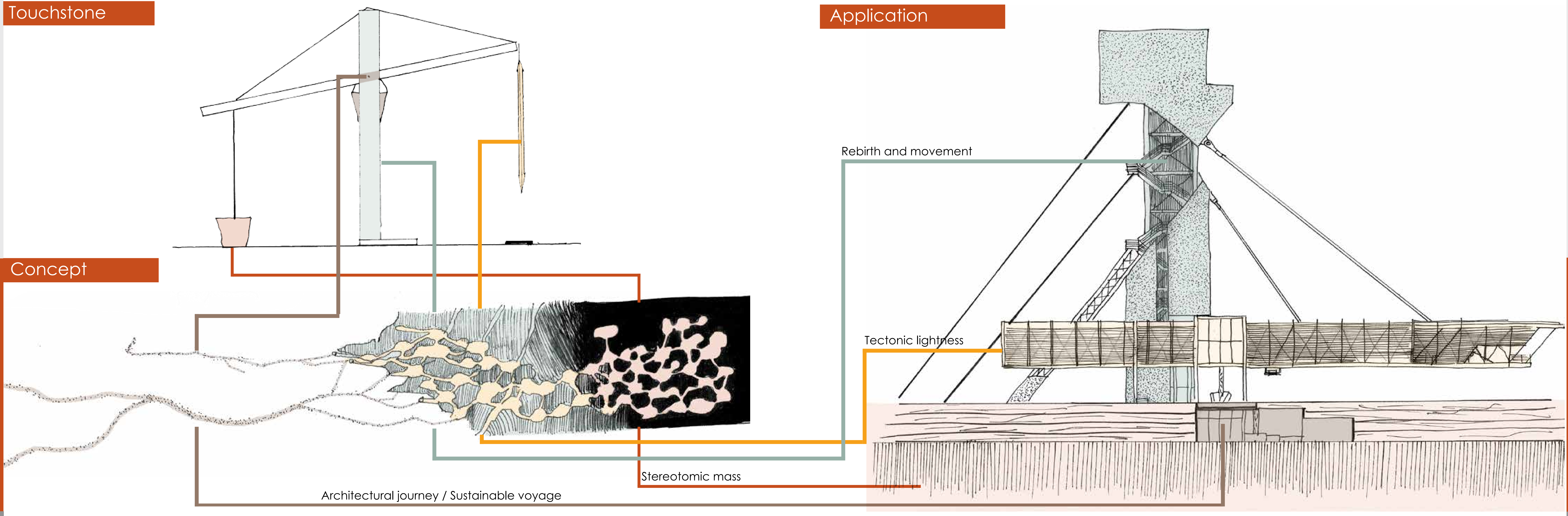


Journeys of ants.

Touchstone

Concept

Application



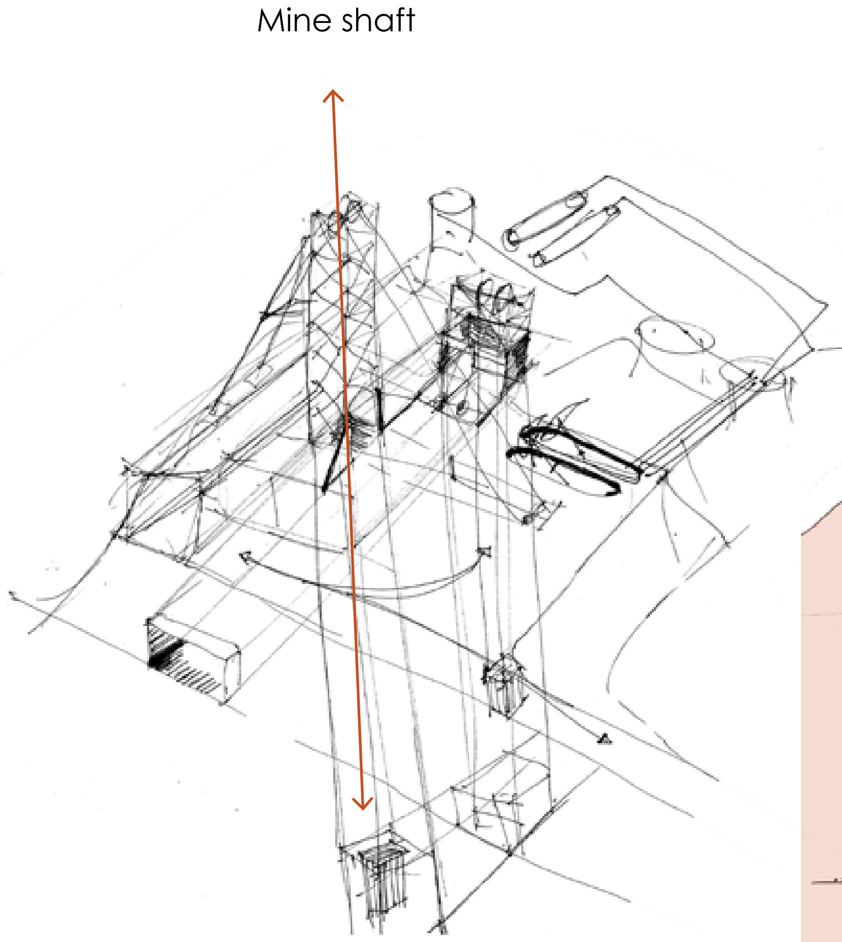
8 Conceptual drawings and
8.3 model development

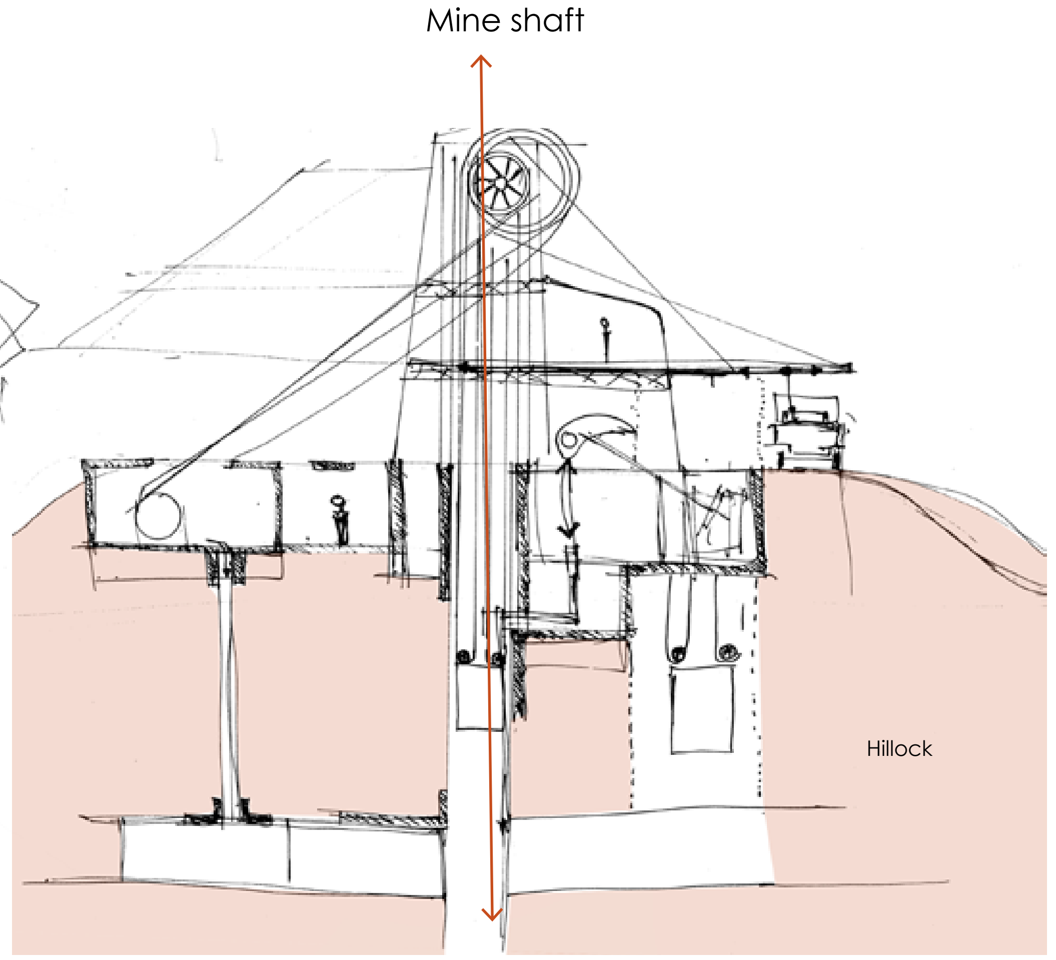
This visual report conveys the journey of the design by means of sketches and models from the concept phase to the final design.

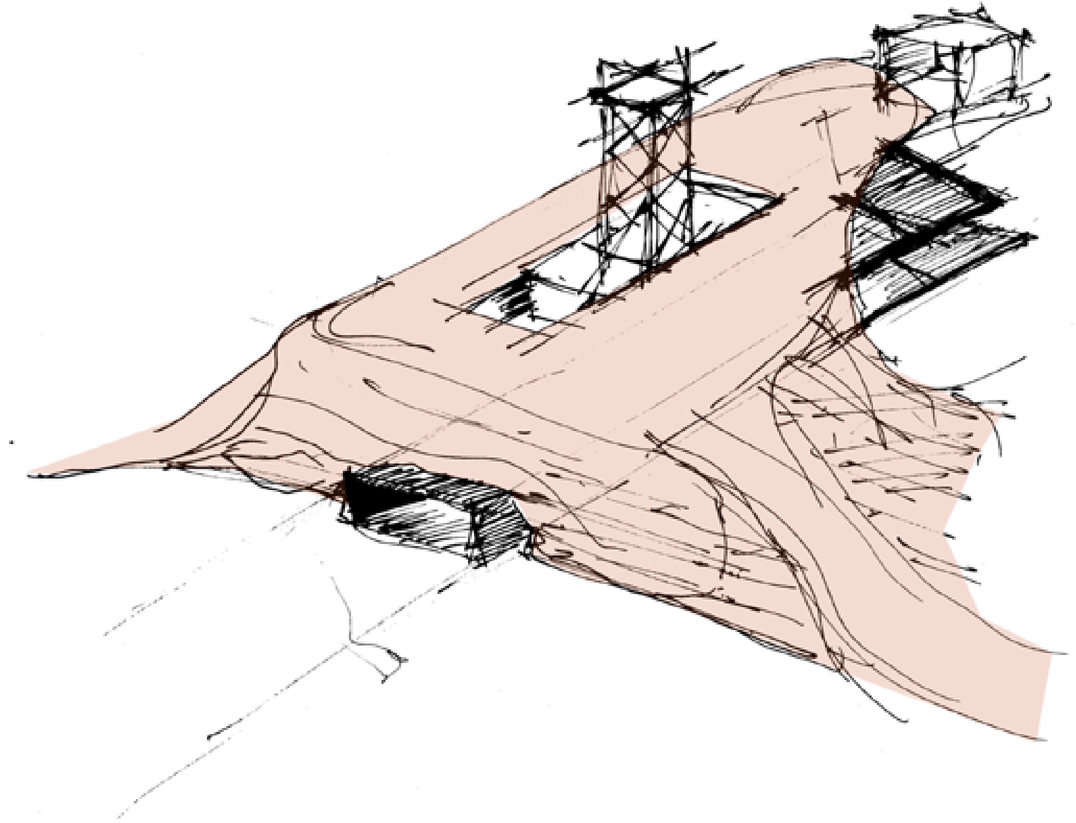
Two aspects were considered from the beginning of the project:

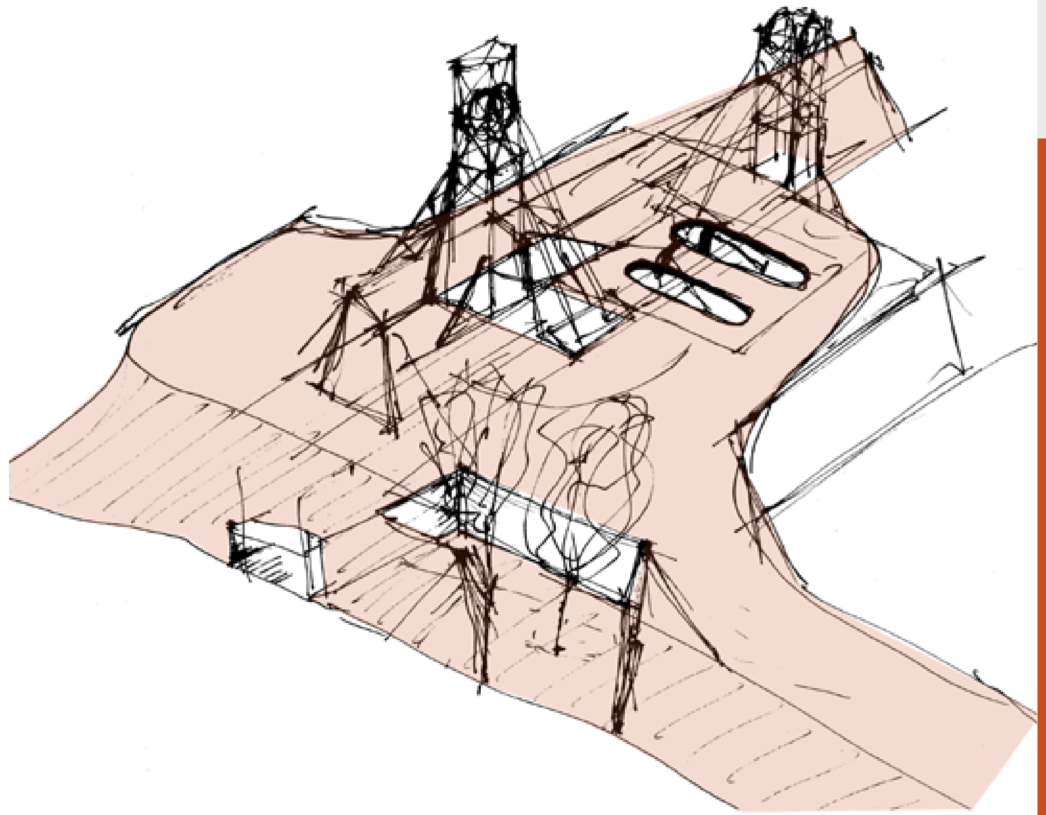
- The aesthetic utilisation of space on the site where certain elements such as the hillock on the site, the mine shaft, and the access to the site had fixed positions.
- A specific layout that drives the functionality of a geothermal plant.

Utilising the hillock

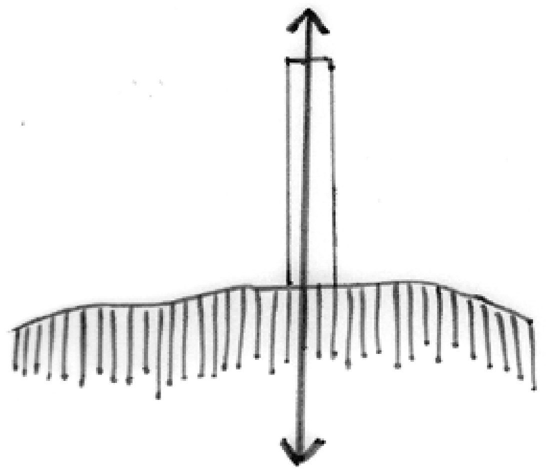


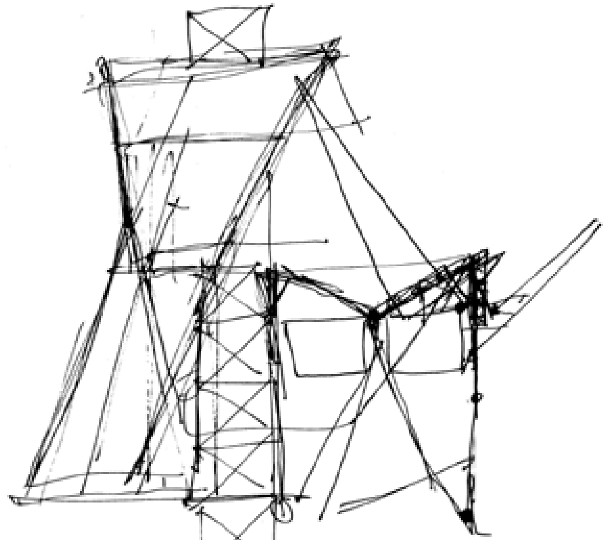


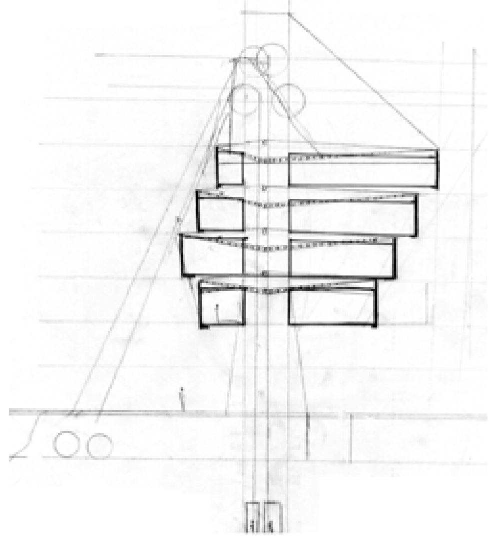


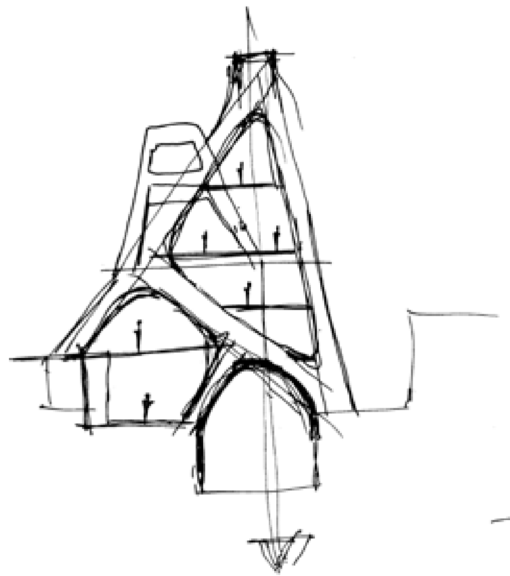


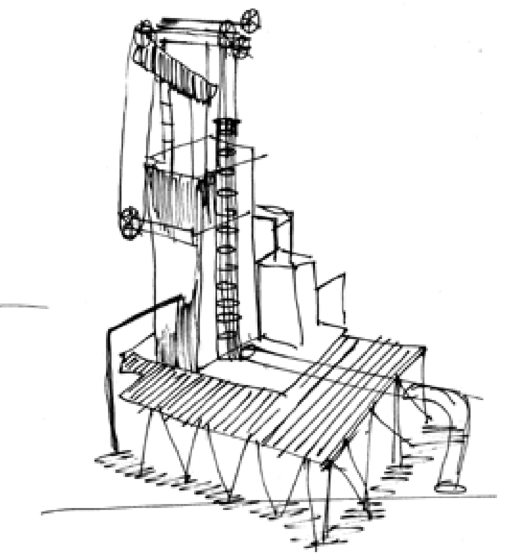
Vertical investigation

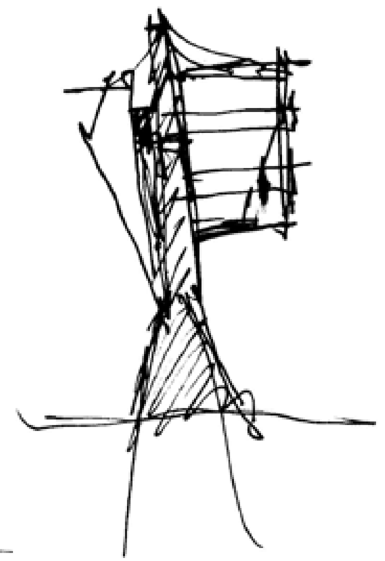


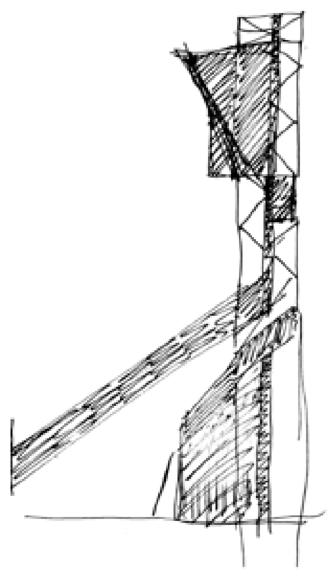






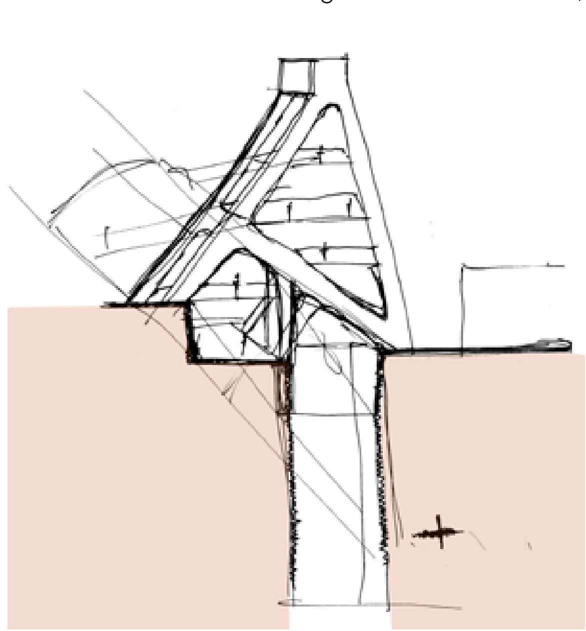


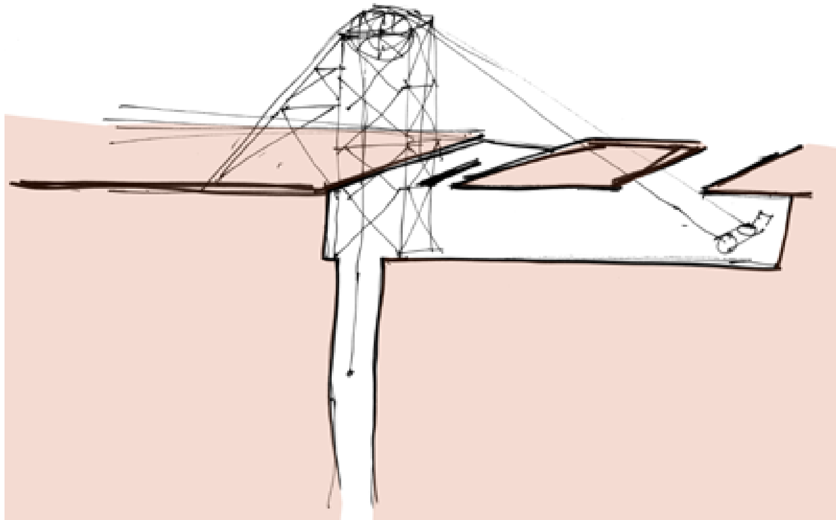


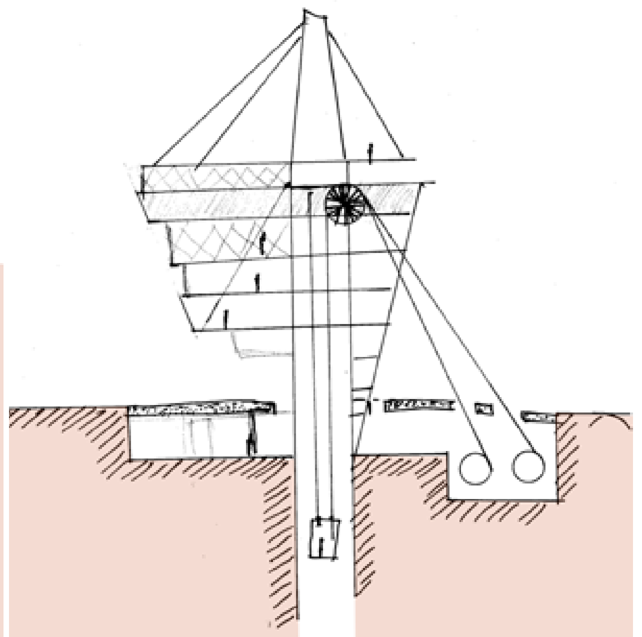


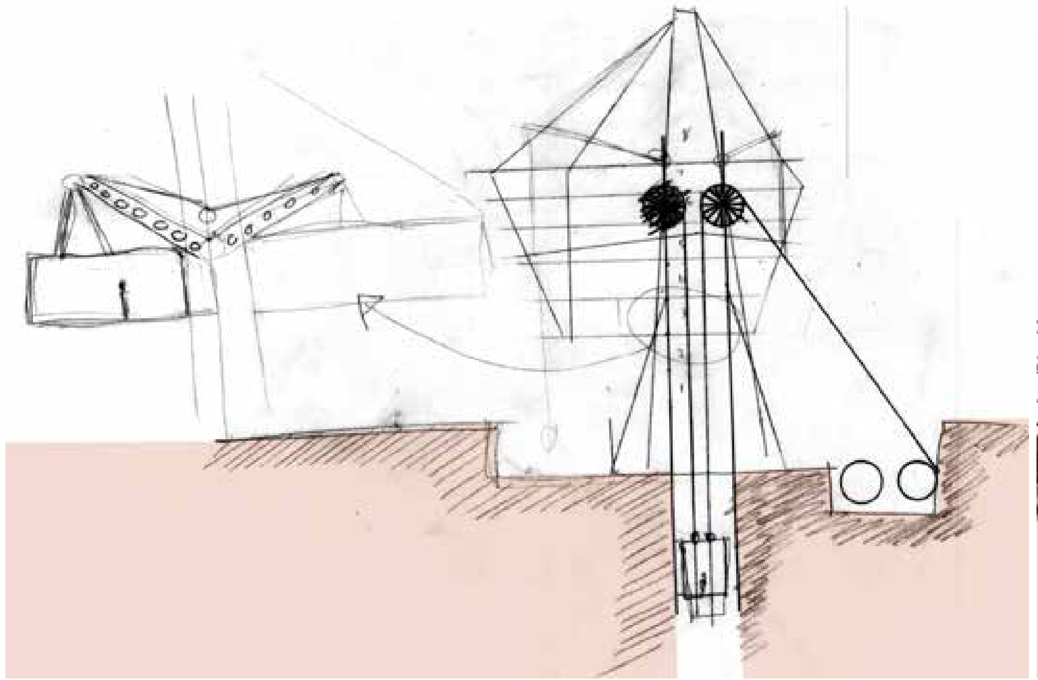
A three stage investigation pays attention to:

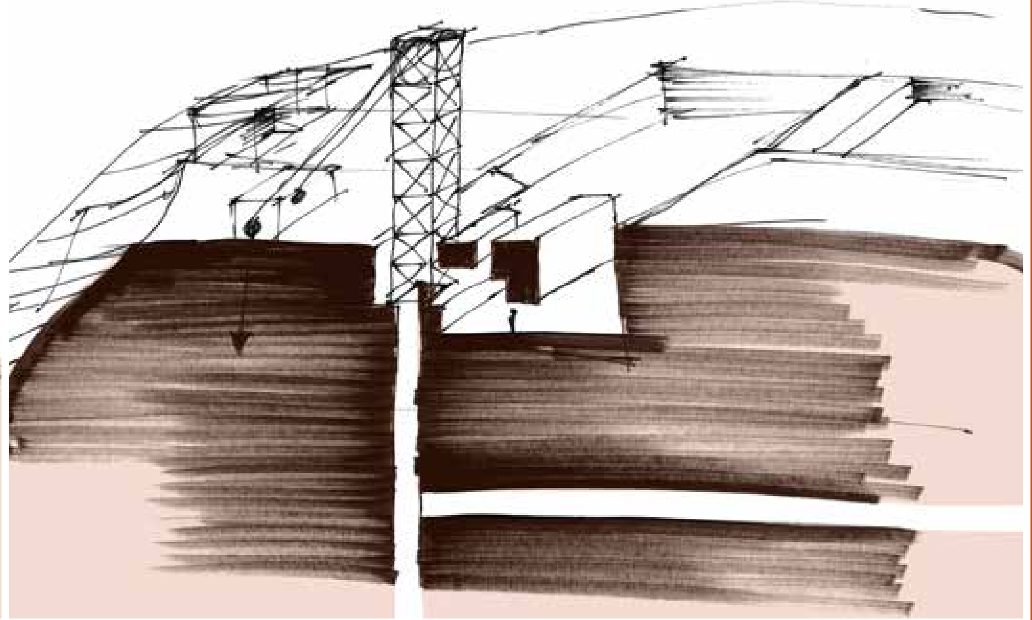
- The usage of the hillock to draw attention to underground activities.
- A vertical investigation where history, space and function connect.
- A horizontal investigation where movement, circulation, function and the entrance are driven by the theory of a journey.



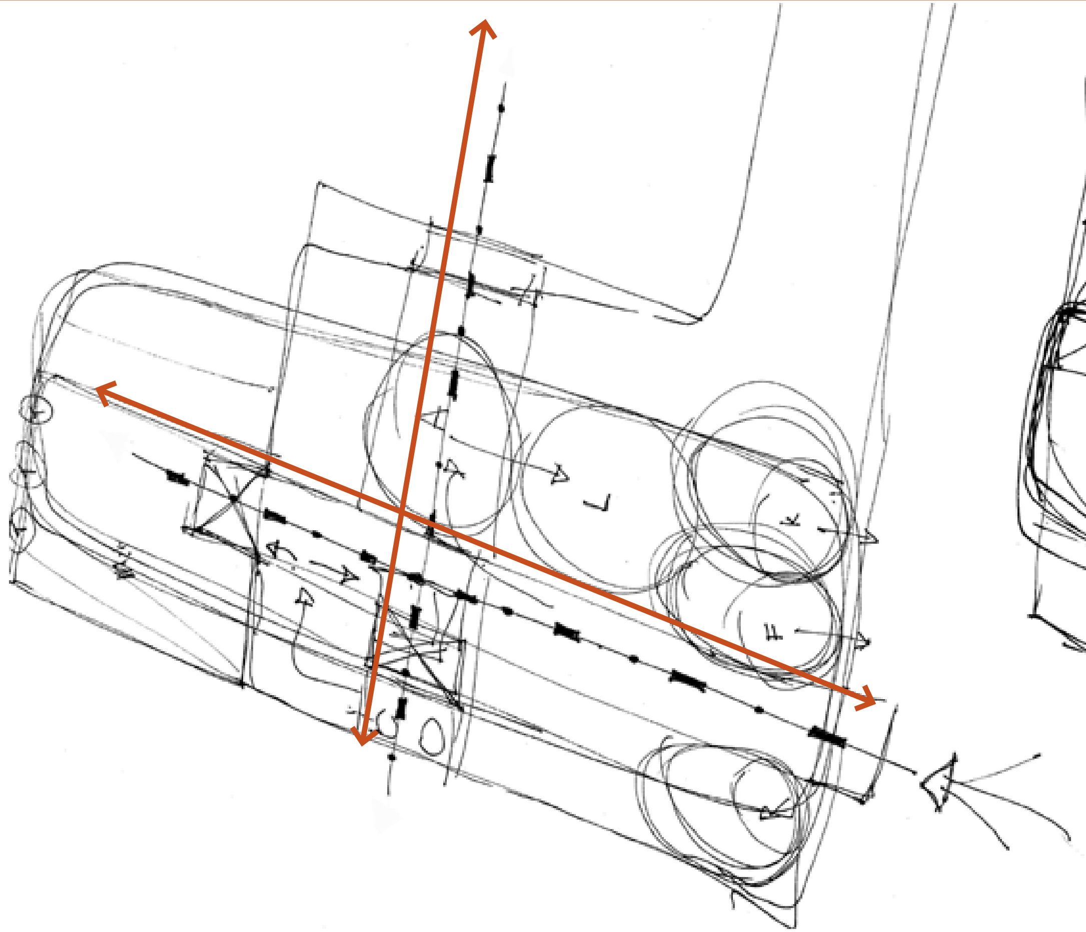


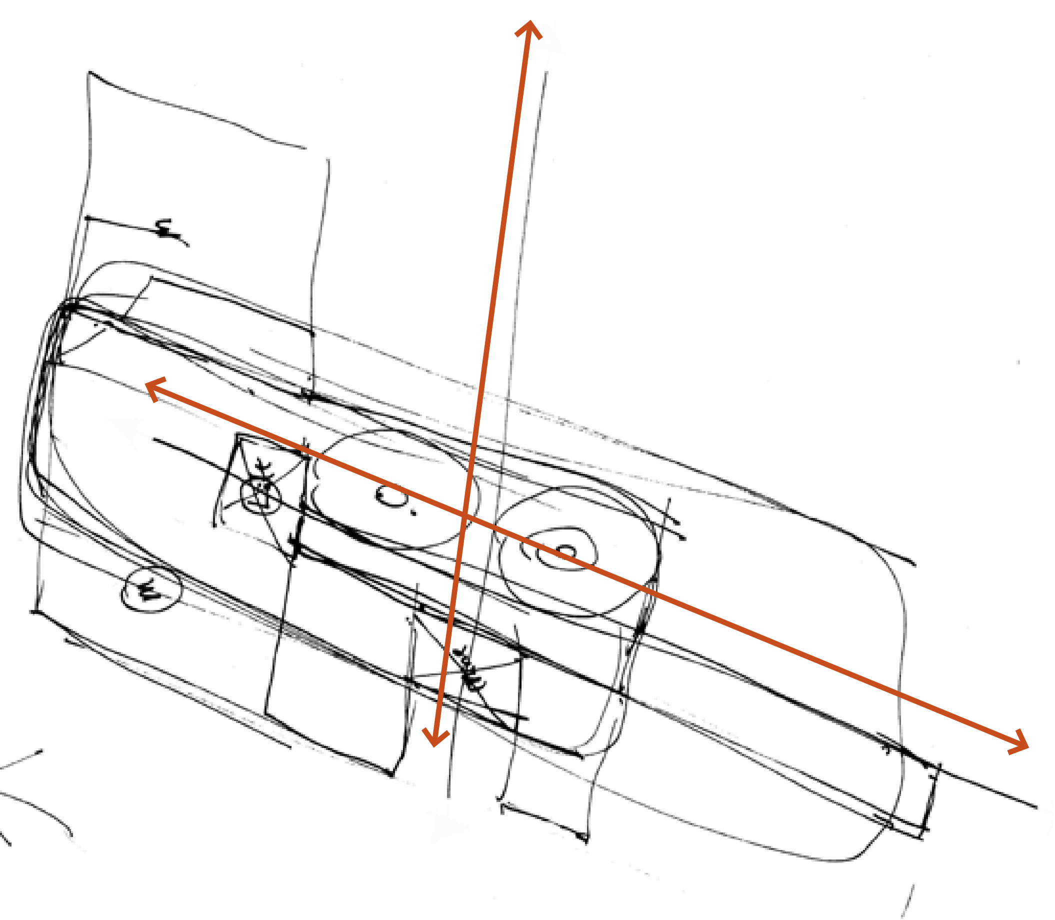


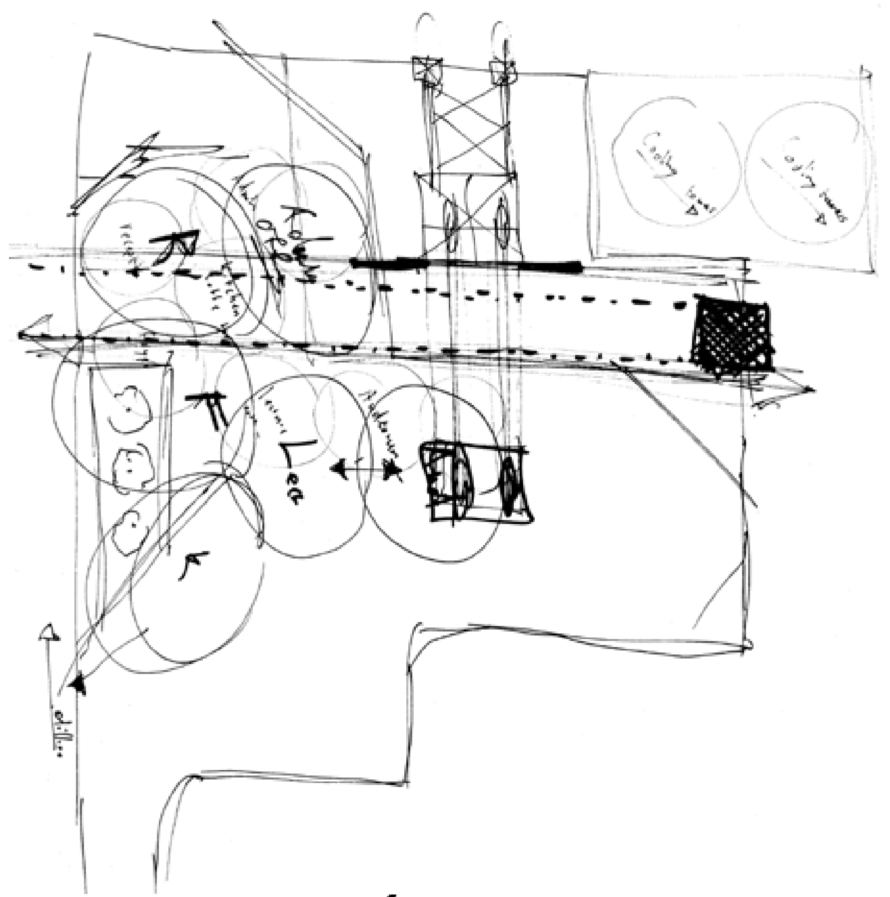


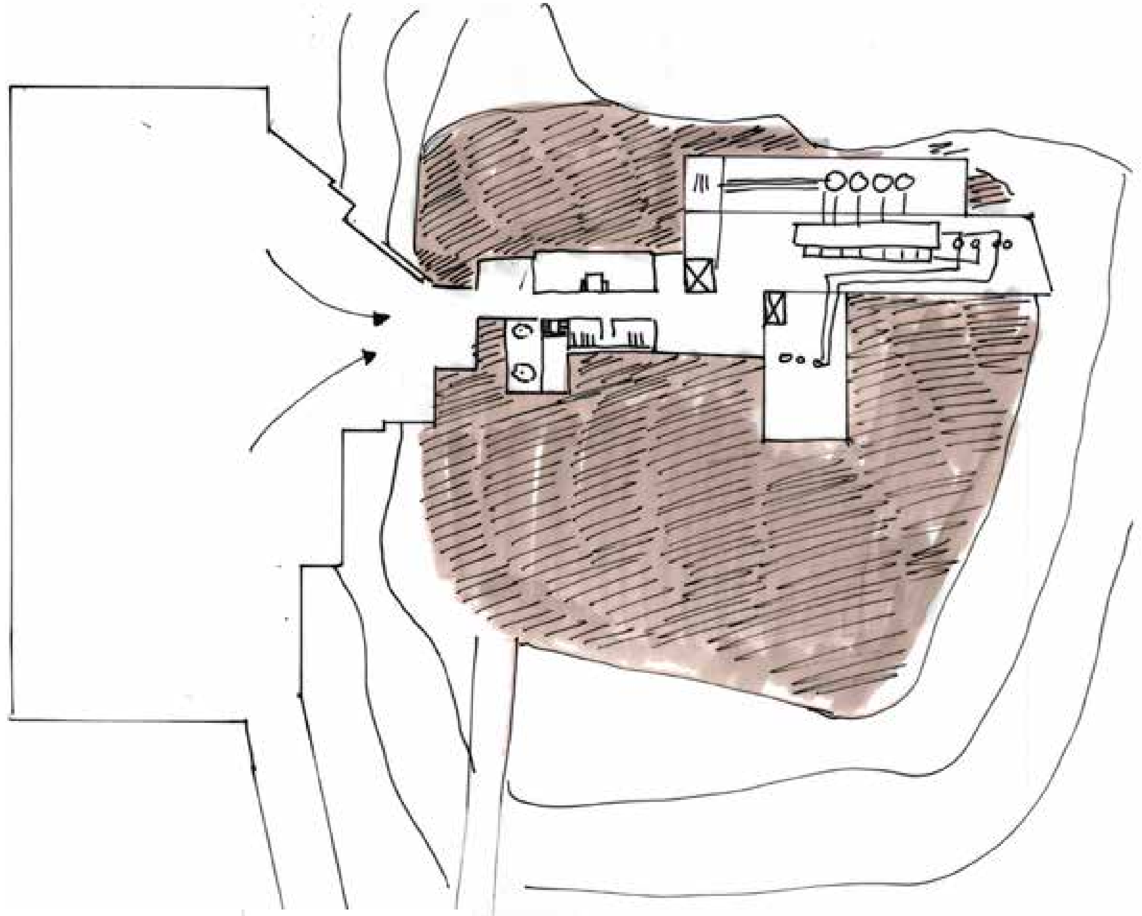


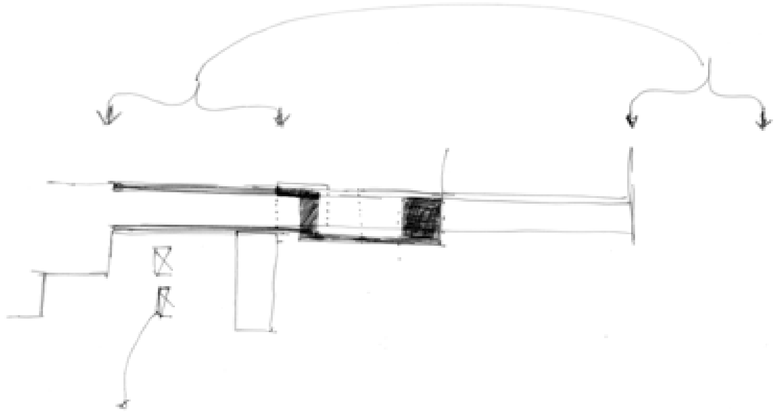
Horizontal investigation

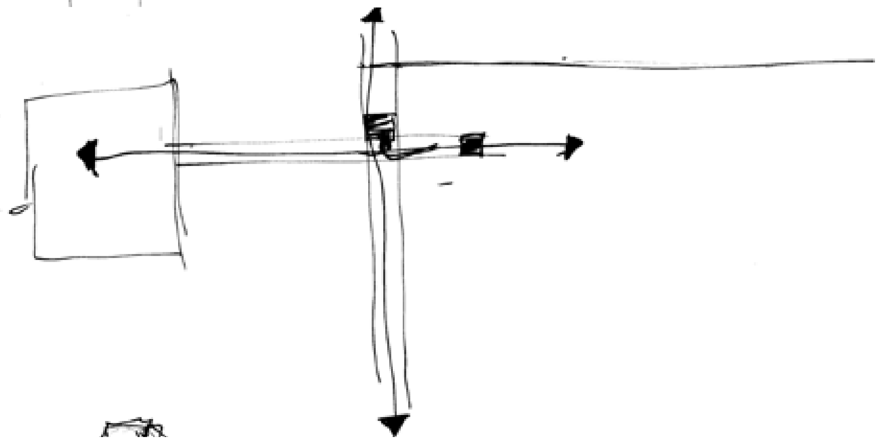


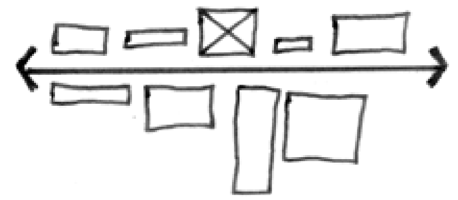










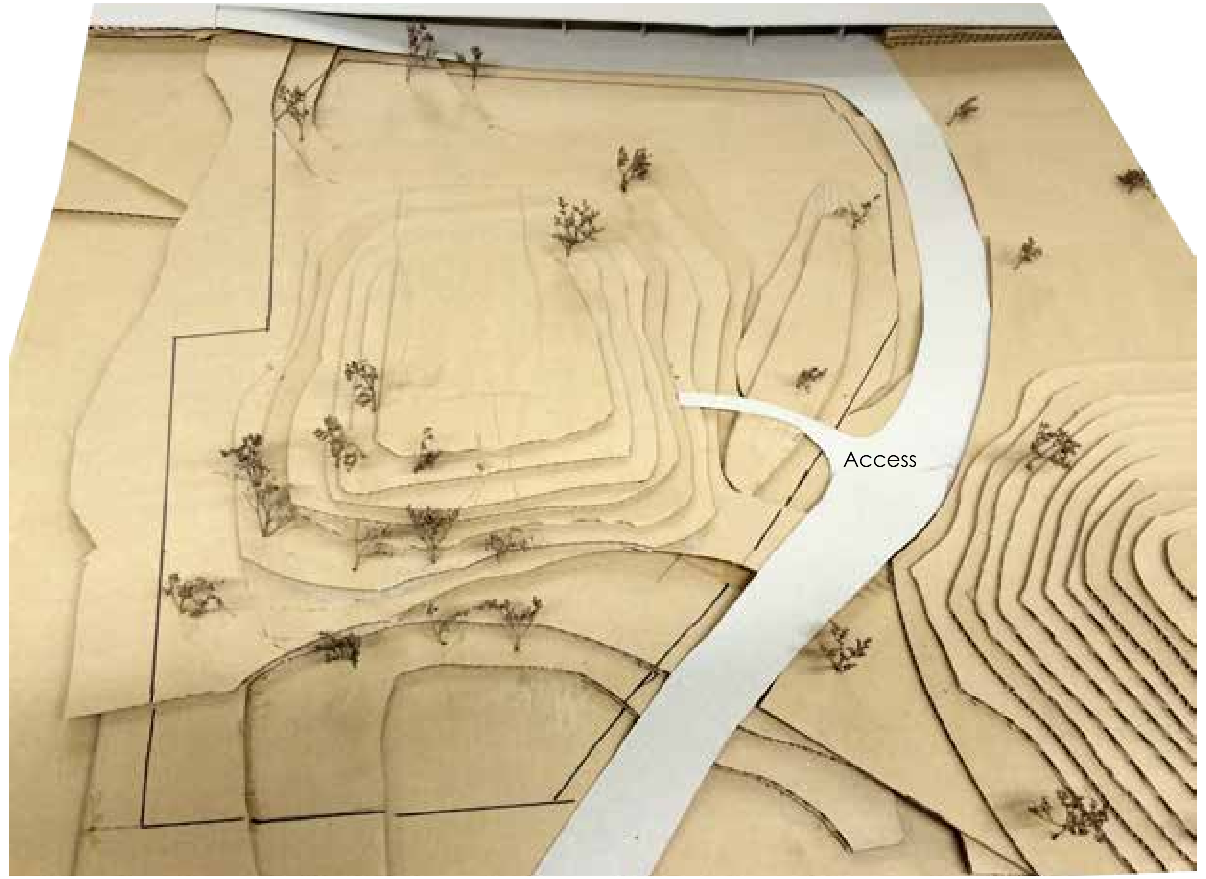


| Design development

Model 1:

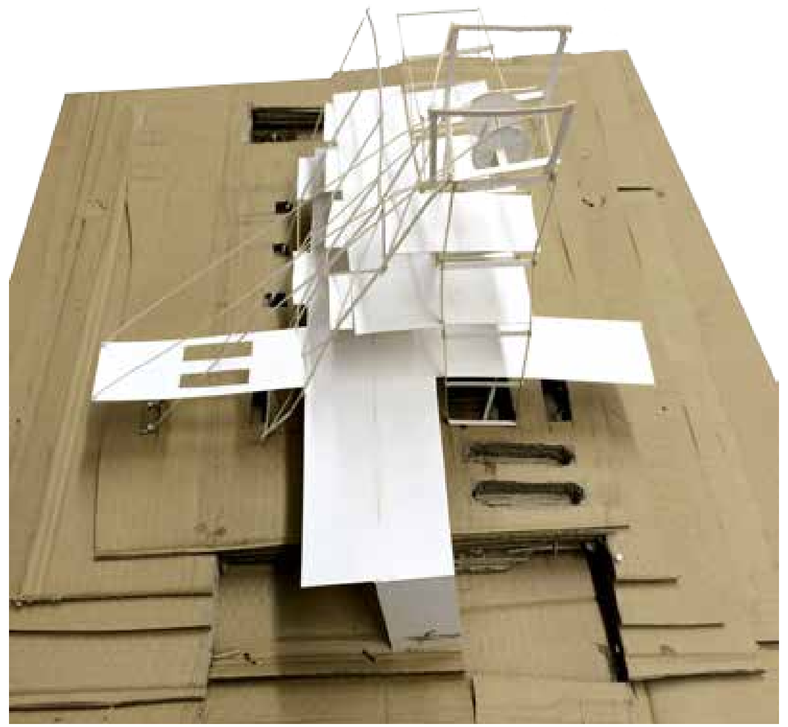
The model building process gives a better three dimensional idea of the site and the proposed design:

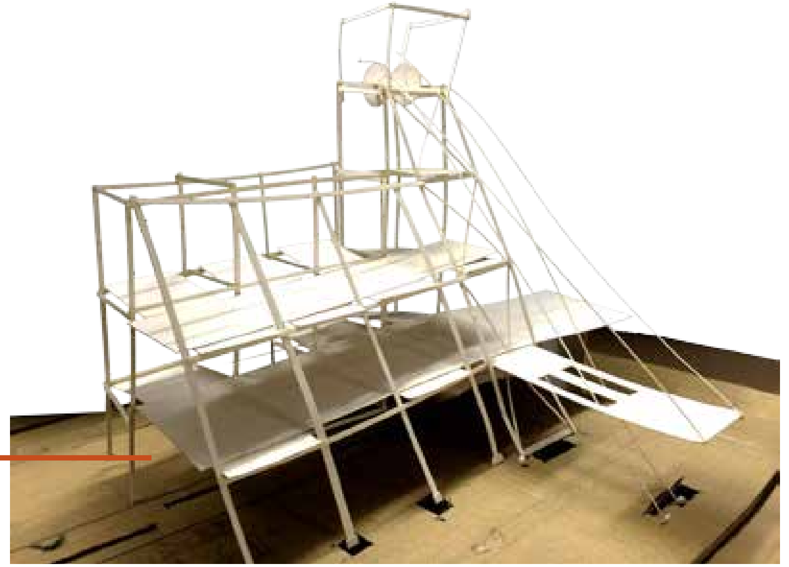
The site model with its contours gives a better understanding of the site, the hillock on the site, and the access to the site.



A representation of a three dimensional model of that which has already been drawn on a flat surface. Only exploring space, but with no idea where spatial creativity might lead to.

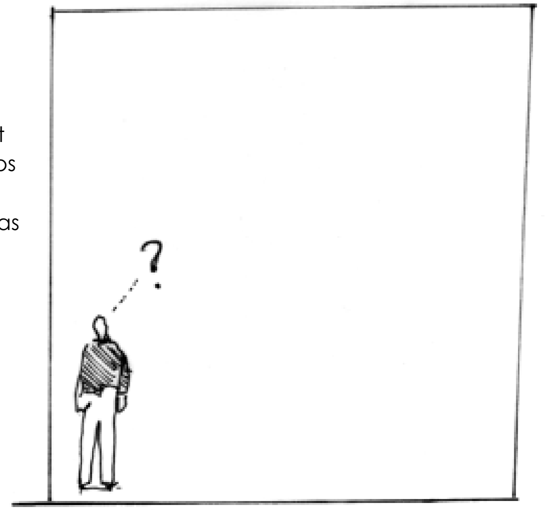
Model 2:

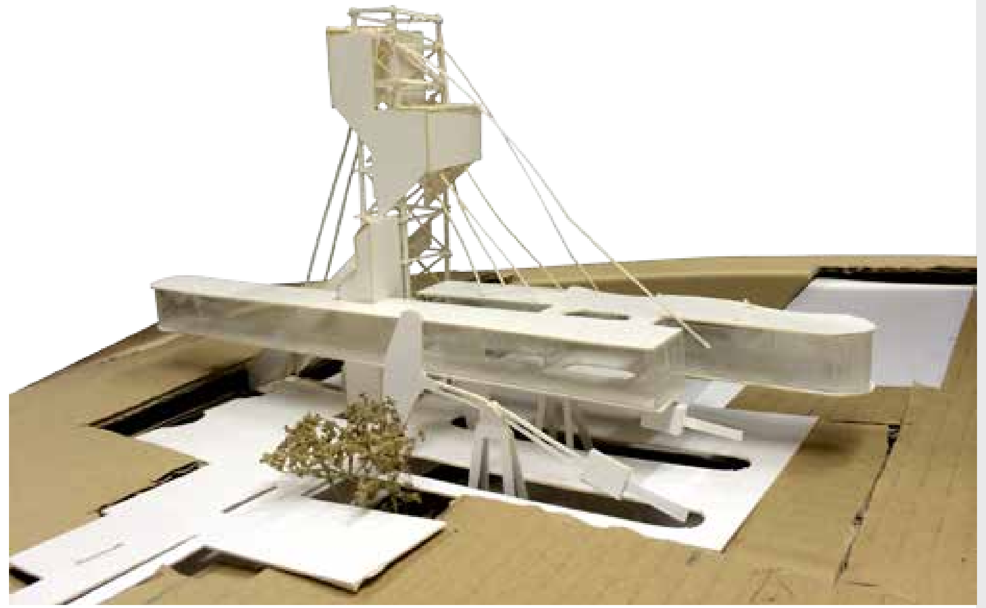


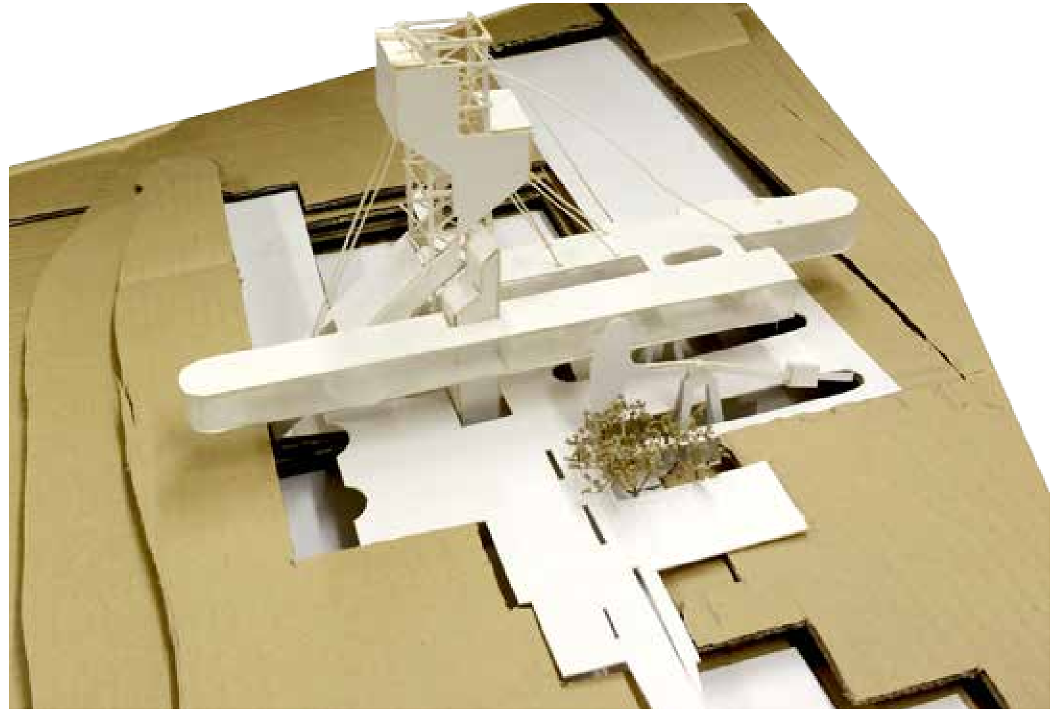


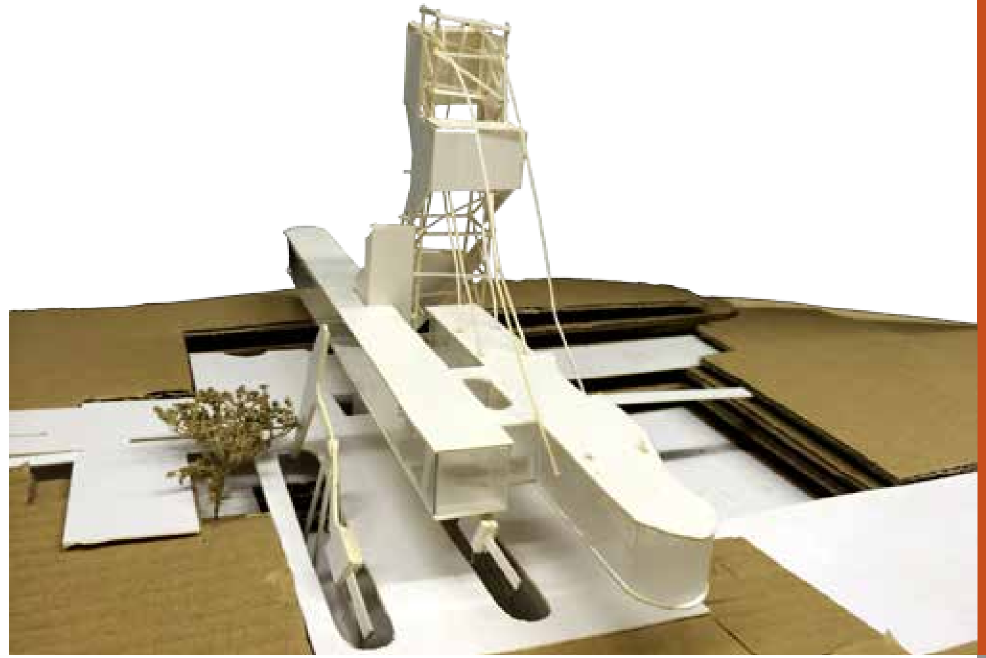
Model 3

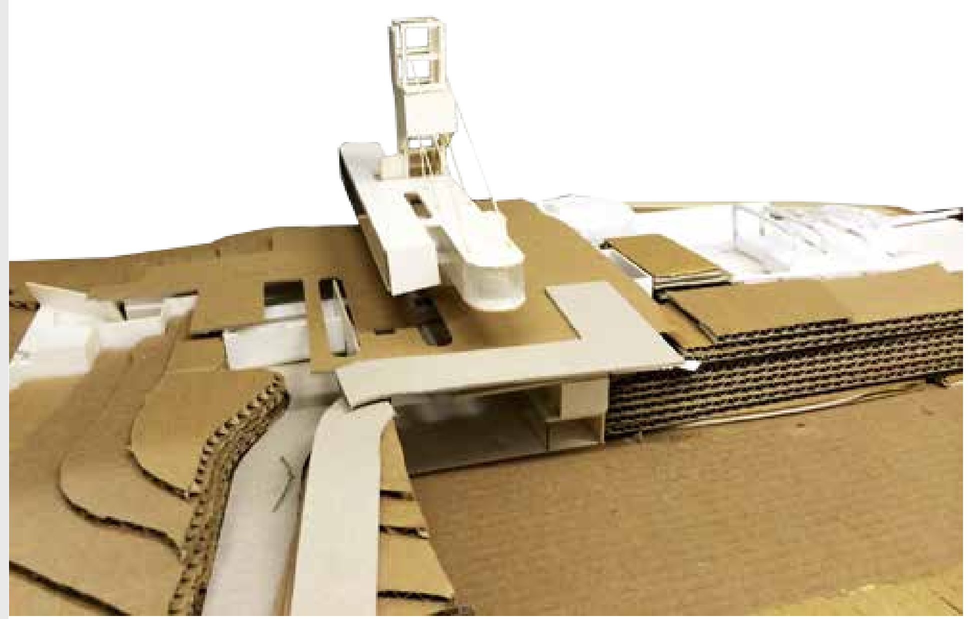
Functions of the building as a research and educational centre and as a geothermal plant are placed. As function and spatial relationships influence scale, proportions and form, more thought should be given to the effect space has on the connection of elements in the design.



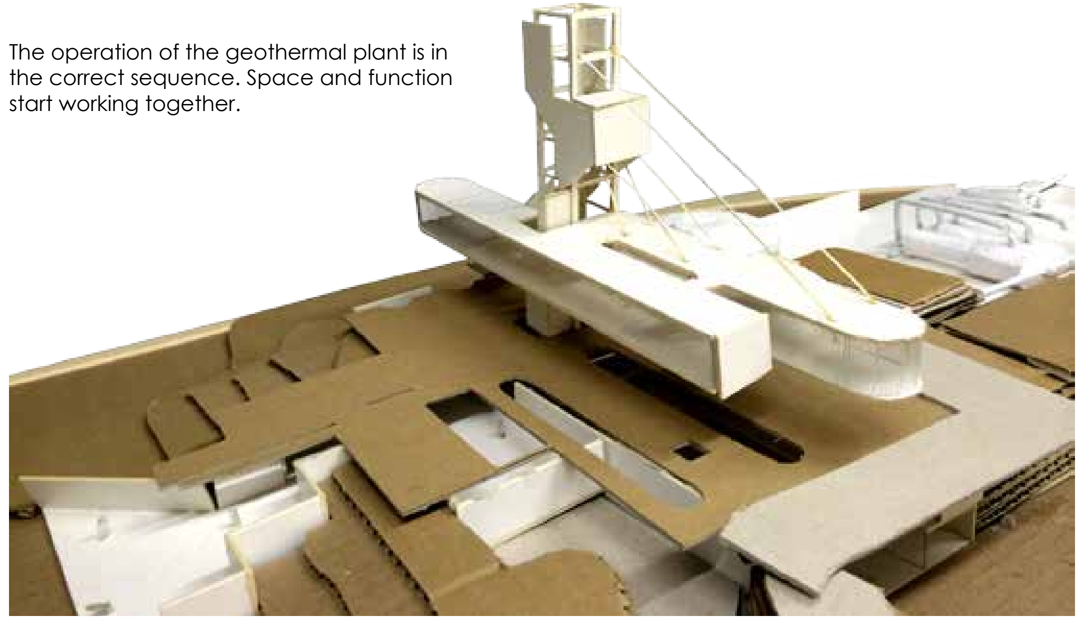


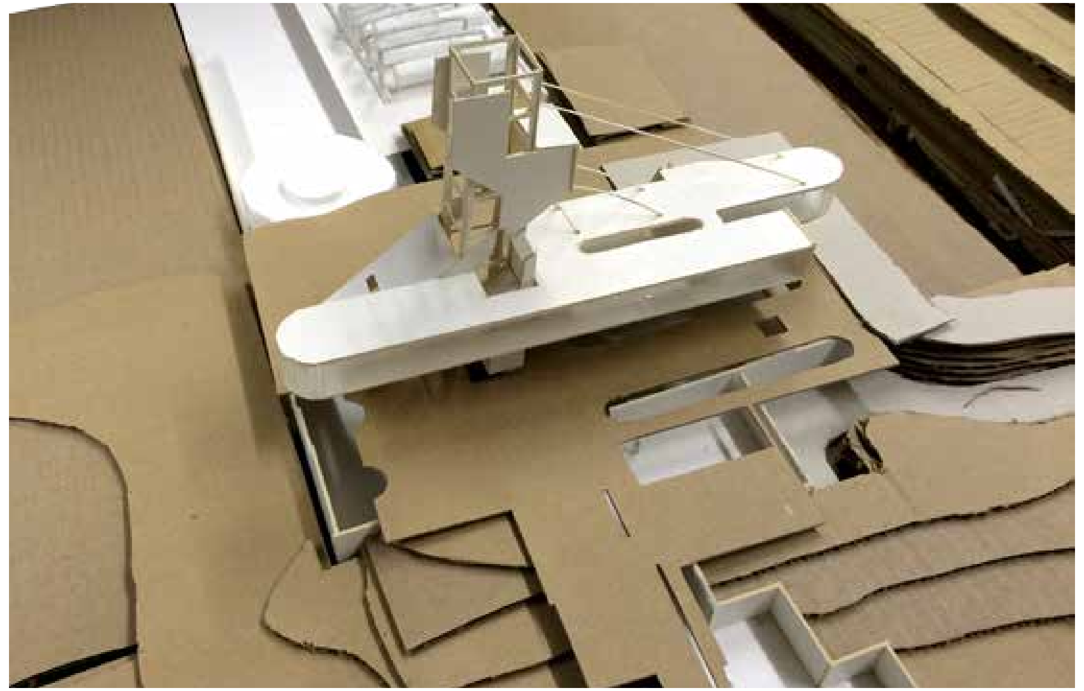




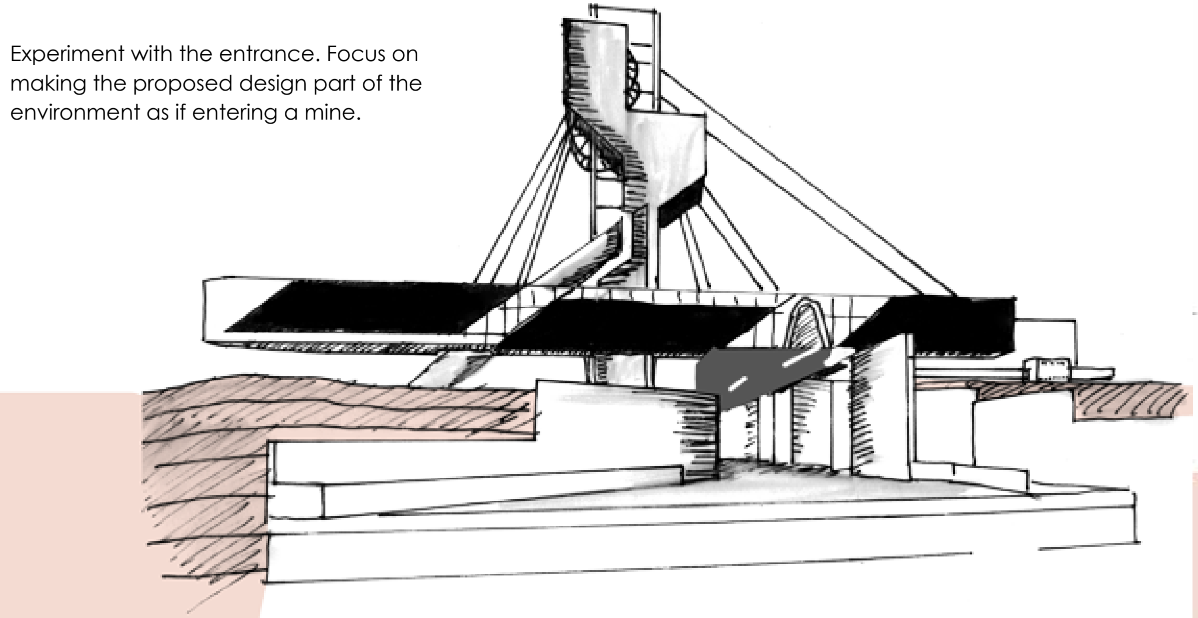


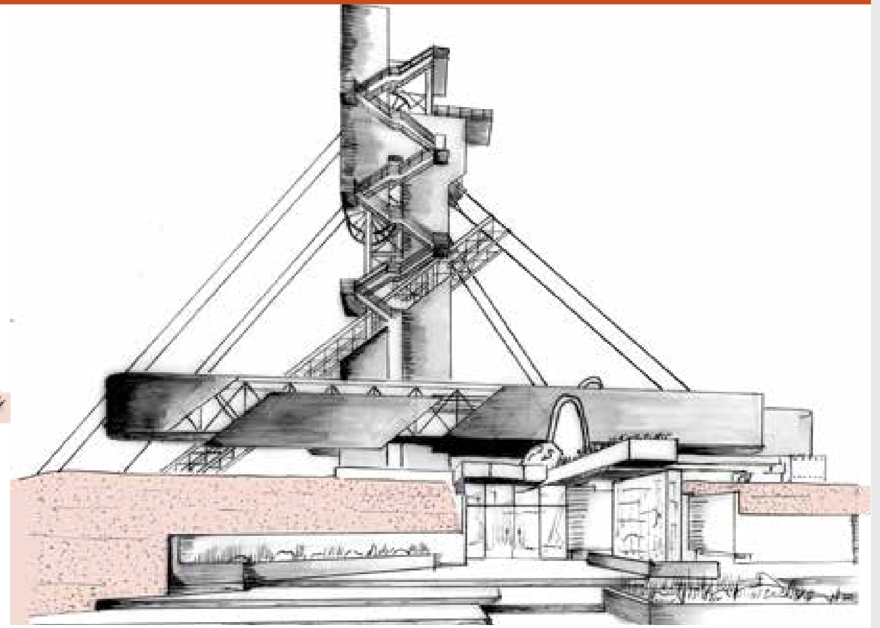
The operation of the geothermal plant is in the correct sequence. Space and function start working together.

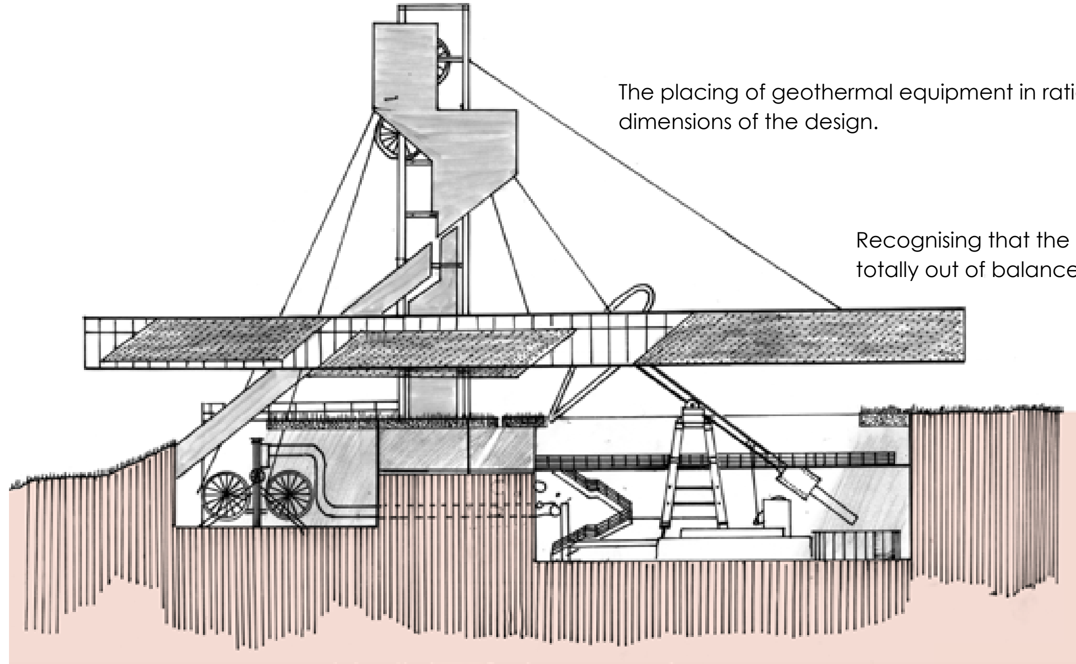




Experiment with the entrance. Focus on making the proposed design part of the environment as if entering a mine.



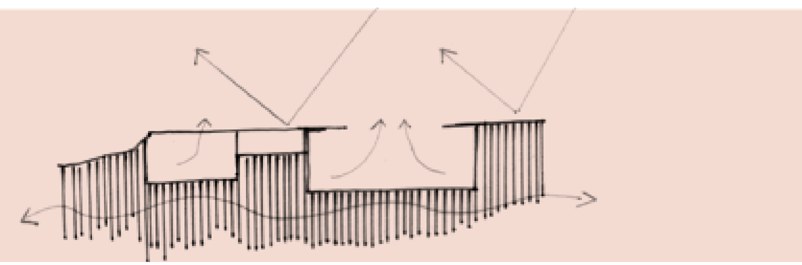




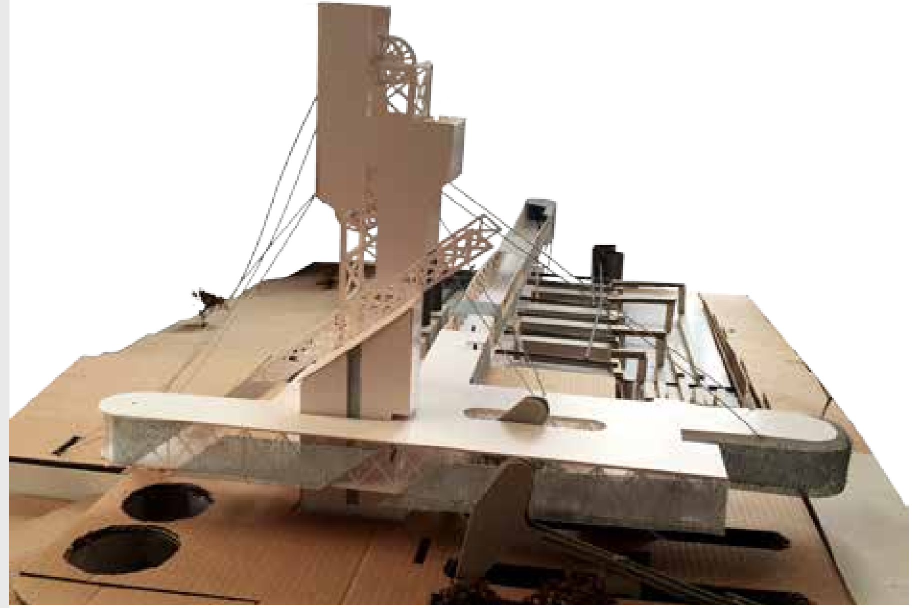
The placing of geothermal equipment in ratio to the dimensions of the design.

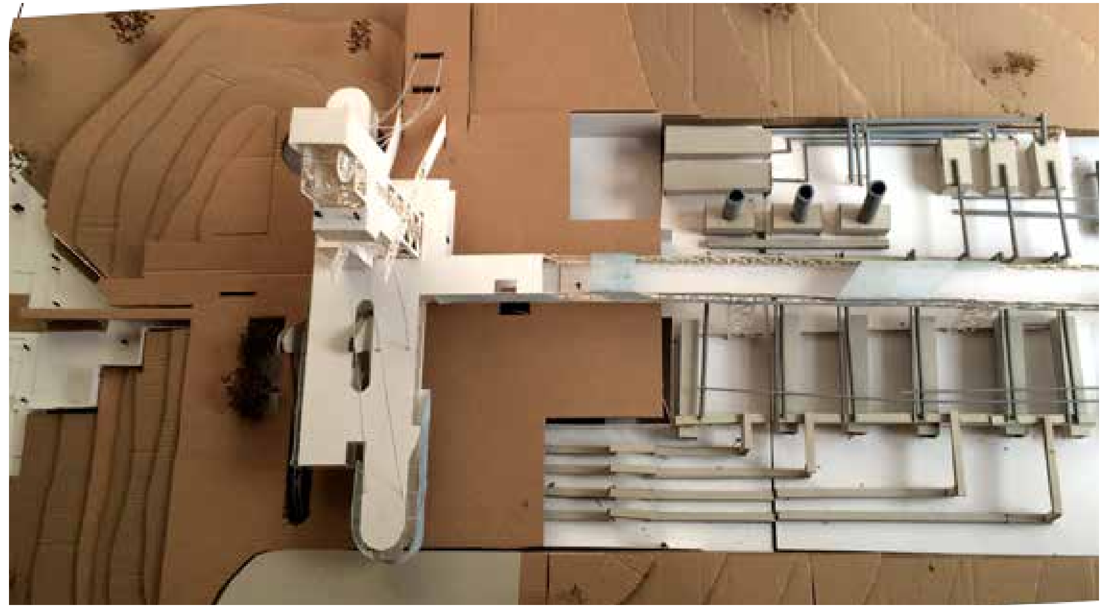
Recognising that the horizontal cantilever is totally out of balance with the vertical tower.

Experiment with ventilation, circulation and the and the invasion of sunlight into the stereotomic substructure.



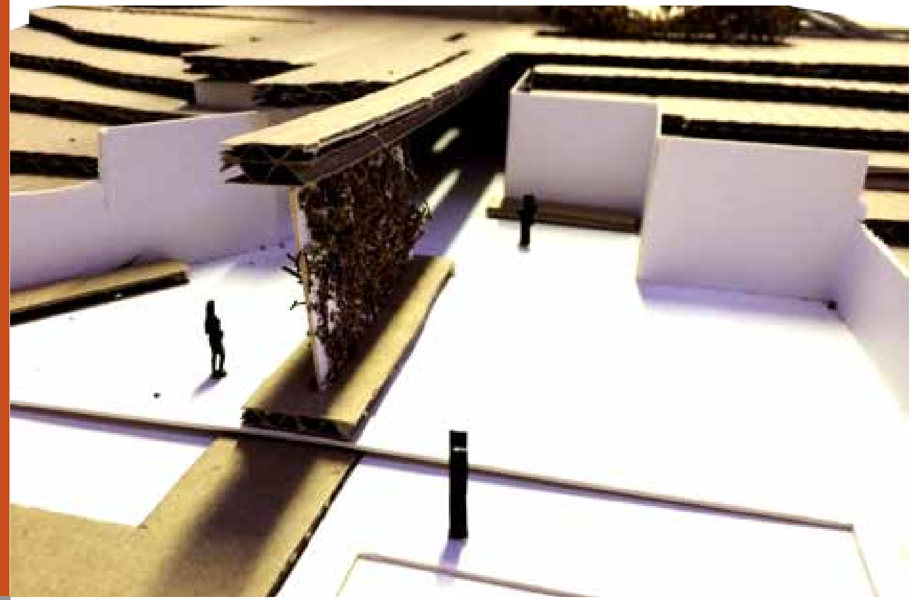
Model 5:





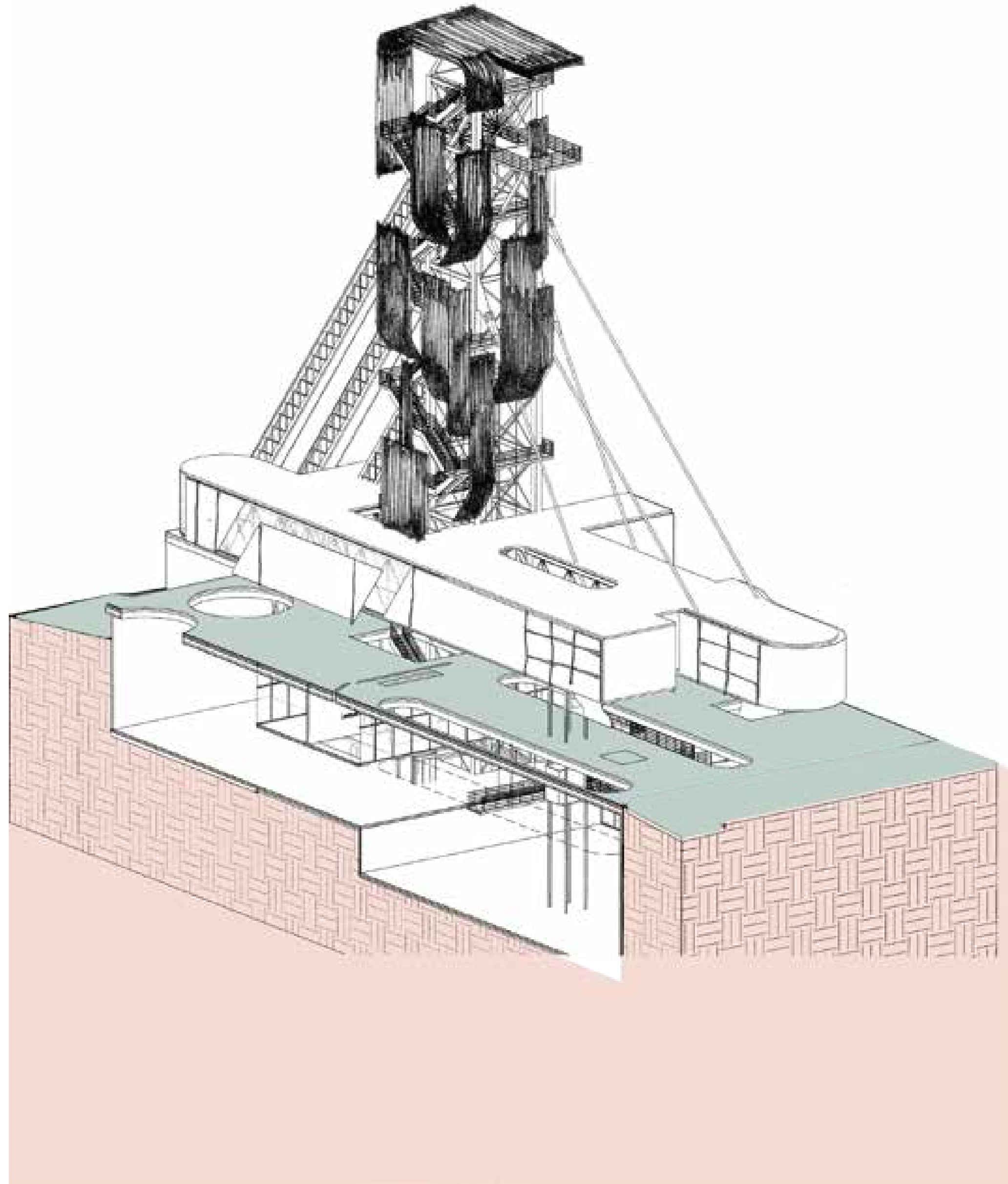
A three-dimensional representation of a geothermal plant to plan the proposed building in terms of function.

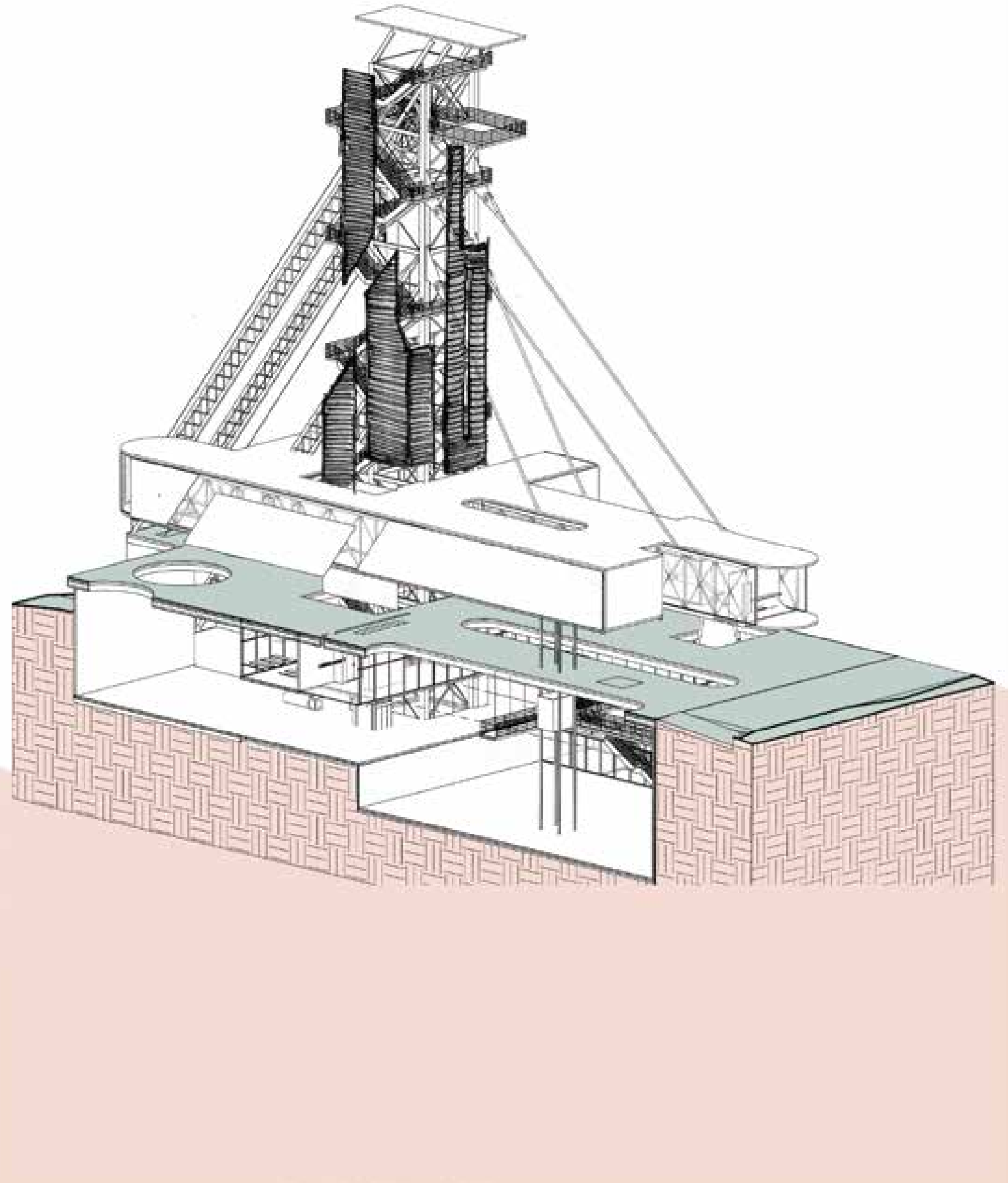
In designing the walkway with vision onto geothermal activities, responsibility is not only taken regarding information to the public, but also in showing that the created space has dimensions, time and flow.



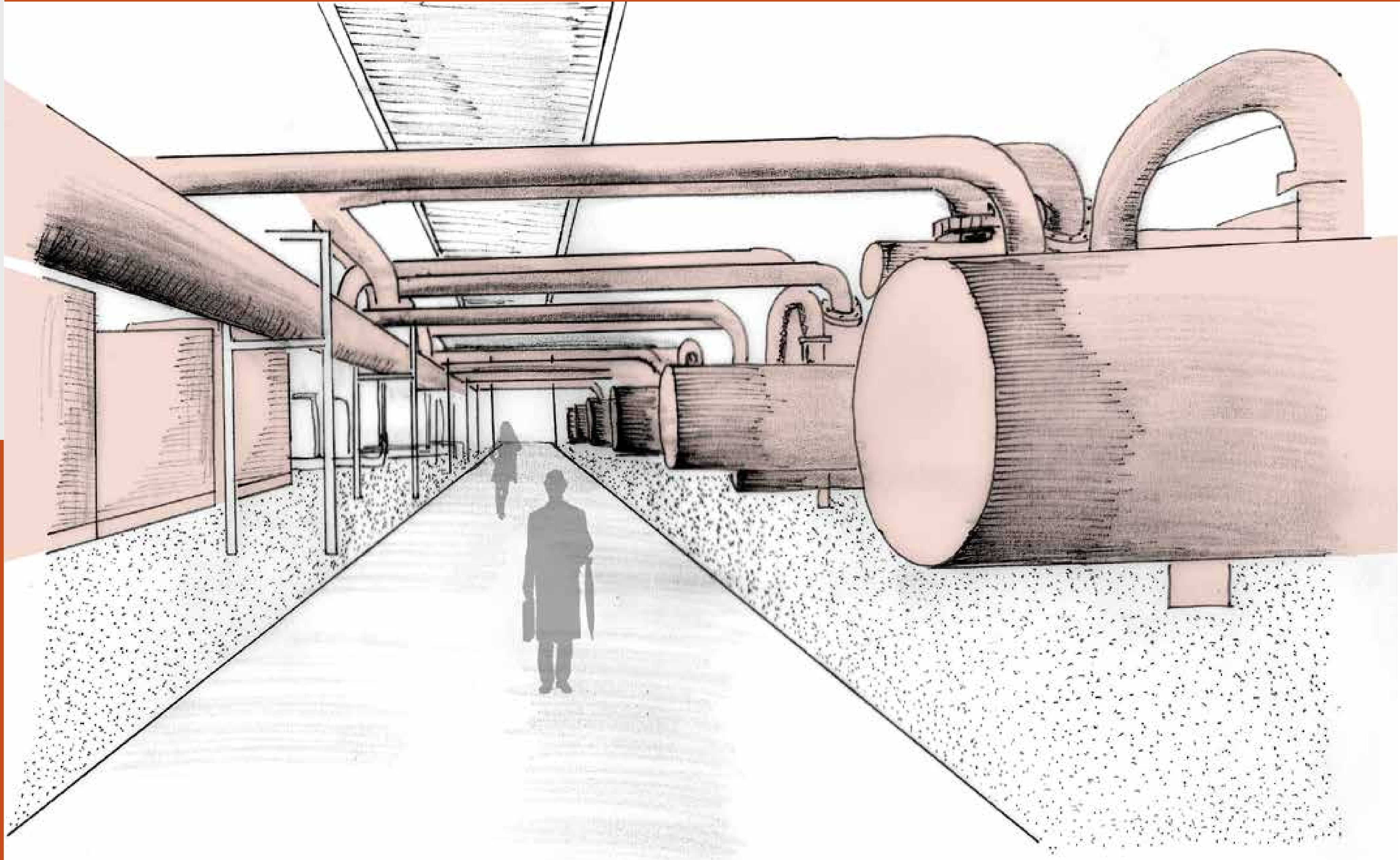
Headgear Design :

Creating the headgear in such a way that it speaks the same language as the horizontal planes. The headgear design reminds of the headgear of the old gold mines on the Witwatersrand. Thus, the expression of history in the design connects with the past.

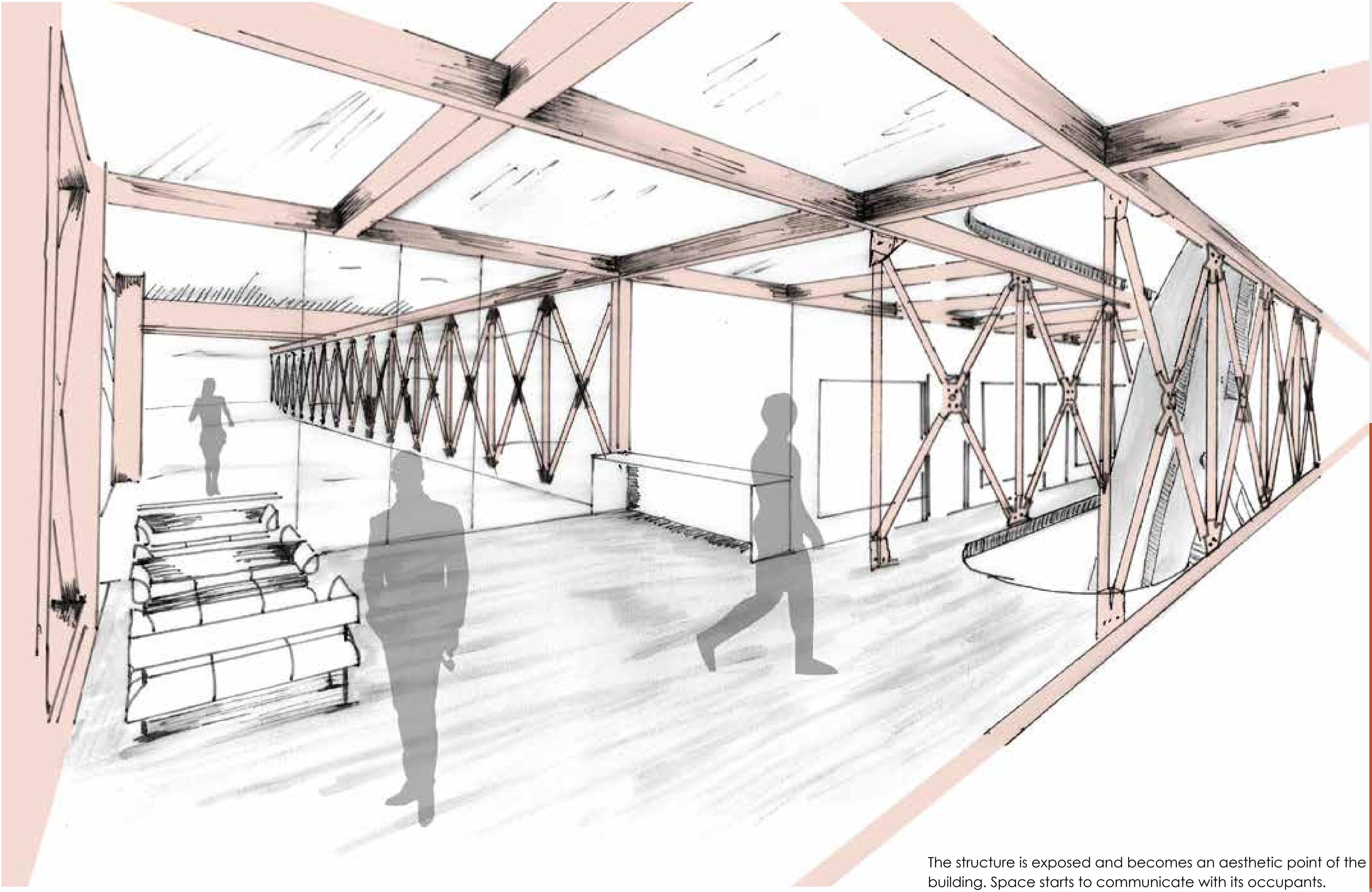




Space Utilisation :

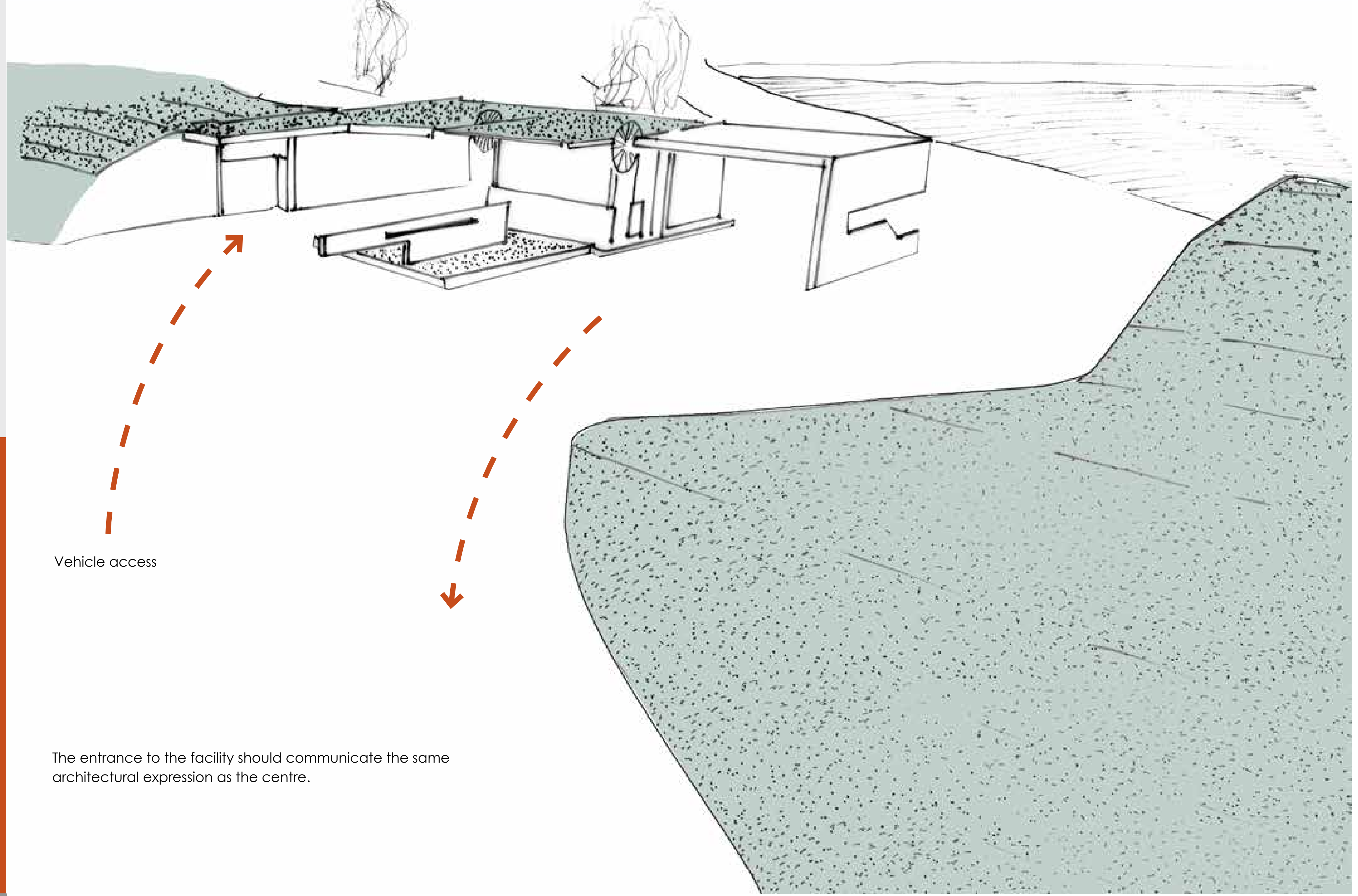


Investigate the connection between man and machine, and movement and moment, and how man experiences the building.



The structure is exposed and becomes an aesthetic point of the building. Space starts to communicate with its occupants.

Guard hut :

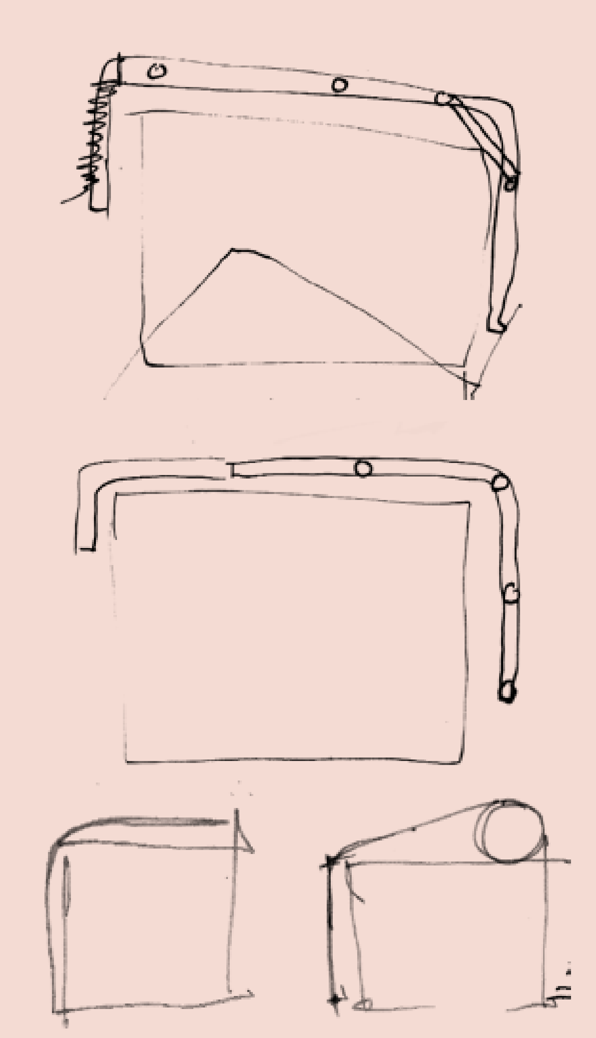


The entrance to the facility should communicate the same architectural expression as the centre.

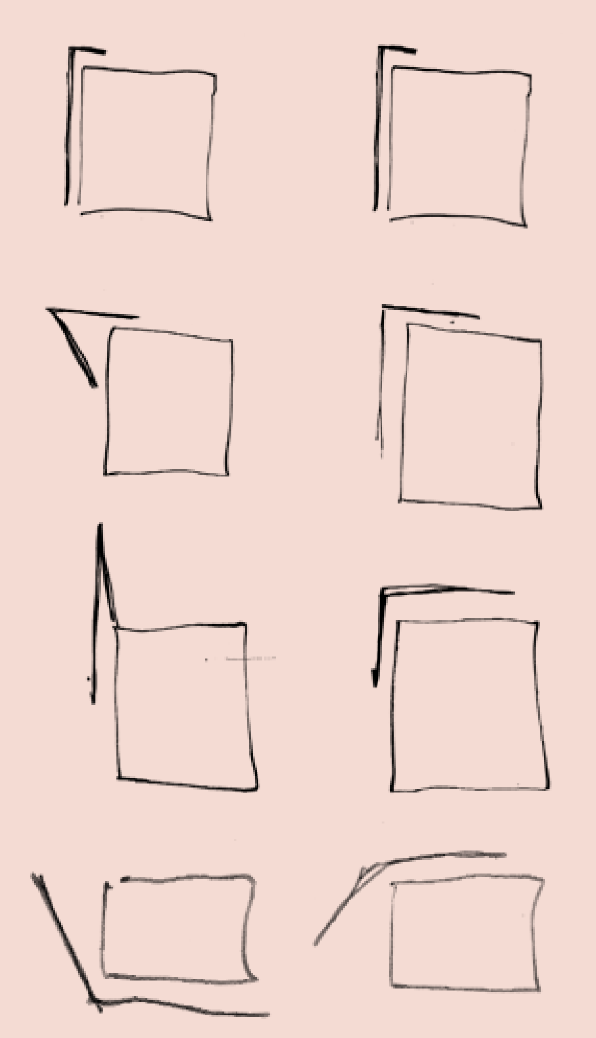
Louvre Design :

These sketches explore the louvre element that folds around the building. It has a responsive reaction towards the aesthetic view onto the building, seasonal changes, and the daily movement of the sun. It also has an impact on the design of the building. It is a mechanical system which is controlled by individuals from inside the building. This individuality will have a movement pattern on the building which differs from hour to hour and day to day.

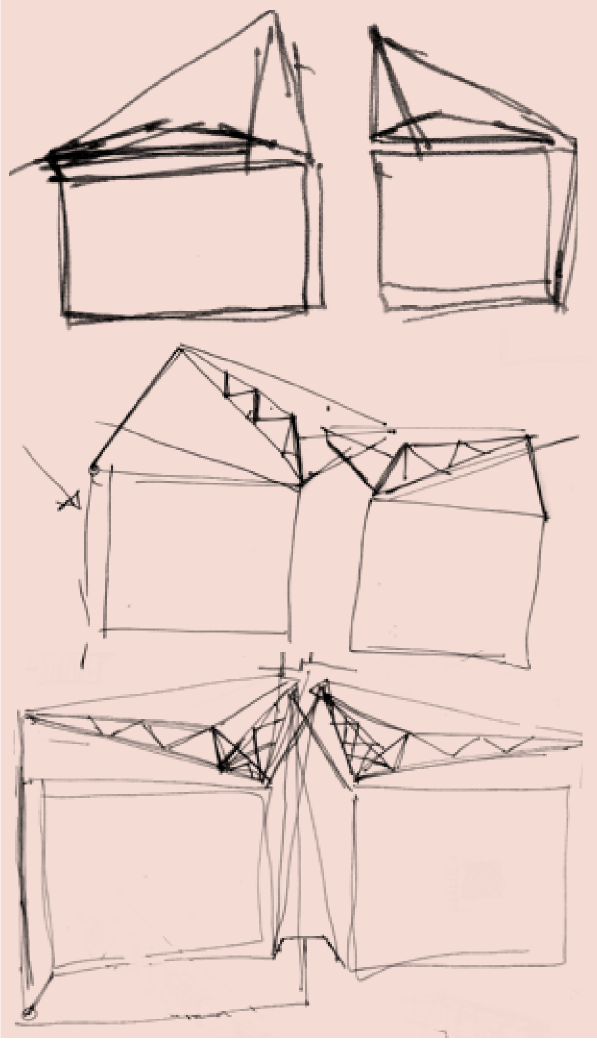
Investigate a louvre system with round edging. These round edges are inspired by the use of pipes and machinery.

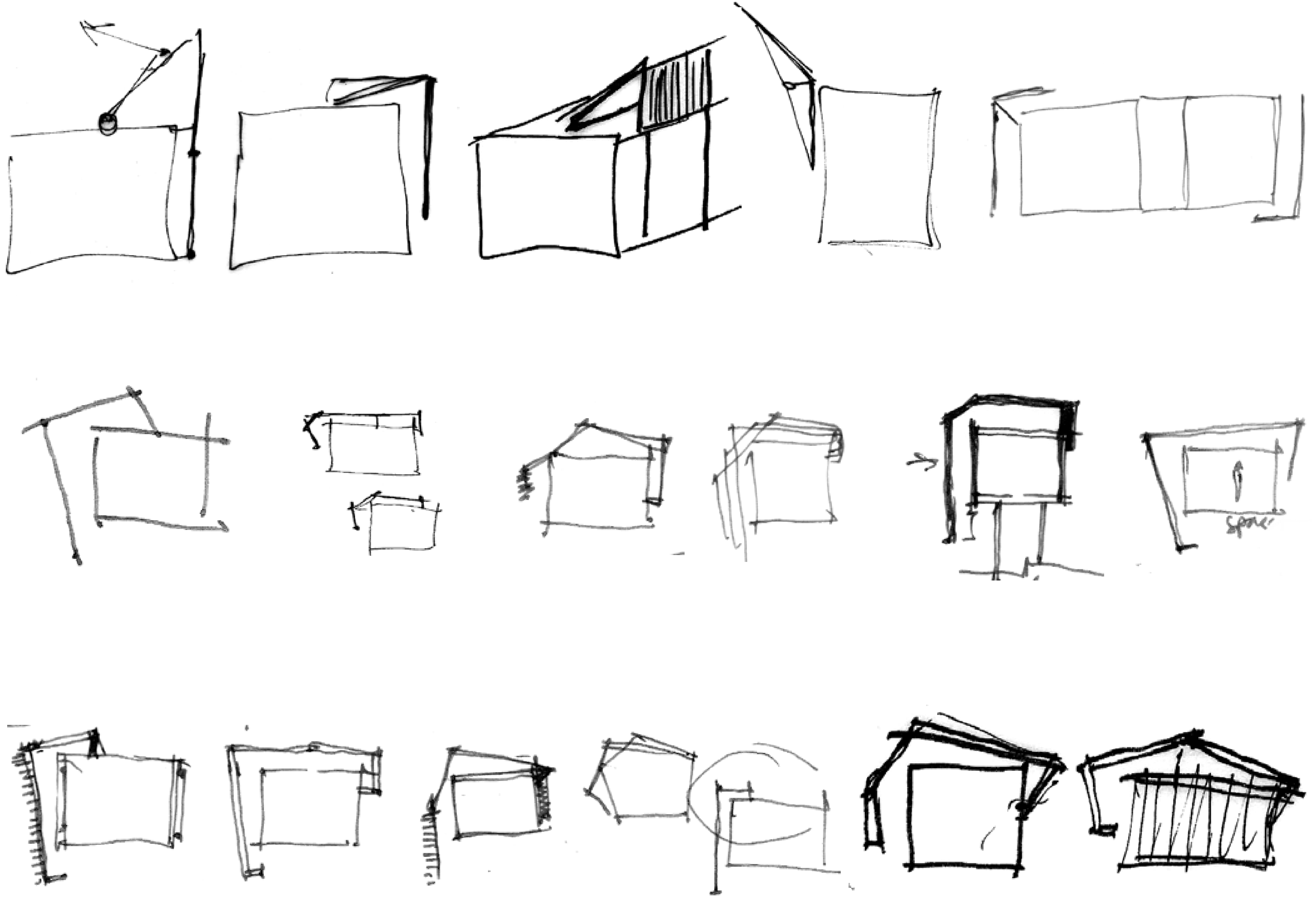


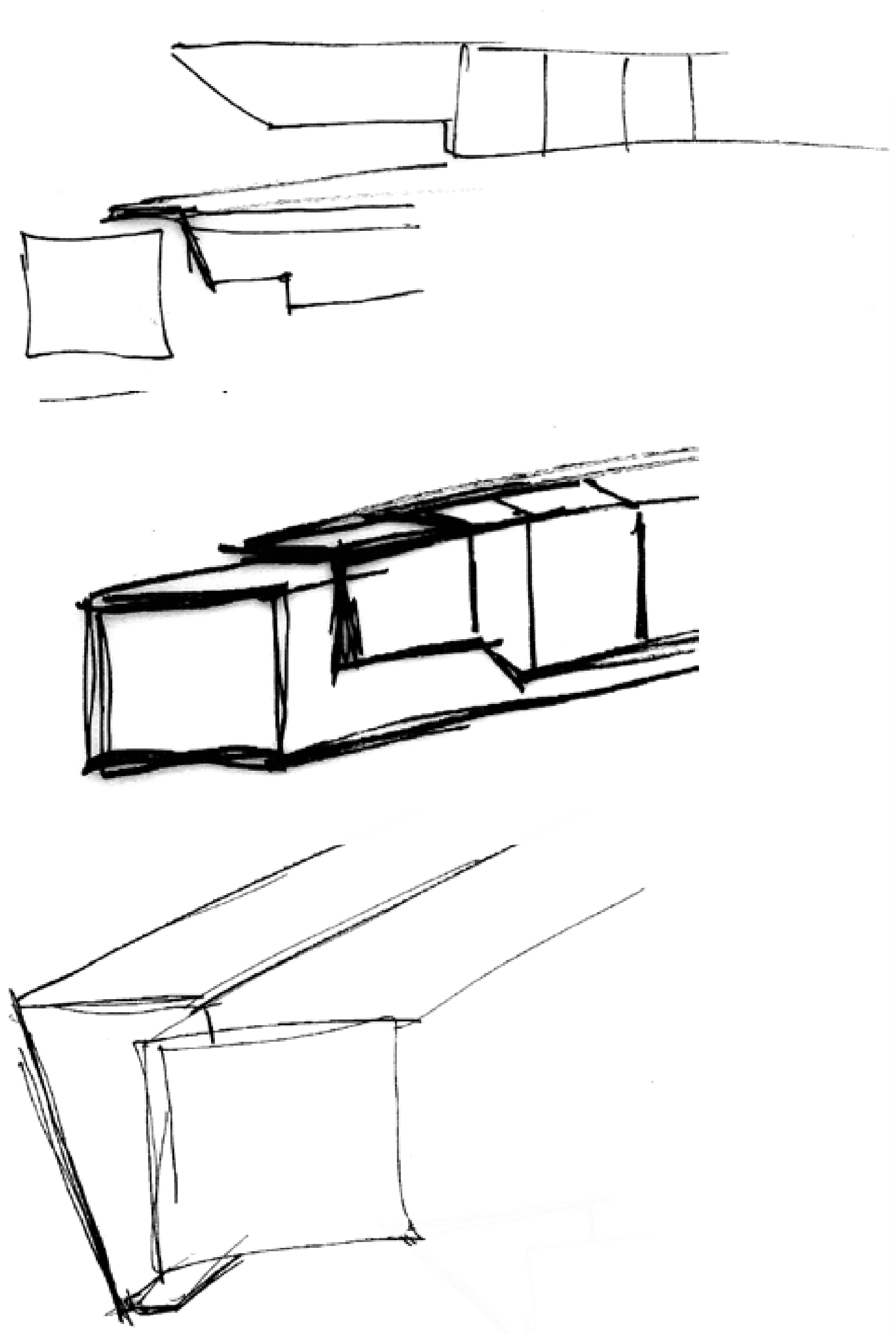
Investigate the movement of the louvre system and the effect it has on the aesthetic façade of the building.



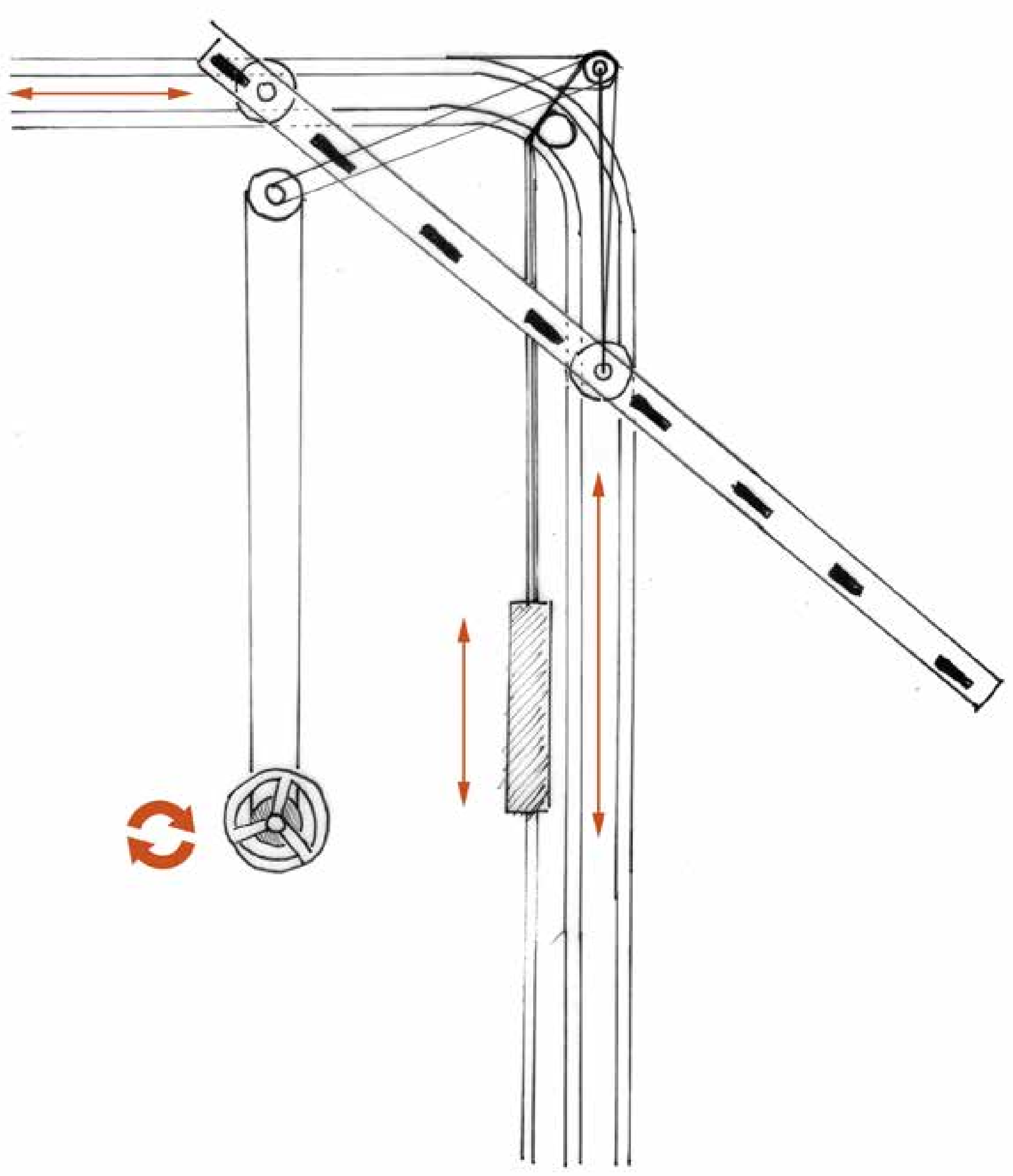
The investigation of a crane movement for the louvre system movement.





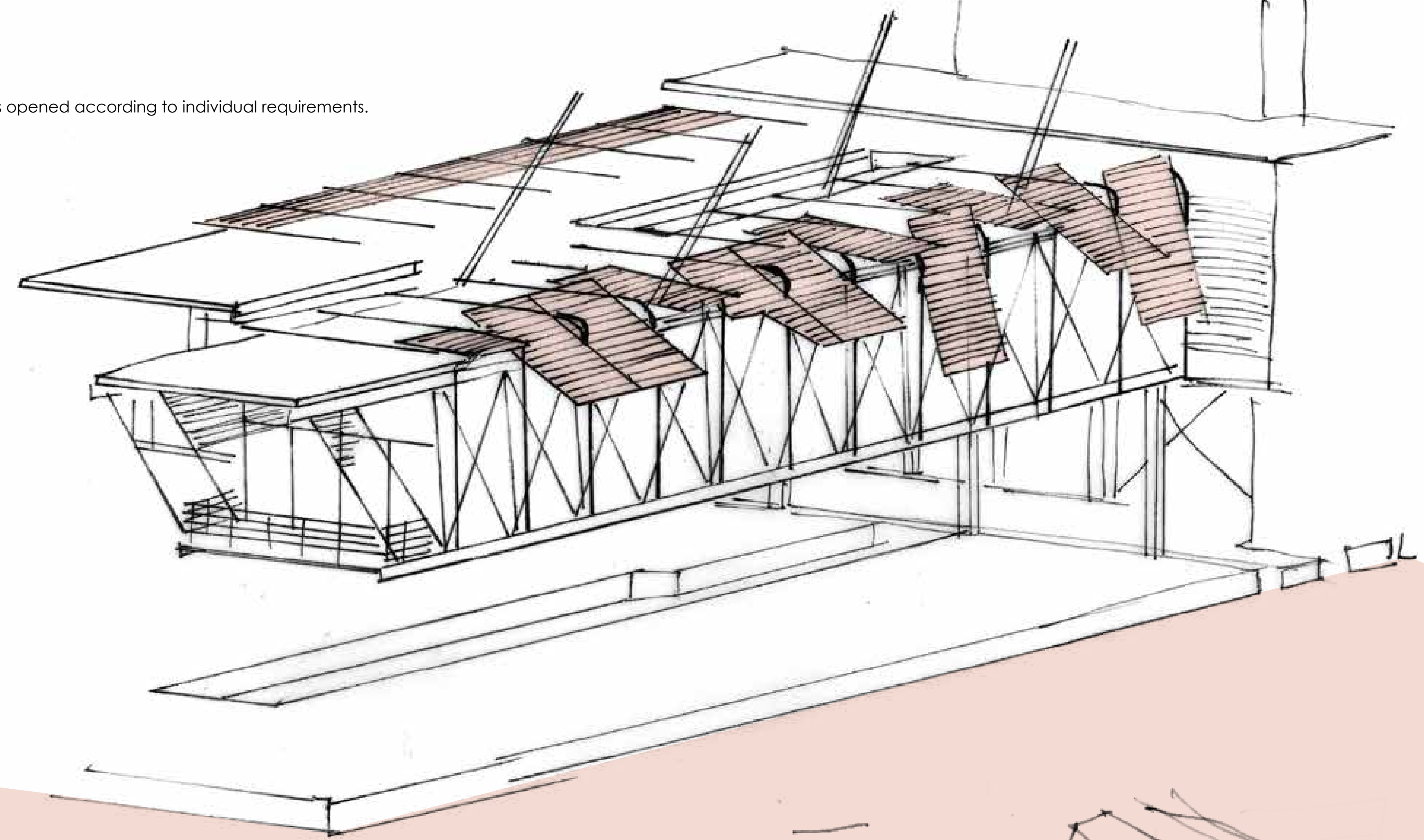


The louvre mechanism works on the same principle as that of lifting a garage door. The curves are designed more rectangular to suit a consistent aesthetic unity of the building.

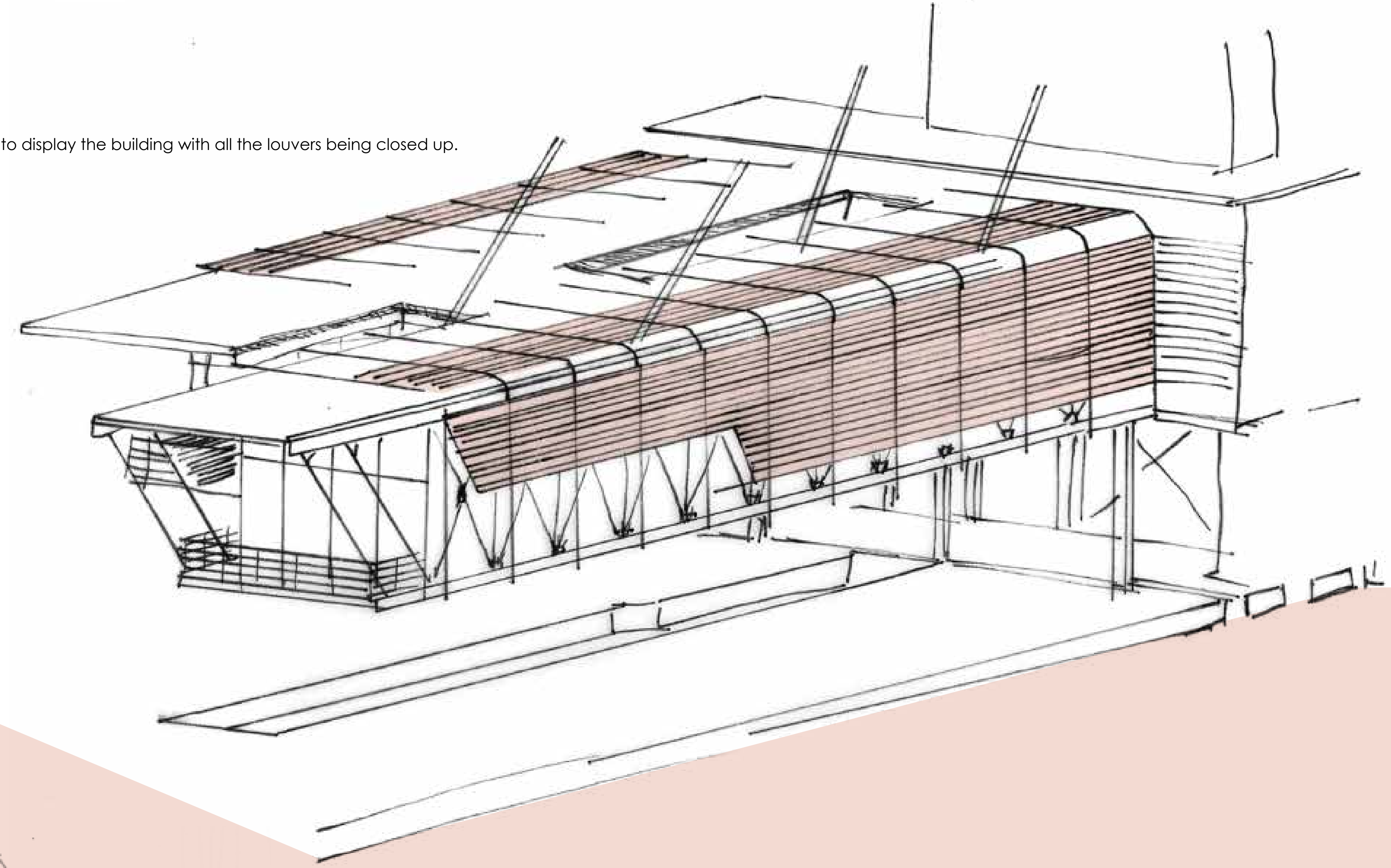


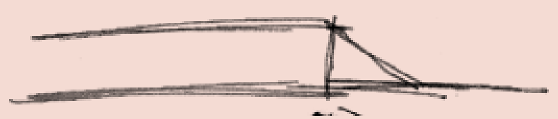
| Design development

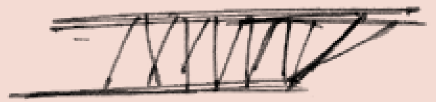
Louvres opened according to individual requirements.

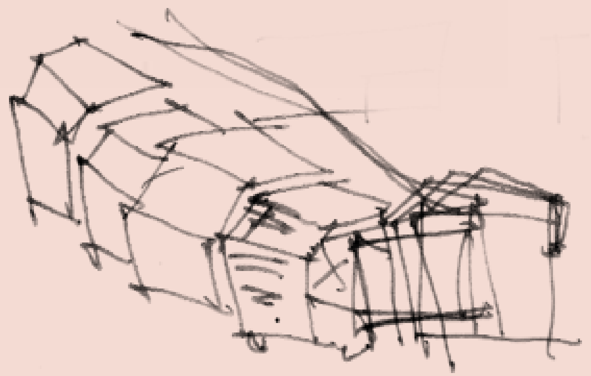


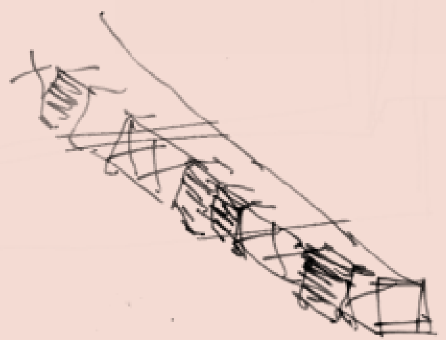
A sketch to display the building with all the louvers being closed up.

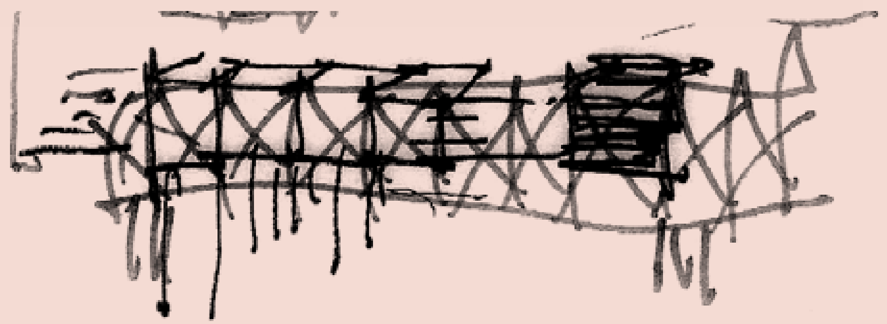






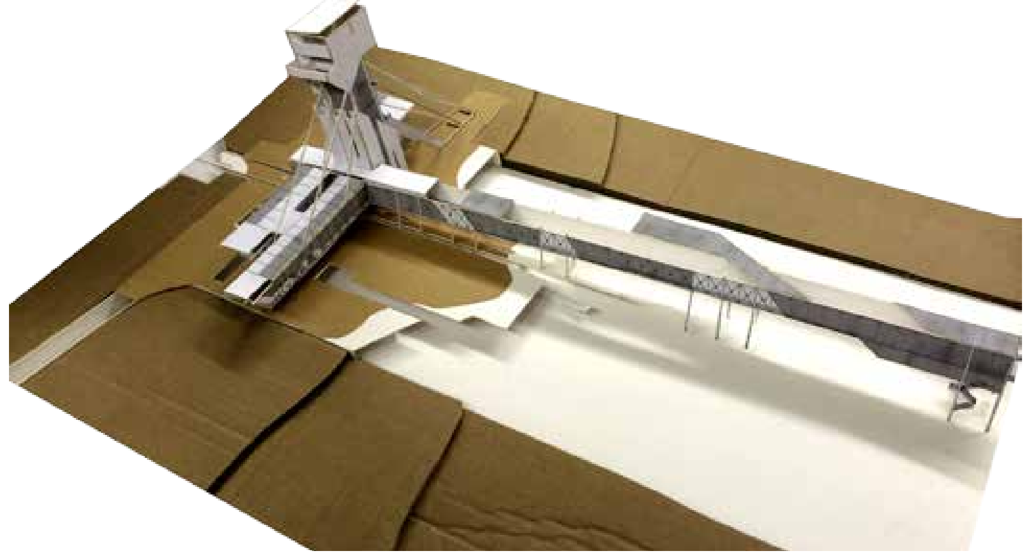


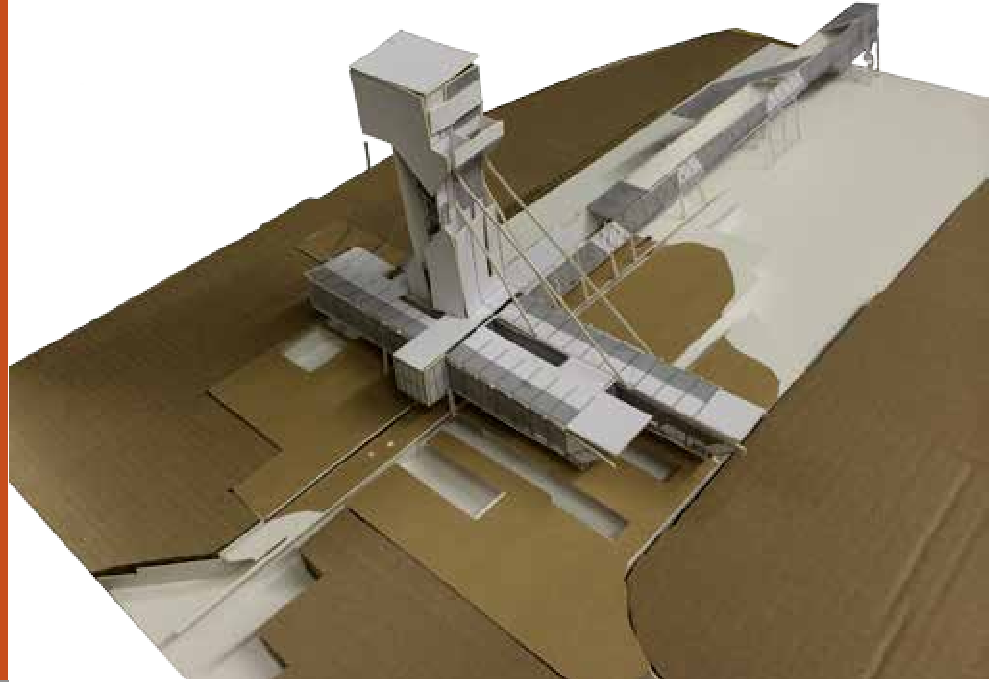




Model 6:

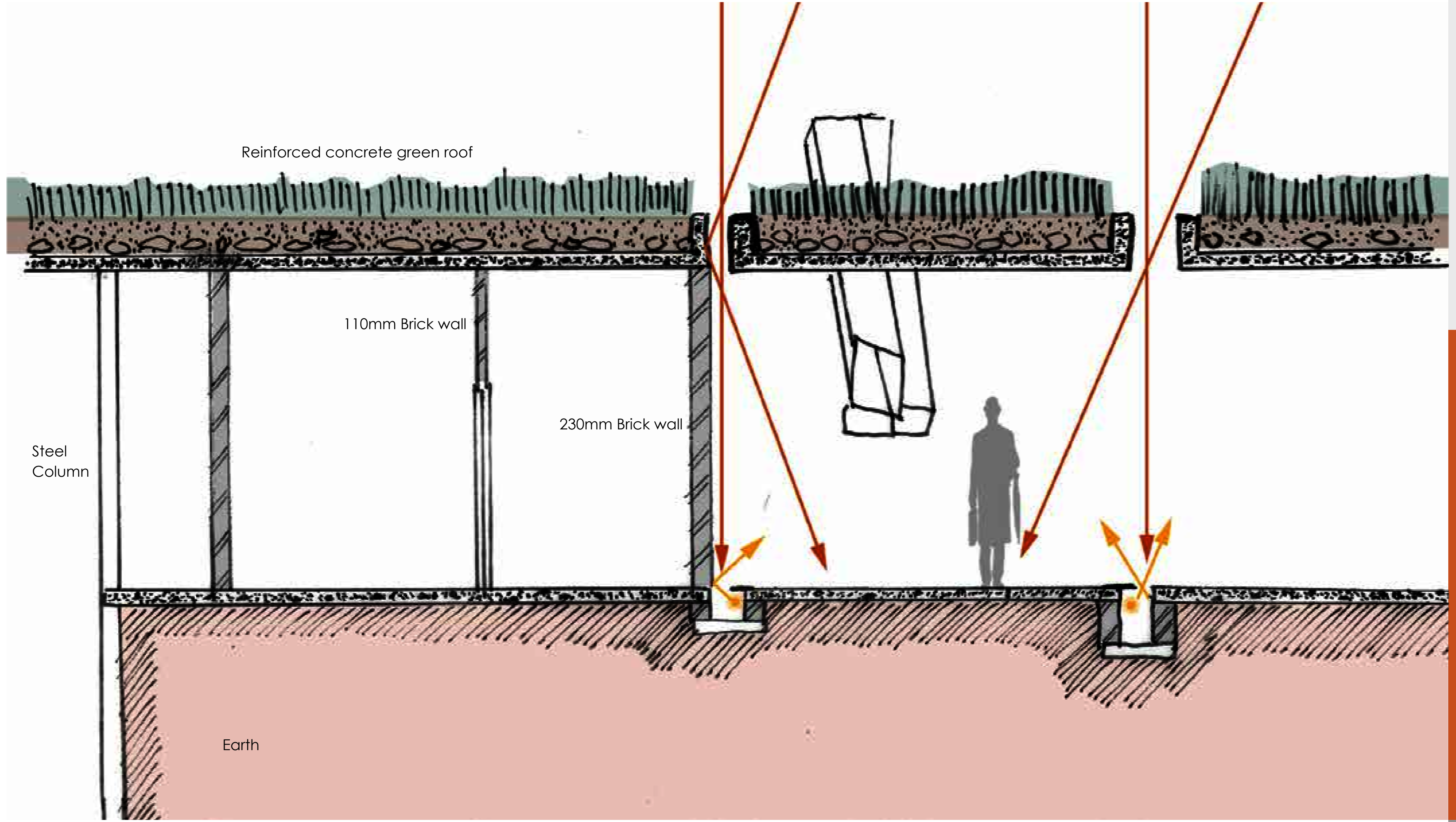
This concept model explores the façades of the building and the view onto it. In this plan a more rectangular elevation on the sides of the horizontal planes was decided on to connect to the face of the headgear that resembles the historic headgear, and the sharper edges of the louvre system.

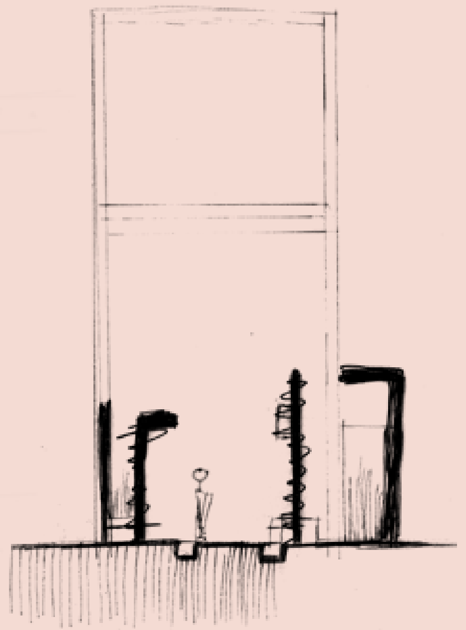


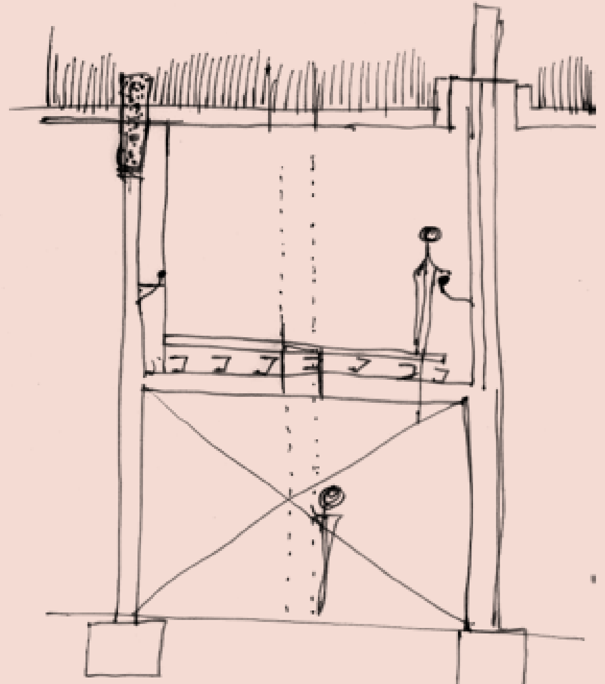


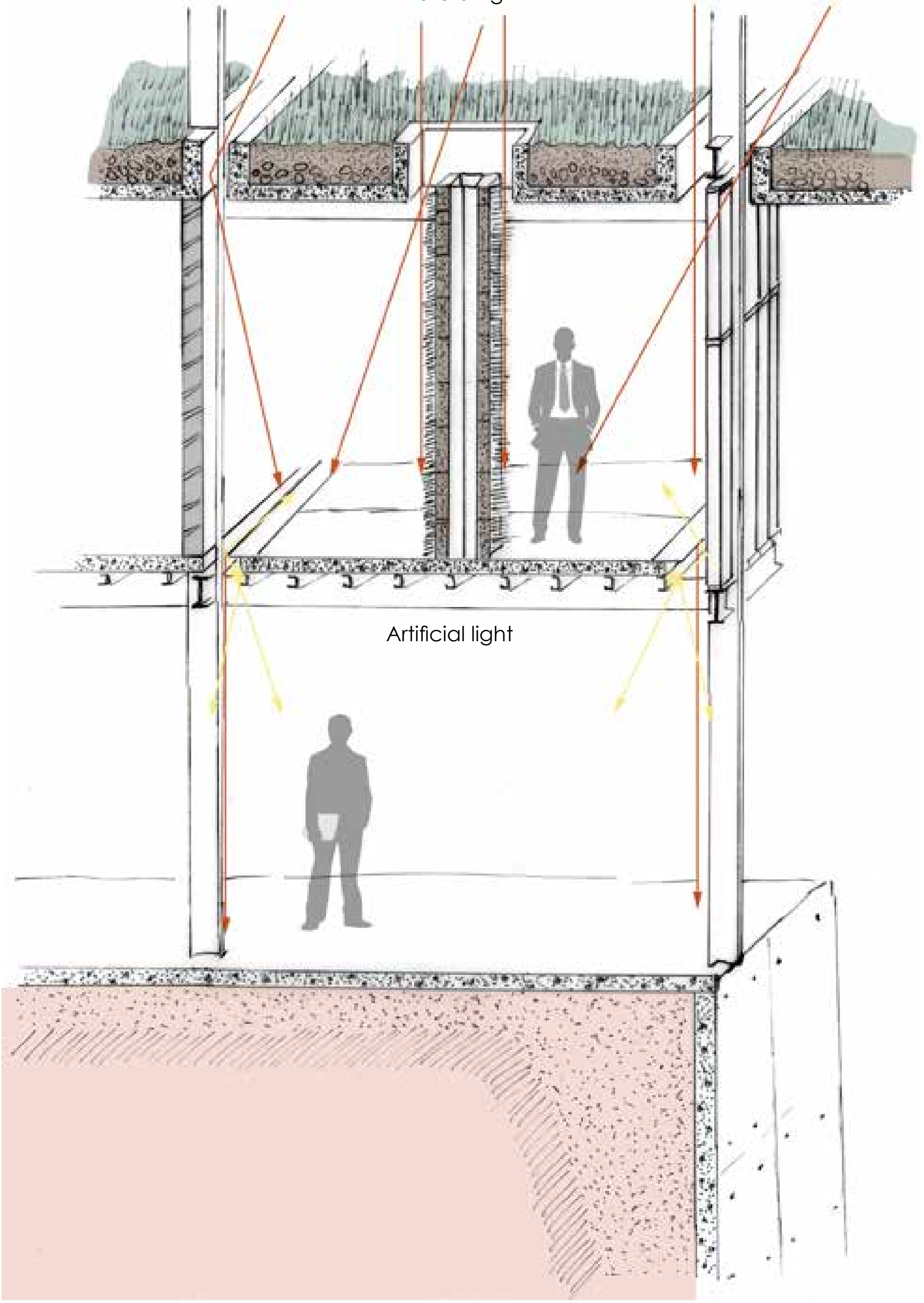
Starting to design the journey experience within the building. Details of design and construction are thought through and applied to propel movement on the journey.

While natural light dances from above, artificial light defines the edge of the pathway.

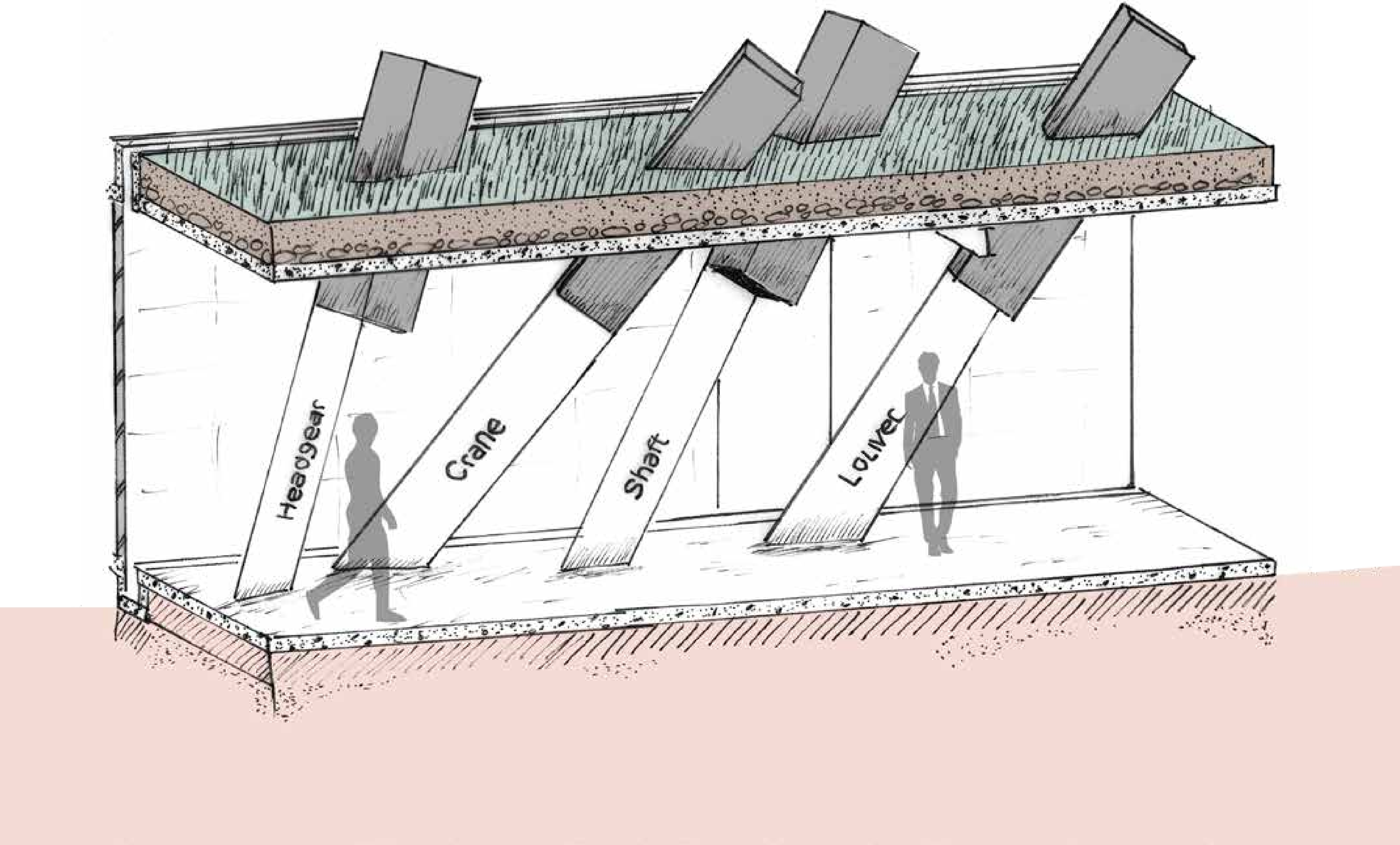


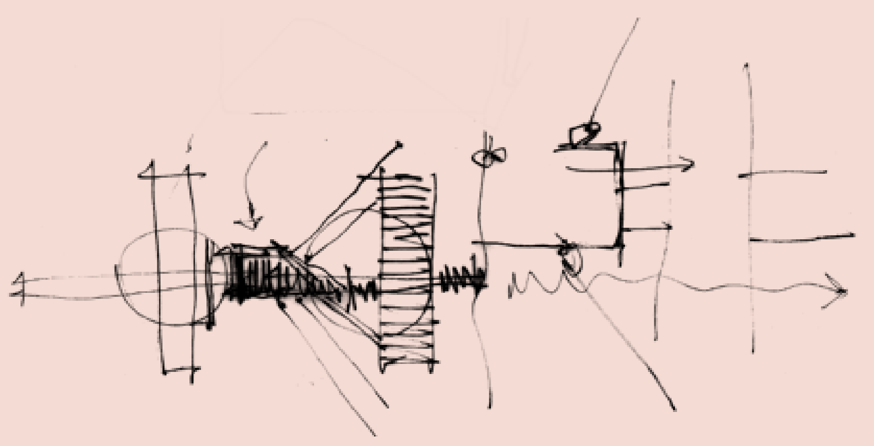


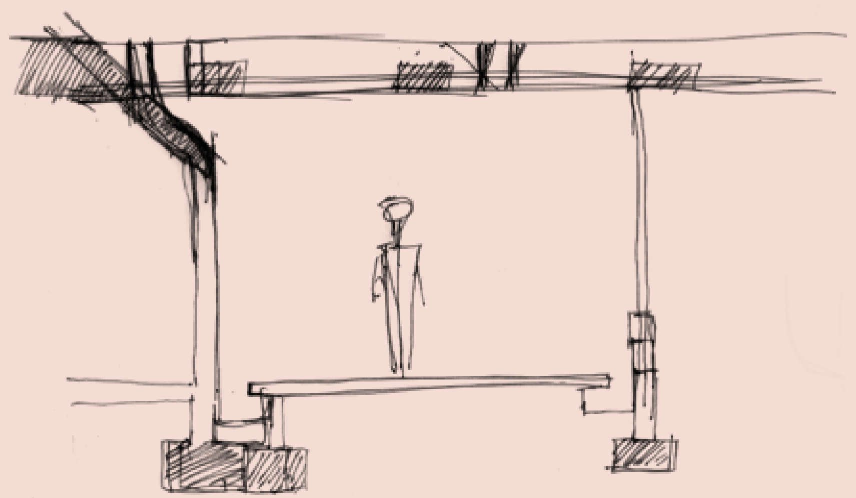




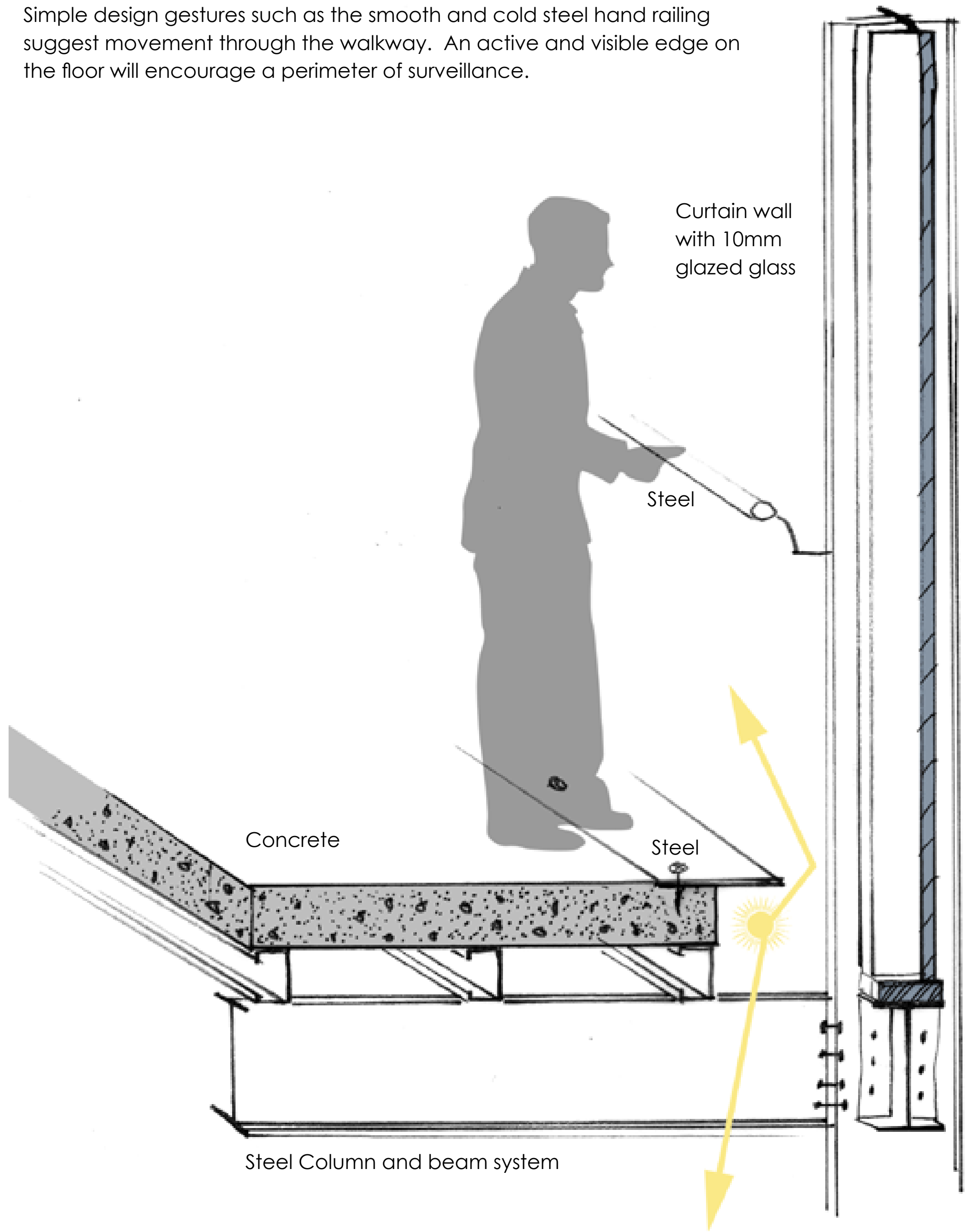
The use of light pods, inspired by Le Corbusier's La Tourette, not only brightens up specific places during the journey, but also provides information about the building and the process.





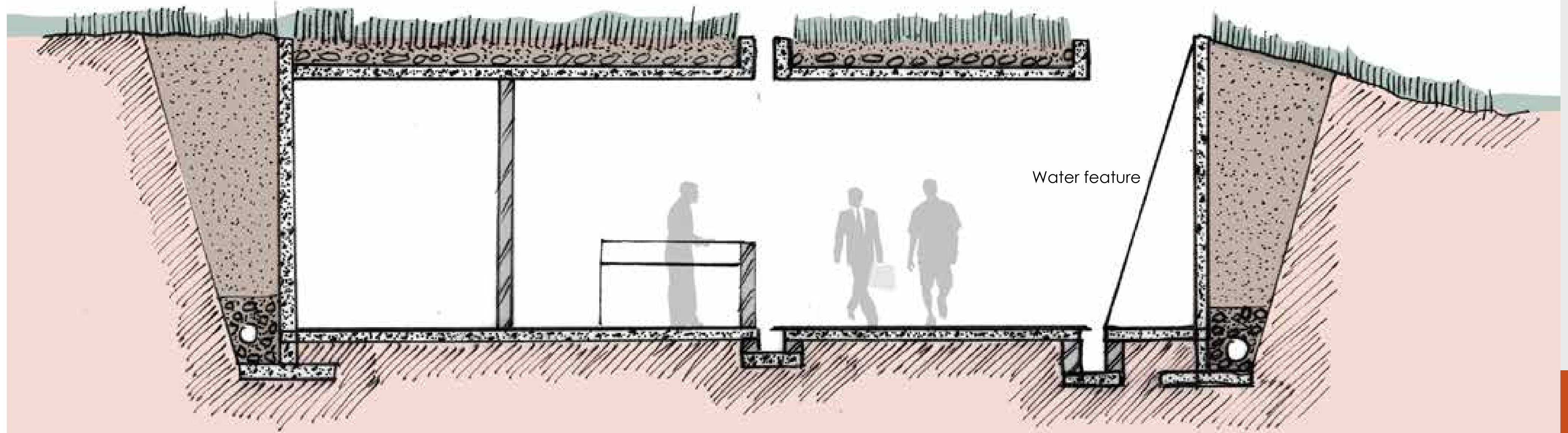


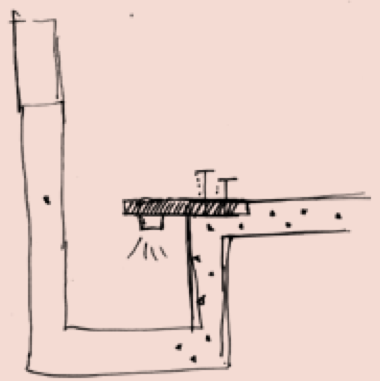
Different textures prepare the senses subtly for the changes in different types of spaces, such the use of glass, concrete, raw earth and steel. Simple design gestures such as the smooth and cold steel hand railing suggest movement through the walkway. An active and visible edge on the floor will encourage a perimeter of surveillance.

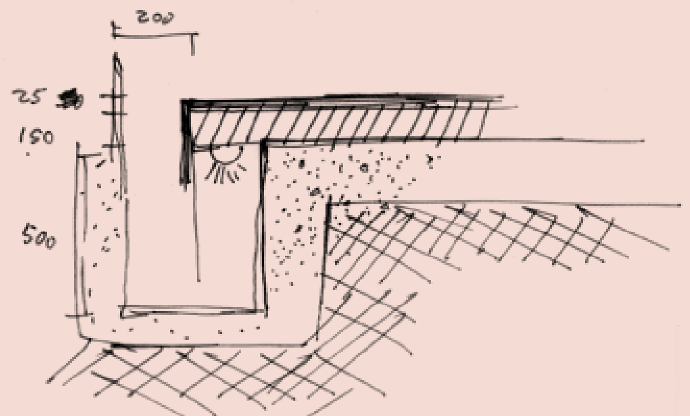


Sound has the magic ability to tie memory with ideas and thoughts. The rocky water feature in the foyer, reminiscent of the use of water and rock in the geothermal process, adds to a sustainable design approach. The tranquil sound of water trickling on rocks also reinforces the haptic experience of the building.

A further experience of sustainability is heightened with the vegetated roof.

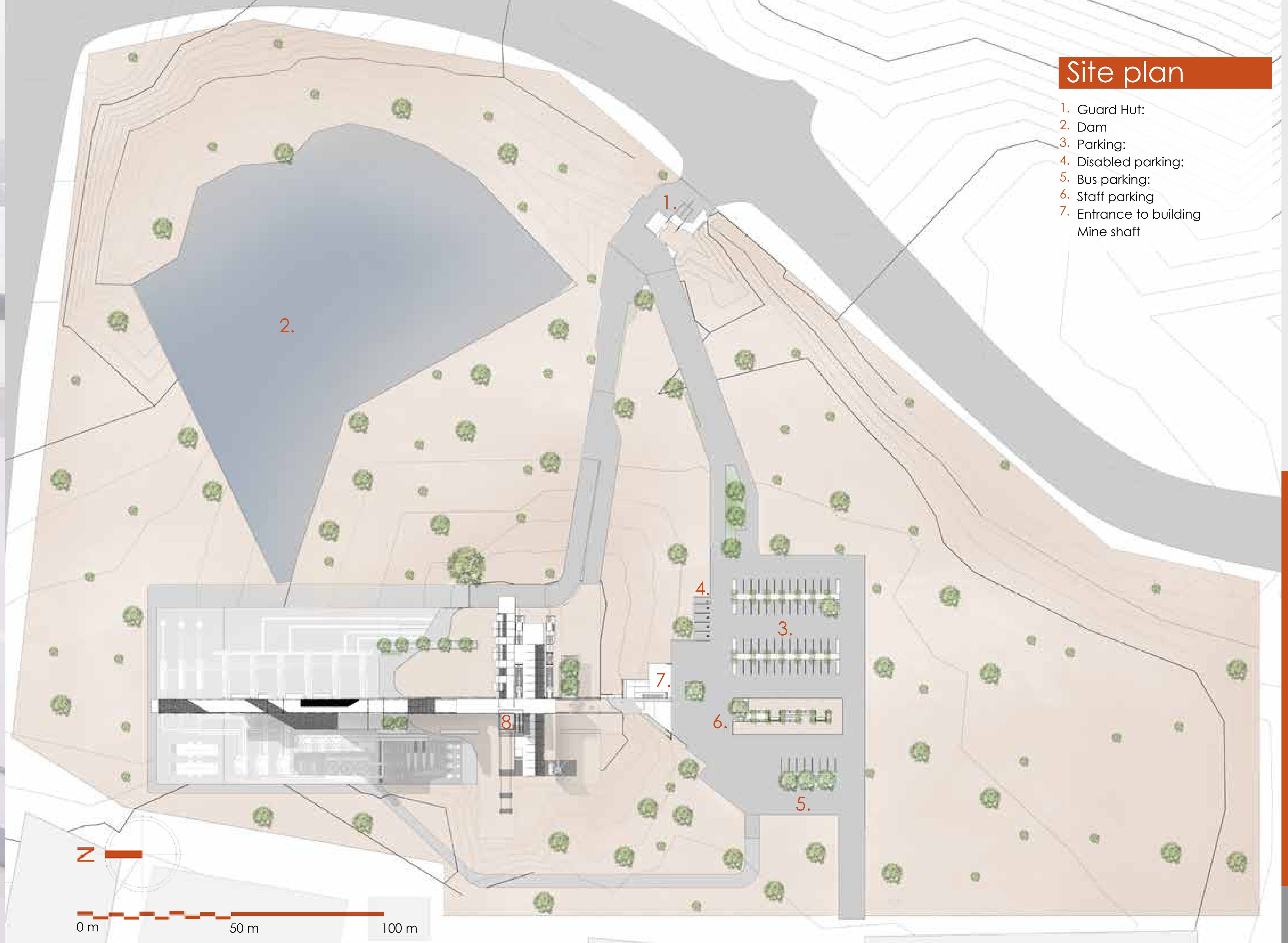


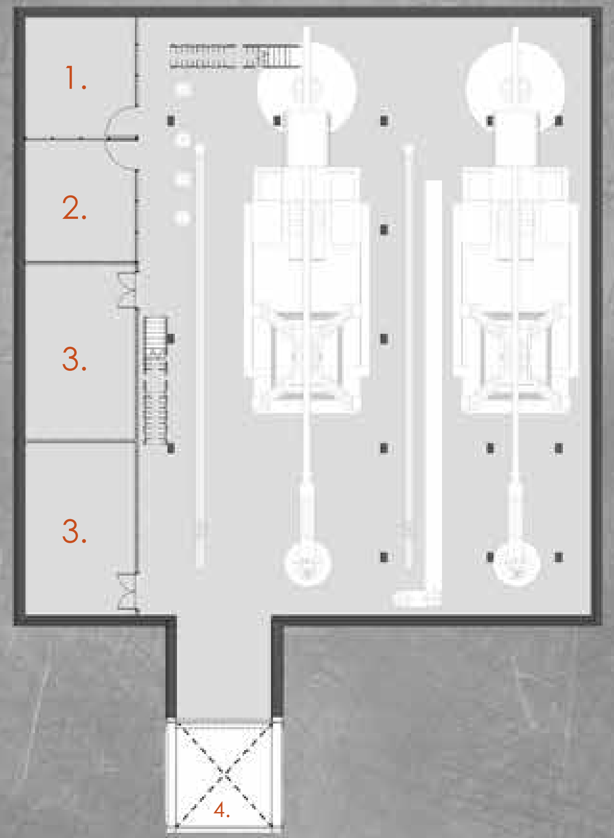




The architectural design of the building responds to its surroundings through materials, texture, glass and concrete walls, and the entrance in such a way that the design includes the entire experience of a journey.

8.2 Final Resolution





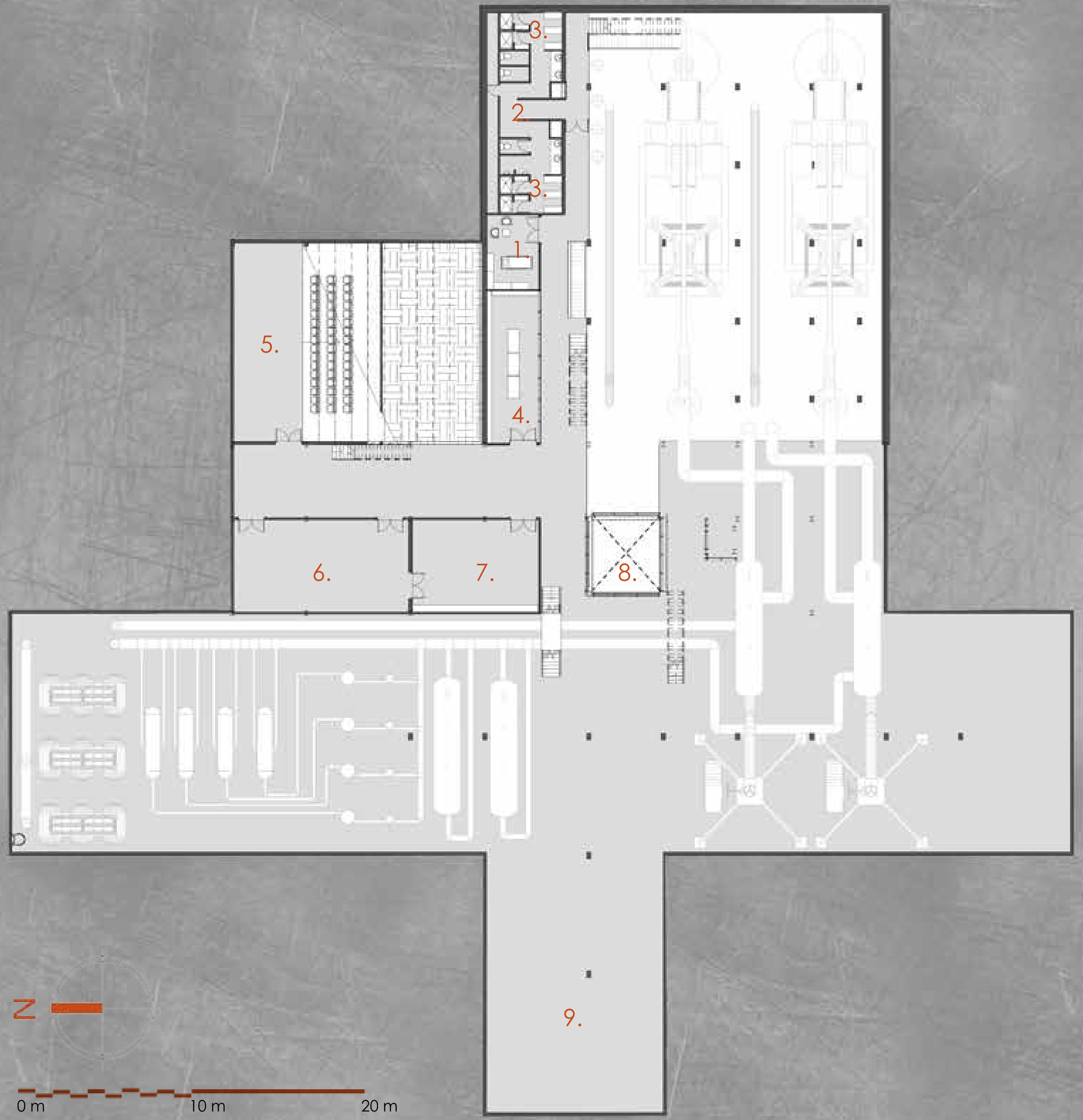
2nd Subfloor level

1. Workshop
2. Machine room
3. Storage room no. 2
4. Mine Shaft

Geothermal plant:
Pumps x2
Injectors x2

N

0 m 10 m 20 m



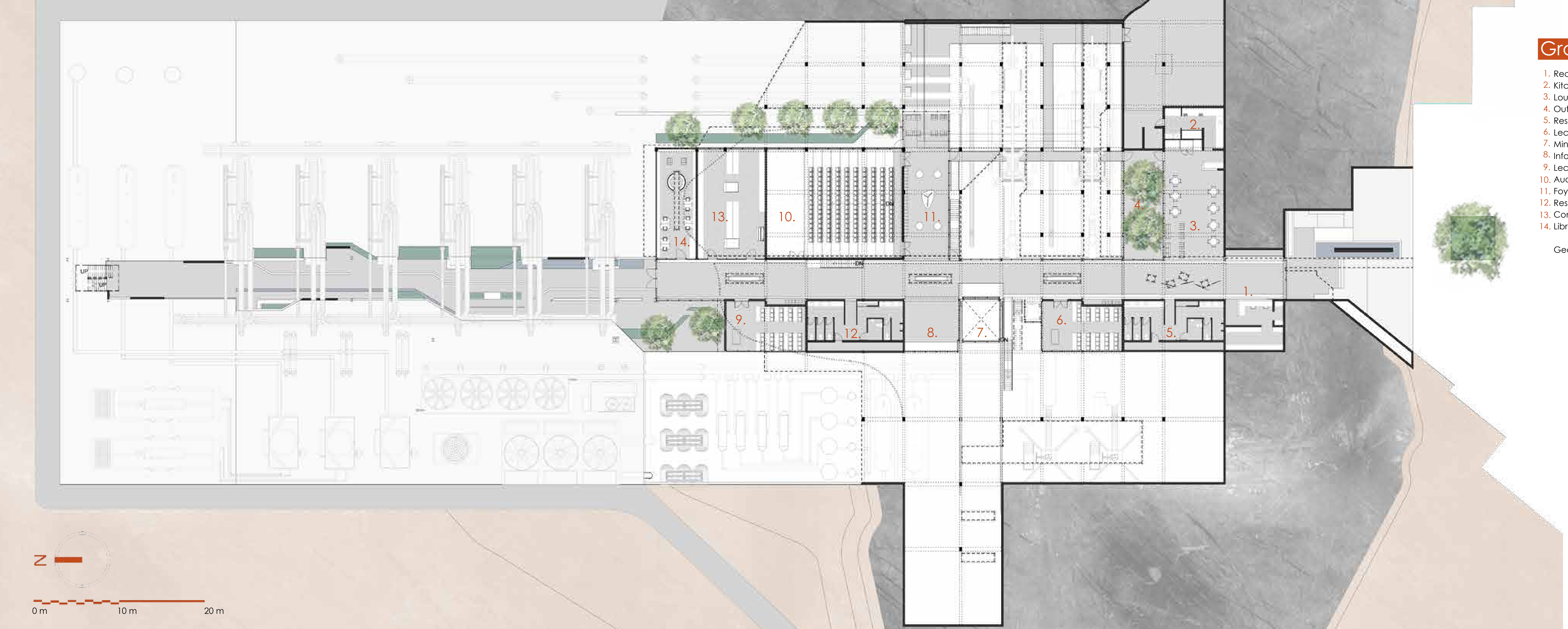
1st Subfloor level

1. Medical facility
2. Restroom no. 1
3. Locker Room
4. Workshop
5. Auditorium
6. Machine room
7. Storage room no. 1
8. Mine Shaft
9. Mine winch x4

Geothermal plant:
Injectors
Water testing
Pressure controls
Test controls

N

0 m 10 m 20 m

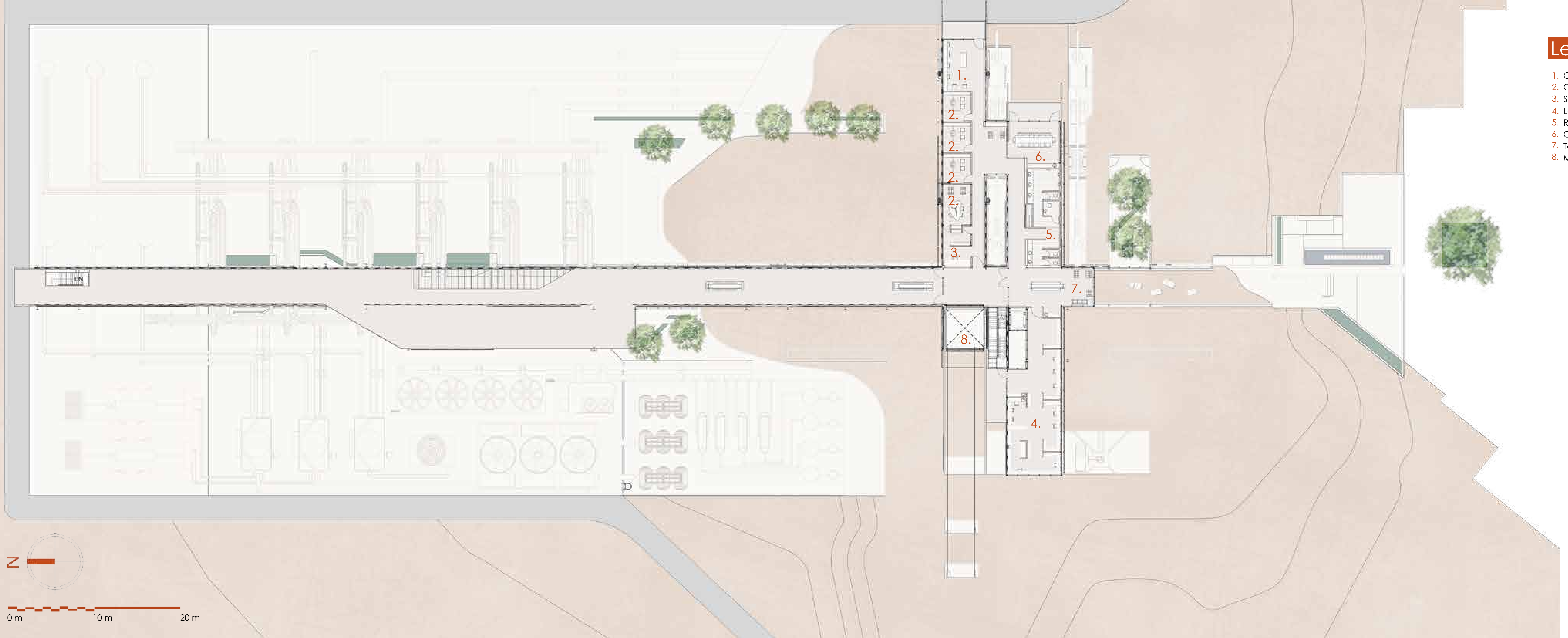


Ground floor level

1. Reception
2. Kitchen
3. Lounge
4. Outside Lounge
5. Restroom no. 3
6. Lecture room 1
7. Mine Shaft
8. Information center
9. Lecture room no. 2
10. Auditorium
11. Foyer to auditorium
12. Restroom no. 2
13. Computer room
14. Library

Geothermal plant:
- Separators
- Turbines
- Transformers
- Pressure release
- Cooling tower

| Design development



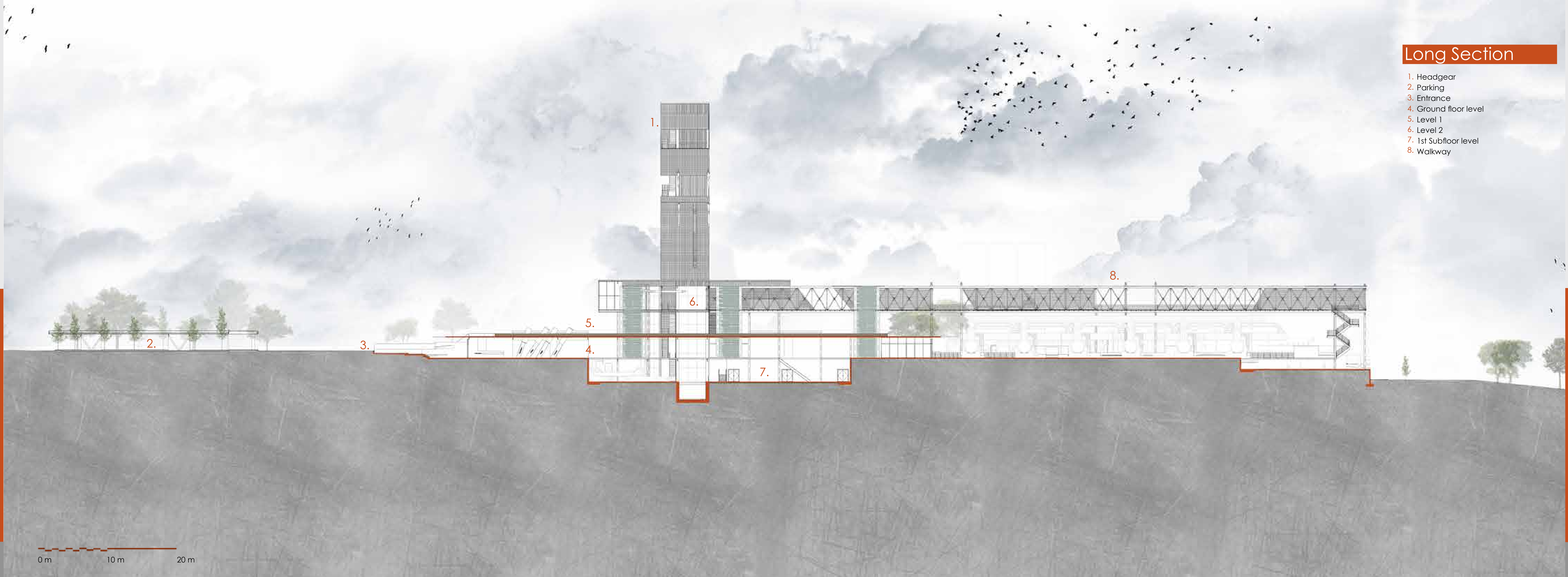
Level 2

1. Open office plan
2. Offices x4
3. Secretary office
4. Laboratory
5. Restroom no. 4
6. Conference room
7. Tea room
8. Mine shaft

West Elevation

1. Headgear
2. Parking
3. Entrance
4. Hillock
5. Level 2
6. Walkway

| Design development



Long Section

1. Headgear
2. Parking
3. Entrance
4. Ground floor level
5. Level 1
6. Level 2
7. 1st Subfloor level
8. Walkway

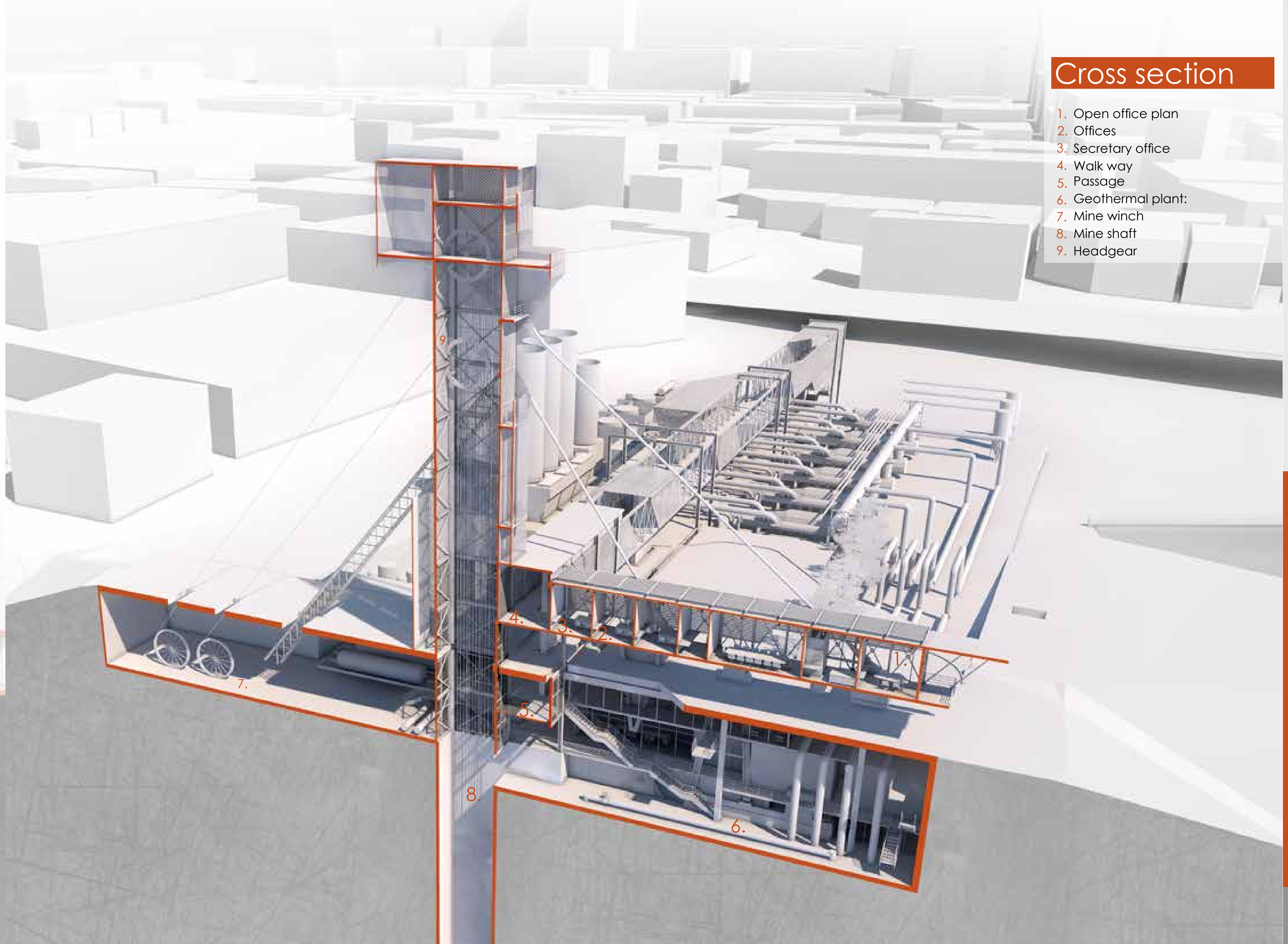
| Design development

Longitudinal Section

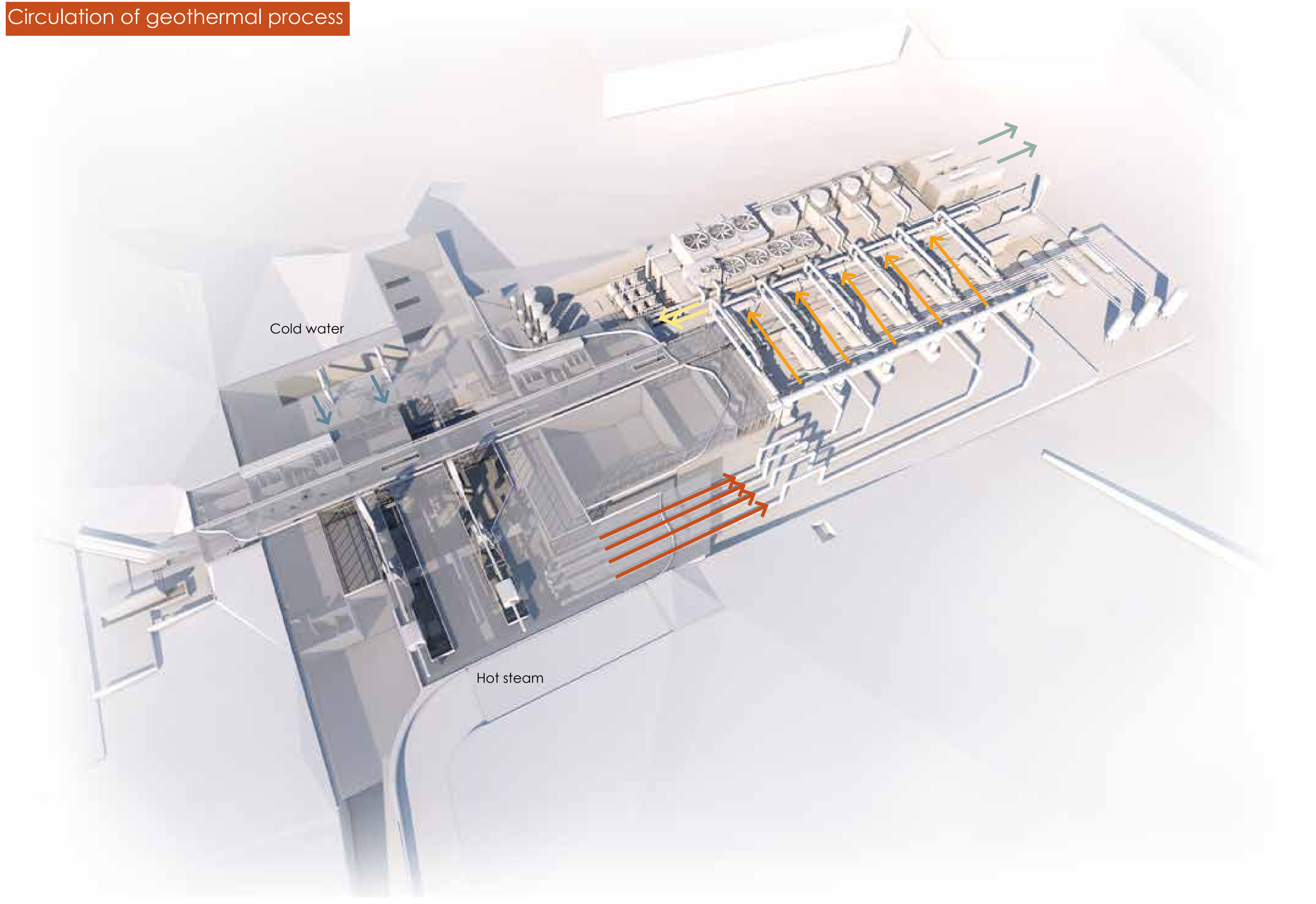
1. Offices x4
2. Restroom no. 4
3. Lounge
4. Outside Lounge
5. Foyer to auditorium
6. Auditorium
7. Computer room
8. Medical facility
9. Machine room
10. Mine shaft

Cross section

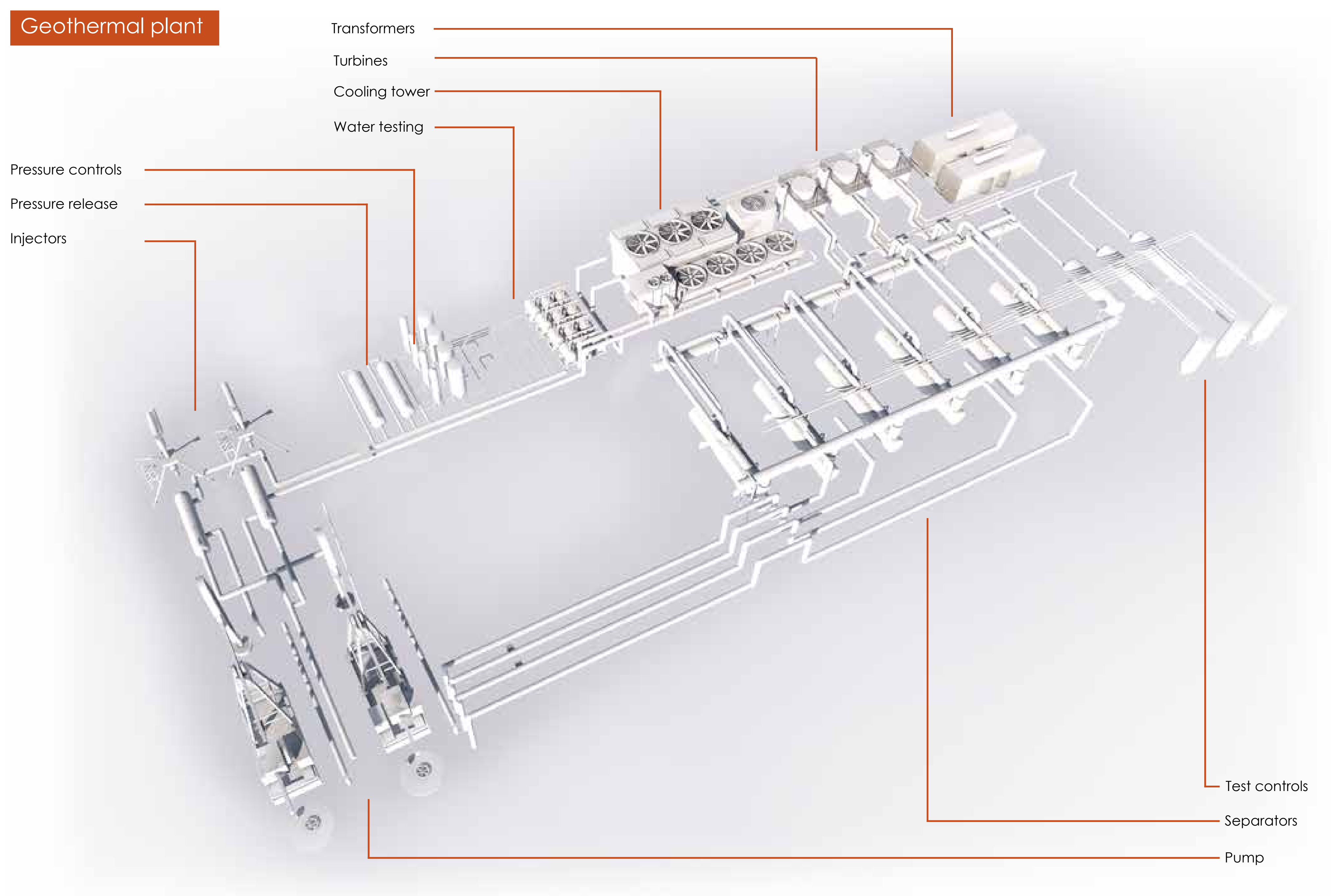
1. Open office plan
2. Offices
3. Secretary office
4. Walk way
5. Passage
6. Geothermal plant:
7. Mine winch
8. Mine shaft
9. Headgear



Circulation of geothermal process



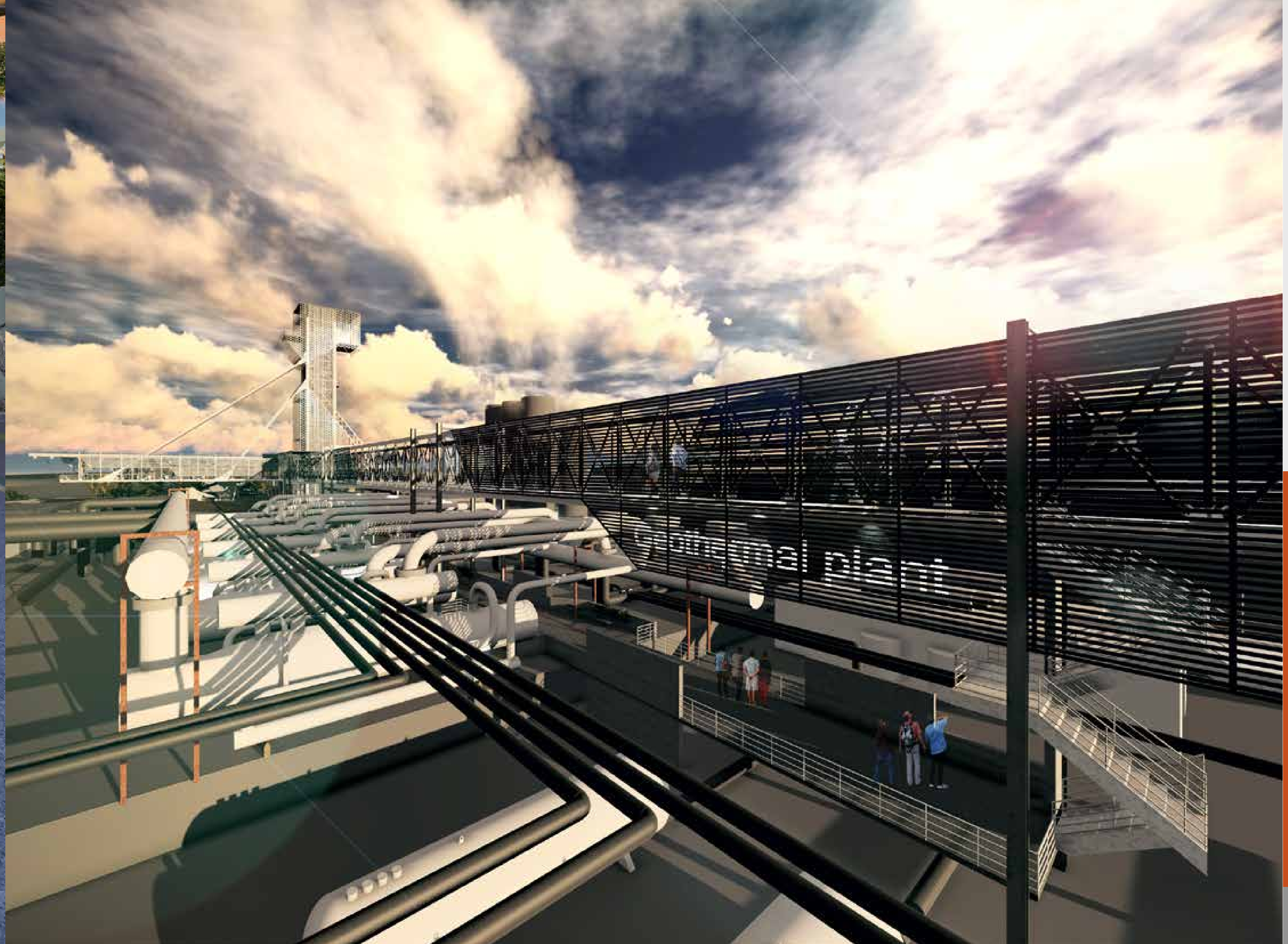
Geothermal plant




Headgear
Crane
Shaft
Louver


Geothermal plant


Separators


plant

Design synthesis

Exploring the journey

9.0 Exploring the journey…

Exploring the journey…

Architecture as a creation is not only about buildings. It is a voyage of thoughts, observation, learning, planning and implementation coming together to create places. Most creations do not originate from one clear thought, but through a development process. This process of research typologies, learning from history and analysis, creates the most innovative solutions. A process requires movement and movement is a very individual matter. For this reason Bloomer & Moore argue in "Body, Memory and Architecture" that the relationship formed between a person and space is very intimate. Intimate relations result from constant dialogue between the human body and its movement with the surrounding architecture and space. Engagement with the environment occurs through movement – as we move along, we see, hear, touch and smell our surrounding environment (Bloomer & Moore, 1977: 78). Movement as a constant force, shapes our world.

By their nature buildings tend to be static, but the architect can create the illusion of movement in a fixed form by following a deliberate studied patterns of how people will move in the building and secondly by telling the story of the building as seen through the eyes of the architectural creator. The shape and the character of the building can emerge from the journey of the architect's imaginative mind through the manipulation of light, shadows, vertical and horizontal lines, texture, mass and voids, the axes of a particular arrangement, the employment of materials, or the just feeling of being guided by the space of the structure.

Scarpa was known to have given a lot of attention to the design of the door handles of his buildings. Intimate building details such as door handles represent moments of physical contact between buildings and their occupants (Owen & Vokes, 2012: 3). In the rushed climate of today's professional world it seems a little unorthodox, but by paying attention to little details a journey of architectural unity can be created.

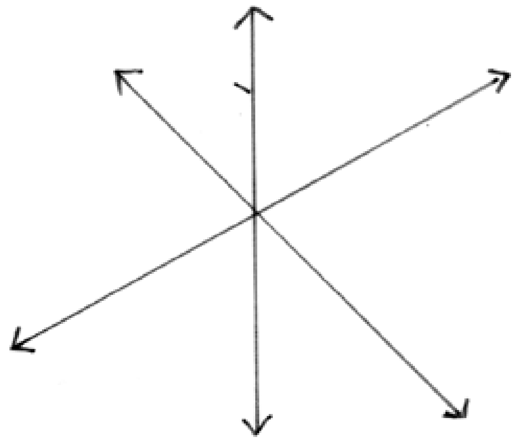
9.1 Architecture begins with Geometry

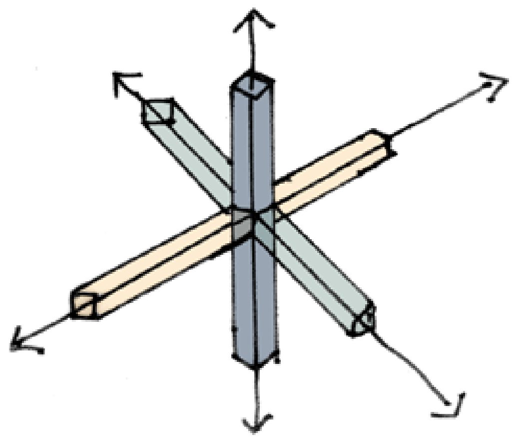
The ancient Roman architect Vitruvius believed that builders should always use precise ratios when constructing temples. The proportions Vitruvius recommended was modelled after the human body (Pollio, 2014: 211). Principles of geometry are not confined to temples and monuments. Geometry shapes all buildings.

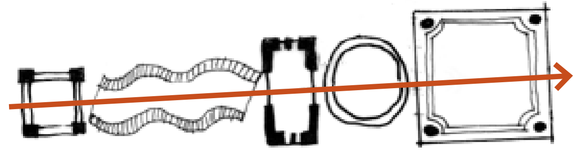
Le Corbusier was inspired by the geometry of the Greek classical world and Villa Savoye is a good example of it. Le Corbusier argued that the Greeks used basic geometric shapes, which evoked emotional responses from observers. At Villa Savoye, Le Corbusier started with a basic cubic volume. By filling in the carved out volume with rectangles, cylinders and cubes, Le Corbusier creates a form that appears to float above a horizontal plane. He became intrigued with technology. Villa Savoye, a second residence outside Paris, was designed with the car in mind. The approach to the house was by car, past the house of the caretaker and eventually parking under the building. The curved glass façade on the ground floor was designed to accommodate the turning radius of a car. The garage is around the curve. This exterior form emphasises his intention of creating architecture to convey movement (Boyer & Le Corbusier, 2011: 287).

Le Corbusier's geometric vocabulary in Villa Savoye serves as a departure point when thinking about form in the design of the geothermal research center . Three rectangles are visible – the long passage, the cantilevered section, and the vertical tower – all in different directions to form an XYZ movement of moving up and down, back and forth, and left and right. Every motion in this design is dependent on the prominent rectangular passage as in a tunnel which in itself relates to the underground tunnels. The vertical line corresponds to the vertical analysis of the Johannesburg skyline. The tower of the mineshaft has a distinctive geometric look that reminds one of the historical mineshafts of the Main Reef.

The geometry of the long rectangles in this design ties in with the idea of a journey.







Rectangular design on an access.

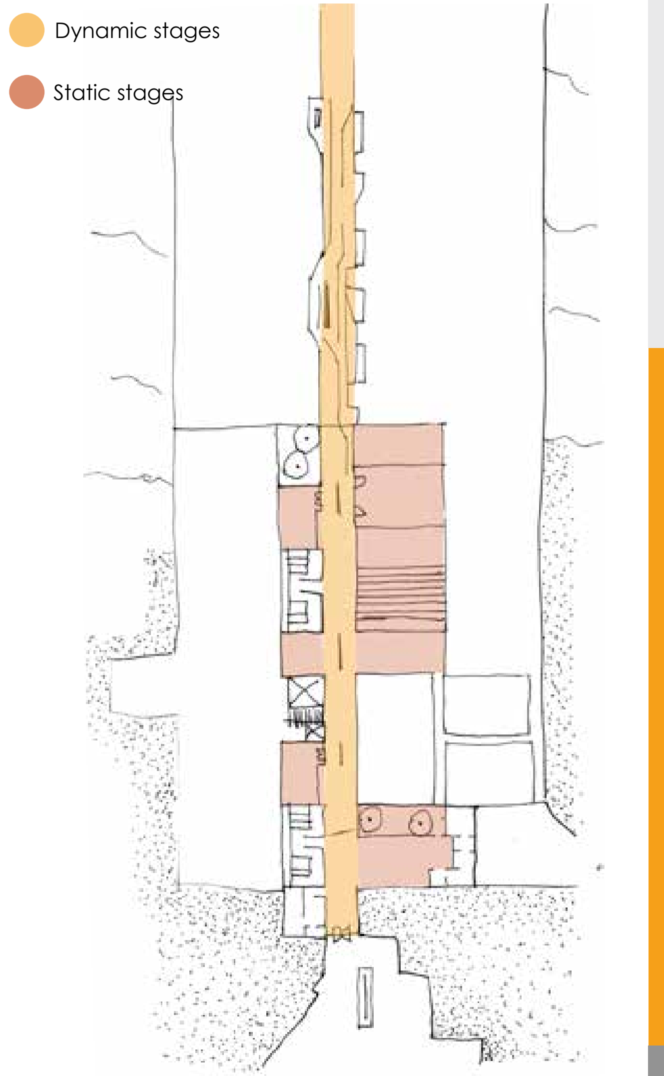
9.2 Expression through Movement

Aristotle argued in his work "On the Soul" that humans must not be seen as bodies, but as a whole being consisting of body and soul. The body is a living organism and the soul helps the body in being. "Being" means movement. In other words movement is not something humans do, but something humans are (Cohen, 2004: online). Movement can be undertaken without any transportation. The smallest eye movement is sometimes the least resource committed, but not the least rewarding. In this proposed project the eye observes the progression of moving architecture into the earth and into the sky and the journey of light patterns. The entrance of the centre follows through an underground tunnel to progress into the sky. The light pods lead the eye down the journey of the passage. The alignment of architecture with the machine viewed from the passage leads to emphasis, all of which is mobile.

Simon Unwin remarks in "Analysing architecture" that one must move around to experience architecture. He further writes that static and dynamic movements influence each other depending on the specific character that they must fulfil in a building (Unwin, 2009: 157).

With this project movement progresses through the building in dynamic and static stages. The dynamic motion of the passage contrasts with the static motion of lecture rooms and sitting areas where the obtaining of information is yet another journey.

Journeying the pathway.

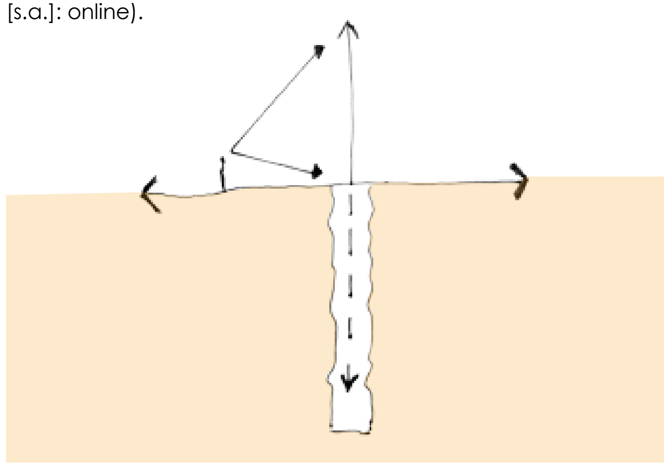


A horizontal line represents architecture of flow. The passage starts outside the building, taking visitors through the entrance (being underground) to a process of movement of energy. The circular movement of the passage demonstrates the recycling of energy. Visitors start their journey where energy leaves the earth and returns to the earth at the same point; thus the end of the journey is reflected in the beginning of the journey.

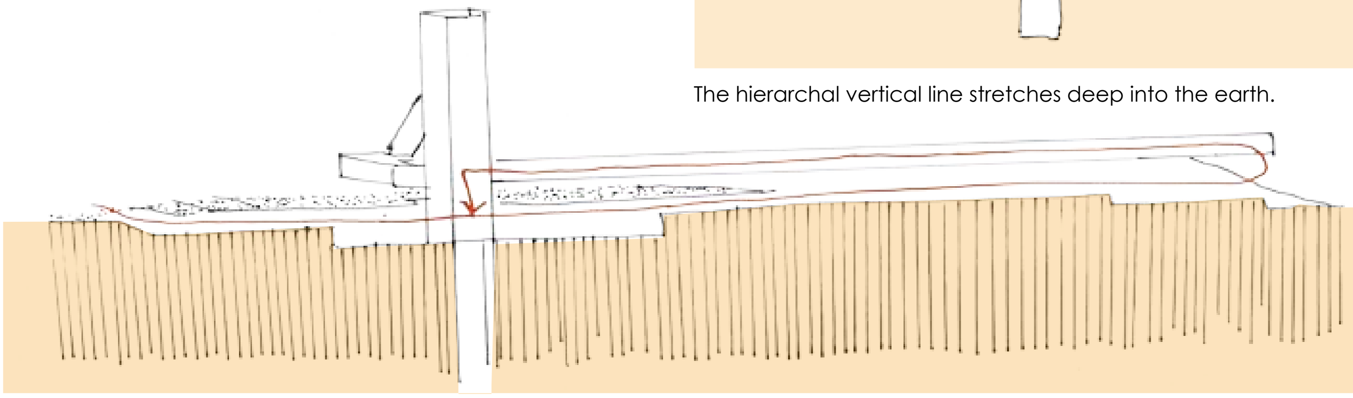
The vertical line of the tower demonstrates how one element of the composition can pull everything together – the old and new, the technical and the aesthetic. Architecture is by its nature an inclusive system – individual building parts are not yet architecture. Every form and detail should work together to form an aesthetic purposeful whole. The vertical line forms a direct hierarchal element. It is immediately seen and takes a visual precedence over any horizontal line. In this case the hierarchal vertical line stretches deep into the earth. The strength of this vertical section asks for the introduction of some kind of design element to establish a satisfactory composition. With the horizontal line that crosses it, image unity is achieved. Apart from design purposes, the tower fulfils a functional purpose – the controls of the lifts and pipelines that run in the tower.

The classic architecture of the Greeks kept the movements of the observer in mind. The master planners of the Parthenon treated it as if the viewing of the temple was a theatrical journey. The emotions of the visitors were choreographed to maximise the effect of an awe-inspiring visit and to prepare them for the ultimate glimpse of the majestic Athena Parthenos at the interior of the temple by the arrangement of the temple, the monumental sculptures of the pediment, and the detailed frieze (Carl, 2009).

The same theory of movement can be experience in the Apartheid Museum. The forms and spaces and the limited use of colour reflect the content of the exhibition and all serve to symbolise a journey of the human condition under Apartheid. Upon entering the museum a barrier of mesh is transparent, but impassable – you can move together, but not touch one another. The routes finally converge and visitors are finally united at an outdoor ramp, about 120m long. Walking up the ramp you encounter images of the landscape and of the original people of this particular place. The ramp diminishes in width as you go up, a false perspective that exaggerates distance and time and that finally leads up to the elevated south western edge of the building next to the high gabion wall that edges the sky. At the top you turn and see the layered landscape of Johannesburg (Mashabane Rose Associates, [s.a.]: online).



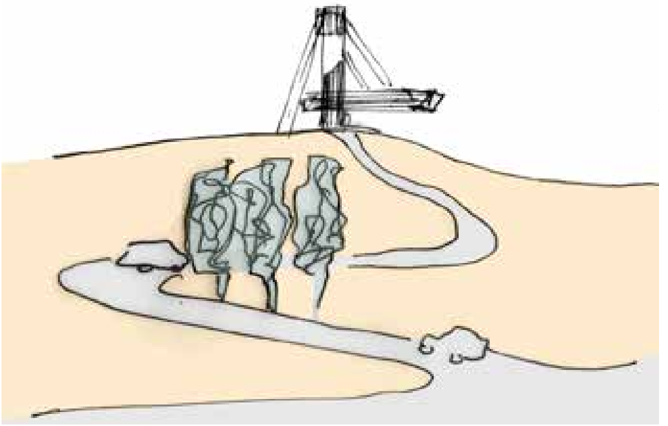
The hierarchal vertical line stretches deep into the earth.



The circular movement of the passage.

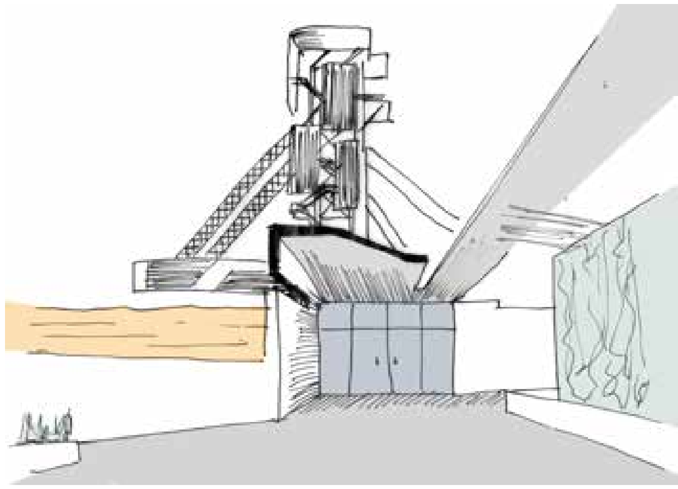
9.3 A Gateway to the Journey

An entrance is an eye-catching first impression of a building. It can be described as the greeting place of the building.



The importance of the entrance.

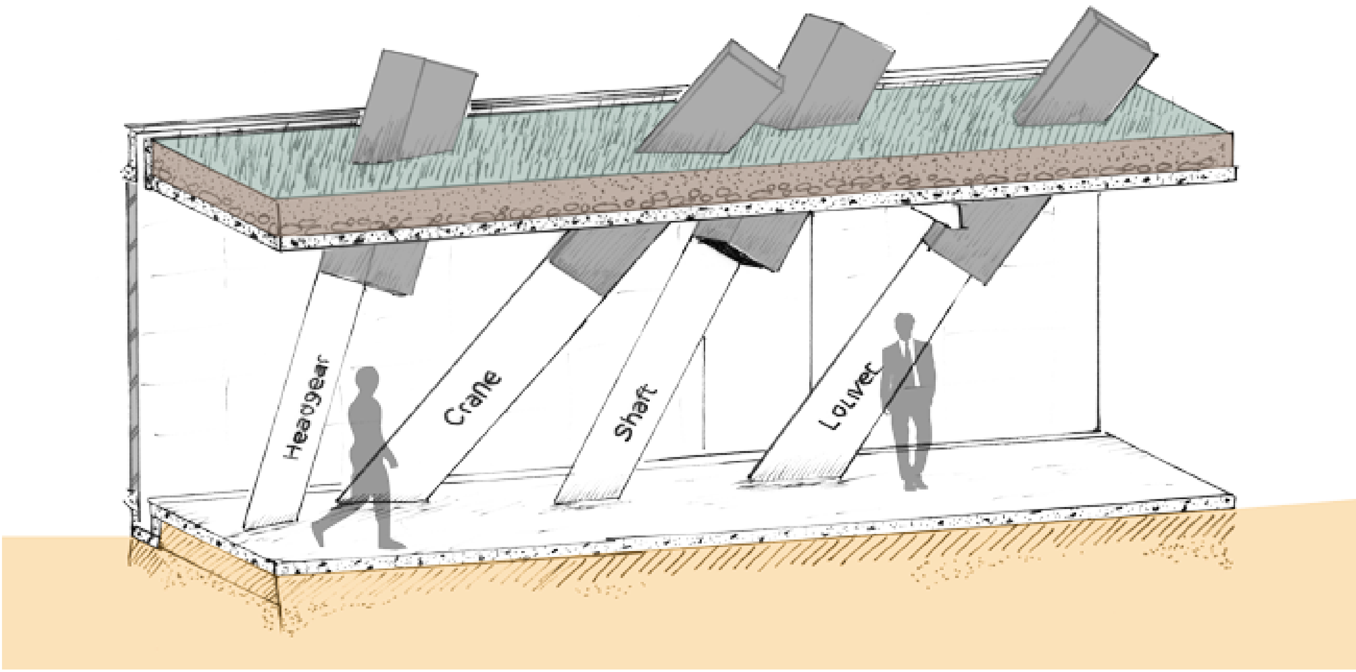
At the Apartheid Museum the entrance starts telling the story of Apartheid. The approach to the museum along an open screened concrete walkway is closed off on the one side by a red brick boundary wall and symbolises the feeling of isolation during the Apartheid era. The seven 15 metre columns in off-shutter concrete represent the seven pillars of the constitution. Visitors, randomly classified as "white" or "non-white", start their journey through a heavy galvanised steel, industrial turnstile (Mashabane Rose Associates, [s.a.]: online).



The funnel shape entrance.

With the entrance of the T Bailey Office, the headquarters of a steel pipe factory, Kundig anticipates the industrial concept and uses of raw material in his building. Visitors enter the building and climb to the main office space via horizontal 3,55m and vertical 5,58m diameter pipes (Olson Kundig Architects, 2014: online).

The funnel shaped entrance of the geothermal centre starts on the outside of the building with the conical mouth outside narrowing towards the stem at the entrance doors. The entrance sucks you in and starts the circulation of motion, energy and sustainability. The architecture at the entrance carves into the earth. It not only reminds the visitor of entering into the mysterious belly of the earth, but contributes to the effect of loss of orientation when entering a tunnel. The waterfall in the entrance also creates the illusion of displacement – one does not know where the water comes from or falls to. The waterfall forms a wall of motion against the stillness of the architecture.



Light boxes with information.

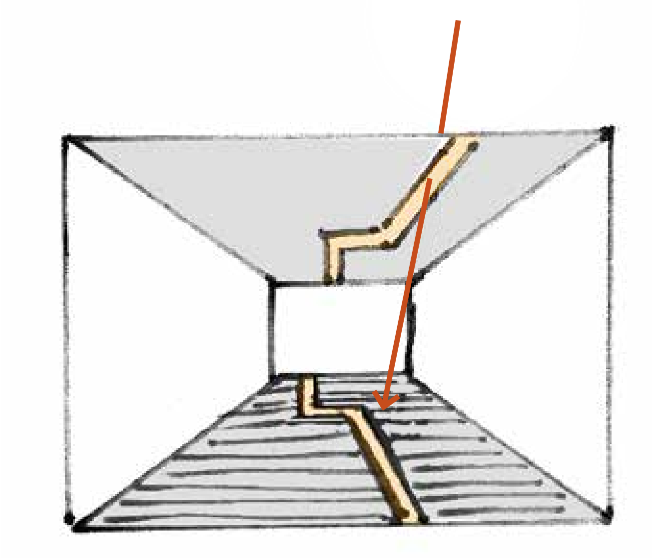
9.4 Open up

As for entrances, the experience can be enhanced when deliberate design decisions are made, without compromising function or quality, in openings, whether doors or windows. It facilitates interaction with the rest of the building when opening elements create unity and it reinforces the dominant design concept of the building. This is a noticeable aspect of NU architectuuratelier in C- Mine Expeditie. With the design of specific openings where light can filter through, which the visitor can look at, glance at or enter through, C-tour reshapes this old mine into a focal point of futuristic experiences.

Unity of design is one of Eero Saarinen's six pillars of architecture. Saarinen remarks that architecture should make a strong emotional impact on man. His words underline his passion for harmonious detail: "Once one embarks on a concept for a building, this concept has to be exaggerated and overstated and repeated in every part, so that wherever you are, inside or outside, the building sings the same message" (Friedman, 2014: online).

Specific design decisions in openings underline the theory of a journey and facilitate the provision of information within this intended building:

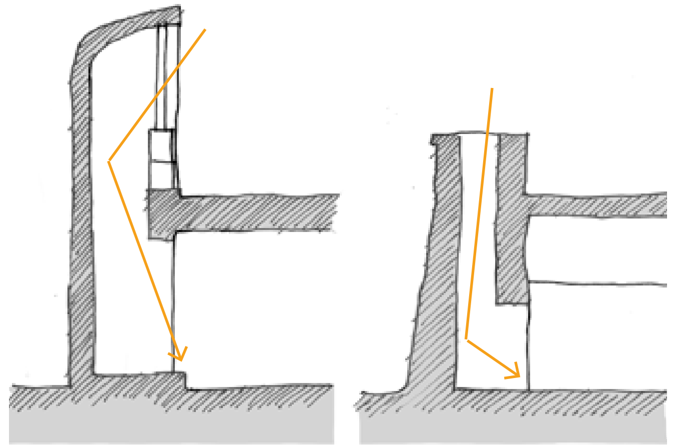
- The funnel-shaped entrance is the only public entrance and exit. This entrance/exit determines the circulation movement and contributes to the circulation effect of the geothermal process.
- Open strips next to the roof of the passage allow natural light to penetrate the interior space. These openings all along the roof of the passage give the impression of a floating roof and contribute to the tension of gravity. Without gravity motion will be unorganised.
- The use of light boxes orientates you and also serves as explanation and info boxes, as it directs the observer straight to the headgear, crane, shafts and louvers.
- A glass curtain wall along the passage allows the geothermal process to be part of the experience.
- Other openings provide natural ventilation for machines through the roof.



Openings through the roof for ventilation and light.

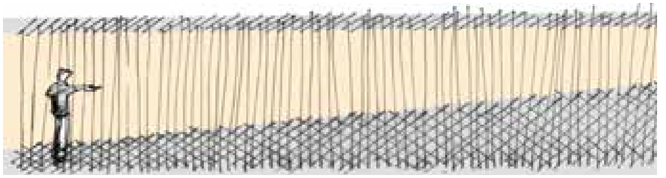
9.5 The Language of Light

Openings allow light to penetrate space. Simon Unwin describes light in "Analysing Architecture" as one of the basic architectural elements and states that the architect should know how to use these elements to give identity to places. He remarks that both natural and artificial light can be manipulated by design to identify particular places with specific character (Unwin, 2009: 26).



Light investigation

Louis Kahn, on the other hand, felt that artificial light had a dead quality in contrast with the ever-changing daylight. For Kahn it was natural light that brought architecture to life. It is noticeable with the large open windows and doors of the Indian Institute of Management that he felt nature with all her laws is represented by natural light and that it is natural light which binds matter together. Kahn saw architectural elements, such as columns, arches, domes and vaults, in their capacity to mould light and shadow. The Kimbell Art Museum is a good example of Kahn's use of lighting. He allowed natural light into the galleries, but softens it with a series of reflectors as to keep direct light from artworks (Ryan Fischer, 2010: online).



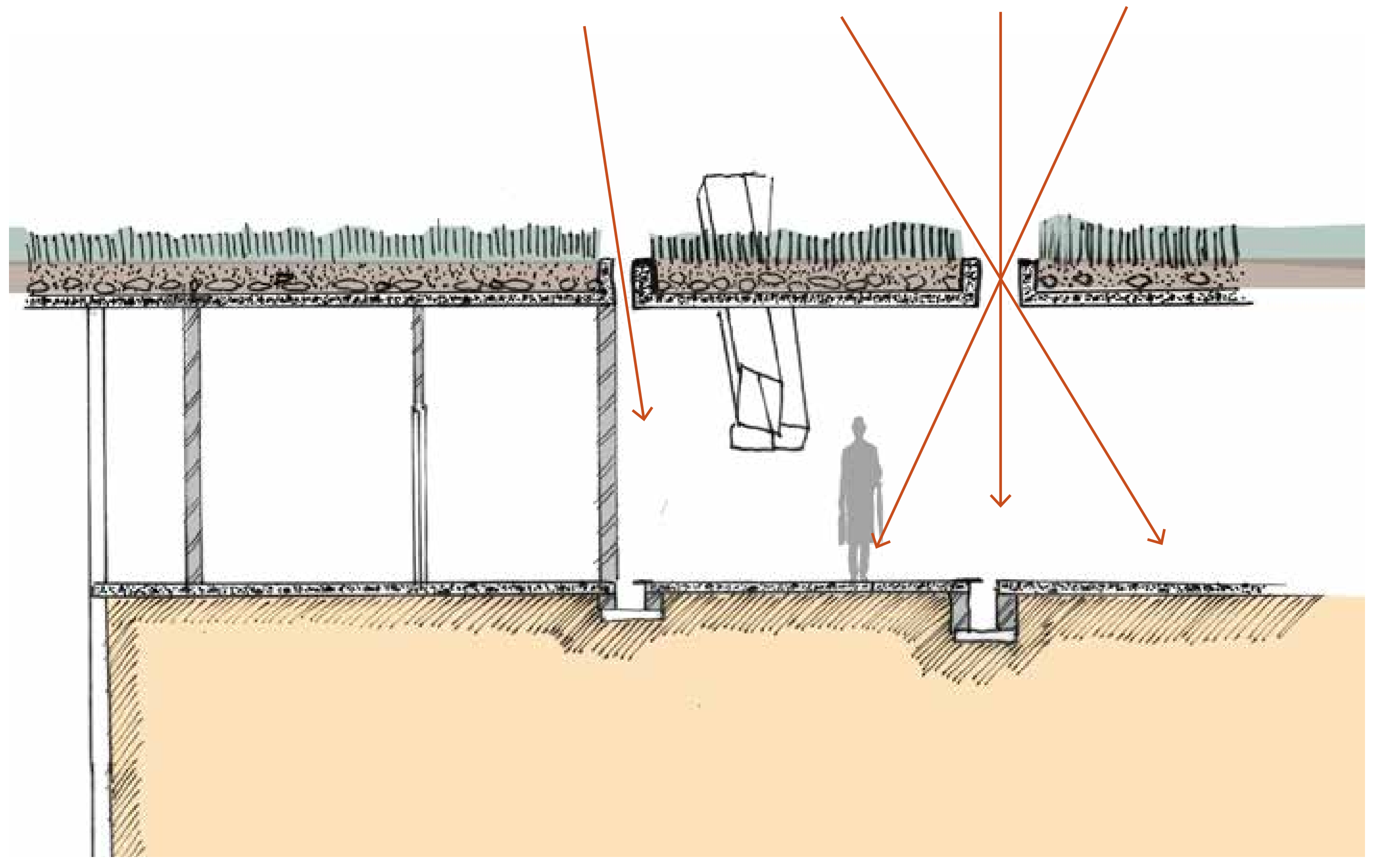
The movement towards light.

The interior of the church within La Tourette of Le Corbusier reveals a concrete box. Le Corbusier uses natural light in the church to lift a sombre atmosphere and to create a spiritual essence in the church. Five different types of openings around the church let in daylight. Some of the openings are sculptured outside. The colours also present in these openings give the church a warm and energetic glow (Henze & Moosbrugger, 1966: 11-14).

Light is used in this design to drive motion. The only reference to time upon entering the dimly lit atmosphere are the light pods from the light boxes within the passage that tumble towards the end of the tunnel.

Seeing that this building is half underground and can become very dark and sombre, the affect that light has on the mood of the observer becomes an important consideration. Light brightens up specific important spaces within this journey – for example the passage, the shaft and machinery. Natural light filters through the passage from above and artificial light lightens the pathway from the bottom.

Light not only propels movement and highlights moments, but also reveals the beauty of form as seen in the architecture. At night the illuminated tower forms a landmark sculpture to signify the regeneration of energy from the depth of the earth.

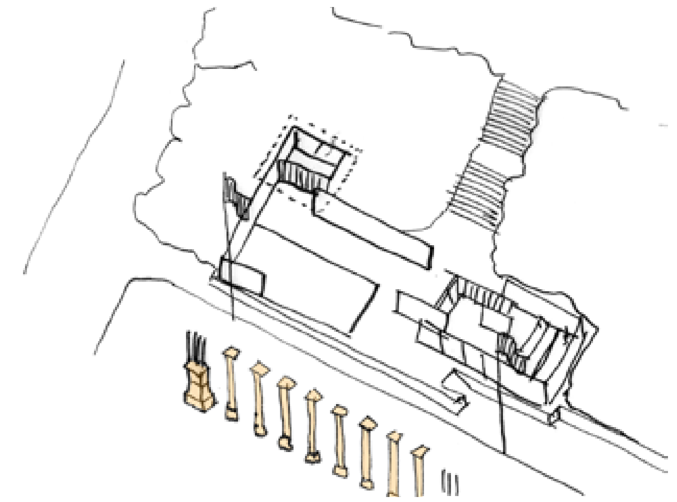


The penetration of light into the building.

9.6 Viewed from a distance

Natural light is not a stagnant element; it changes during the day and during seasons. Changing light reveals a quality of discovery. Architecture should also create a sense of exploration. Spaces unfold around the observer; the observer should experience it slowly and be carried along a memorable path.

This is exactly the feeling one experiences when viewing the Barcellona Pavillion of Mies van der Rohe. From afar, the closure of the podium with the concealed entrance, seen together with the series of Ionic columns, create a sense of loneliness. On closer examination you realise that it is not really a closed structure, but an open structure without doors, with wide corridors, a floating roof and large glass panels (Quetglas, 1980: 385-387).

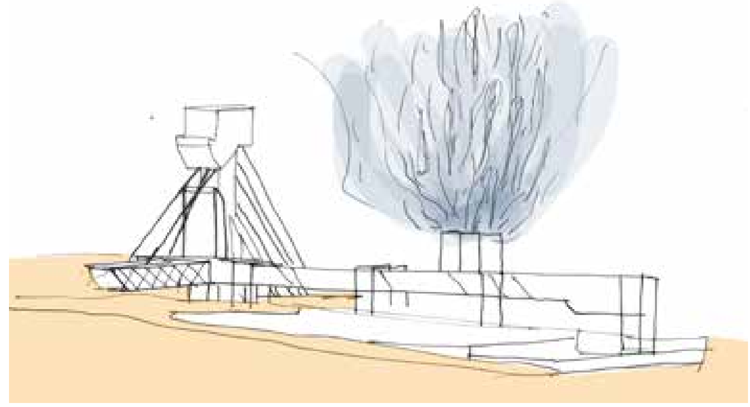


Barcelona Pavilion from behind the columns.

In the case of the proposed project the tower raises the consciousness of the building without being obnoxious, as it corresponds to the verticality of the nearby CBD of Johannesburg. The first awareness that one has of this building is the smoke from chimneys that is revealed to be steam upon closer examination. Further curiosity is aroused when viewing the tower and the movement of machines from afar. Once underground one momentarily loses orientation, but by discovering the interior of the building through light and info boxes, the feeling of displacement is replaced with a feeling of surprised orientation.

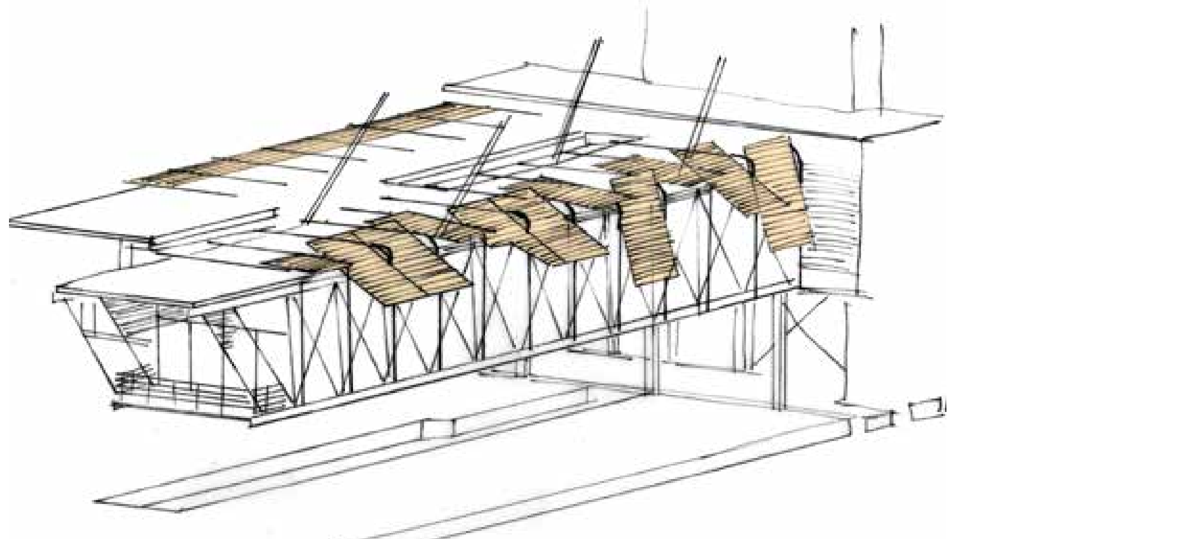
A different image at different times will be portrayed due to the opening and closing of the louvre system.

The tower, like the concept of an ant heap, reveals the underground ferment. This point of view can even be taken further to what Heidegger meant when discussing the painting of the Van Gogh's shoes. Heidegger felt that it does not really matter if it were the shoes of a farmer or his own shoes. What matters is that the observer must learn to see past the obvious truth to that which has not been revealed so distinctively in a work of art (Thomson, 2011: online). In this case the obvious truth lies underground.



The tower and the steam emissions as seen from a distance.

The hierarchal element of the tower.



Different images of the building portrayed by the closing and opening of a mechanical louvre system.

9.7 Served and Servant Spaces

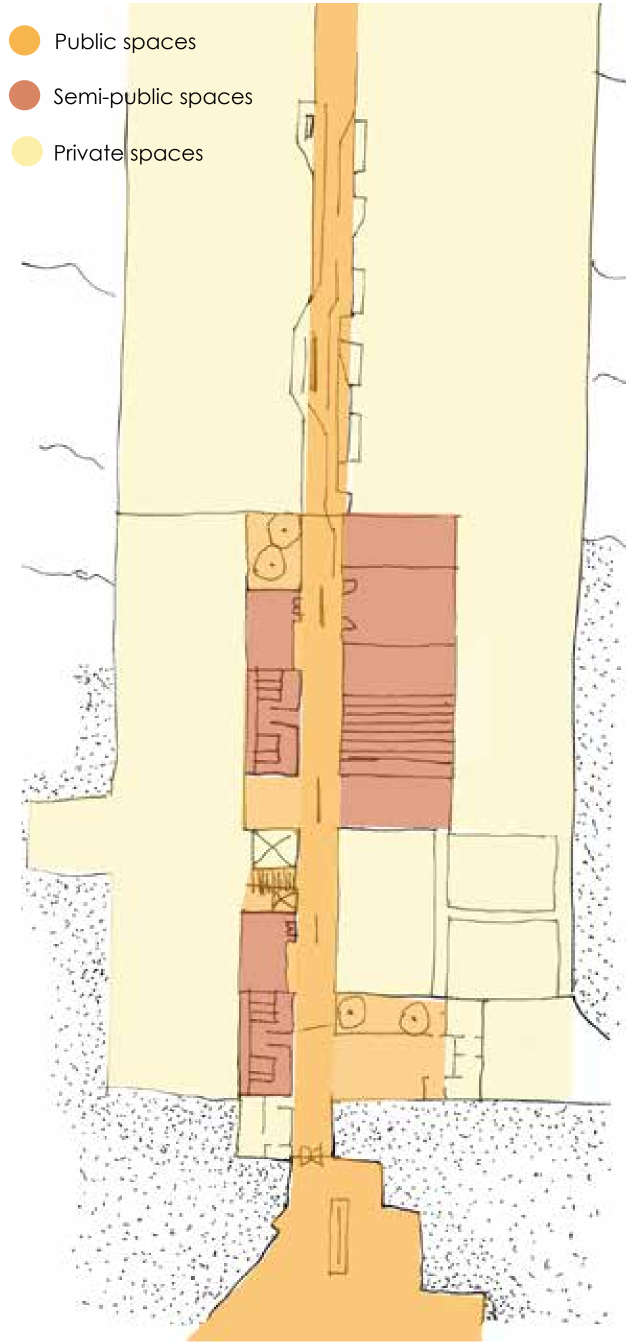
Ant hills, observed from above ground, are just the entrance to their underground structures. From the outside there is no hint of the spatial distribution in respect of different work performances. There are special chambers where the queen is fed and lives and produces eggs. In other chambers the ant larvae and eggs are stored by worker ants. Further chambers are being used for food storage (Hinckley, [s.a.]: online).

Louis I. Kahn: "Architecture is the thoughtful making of spaces. It is the creating of spaces that evoke a feeling of appropriate use" (Mazzola, 2009: 3).

Louis Kahn made a distinction between served and servant spaces. The Trenton Bath House is the first building in which Kahn utilised his concept of service and servant space. He used the columns for various functions, including bathrooms and storage. Louis Kahn's idea of served and servant spaces can also be seen in the Richards Medical Research Building at the University of Pennsylvania. The servant spaces, containing stairs and exhaust chimneys, become monumental brick towers attached to the laboratory spaces, the served spaces (Architectural Case Studies, 2006: online).

Although his point of departure was functional, he explored function philosophically through man's desire to express himself. Man must want more than just the necessary – man must search a dream and share it with others. Kahn describes architecture in this way: "emerging from inseparable aspects of mind and heart… it shouldn't just exist for itself; it should throw sparks to others" (Pedret, 1993: 77).

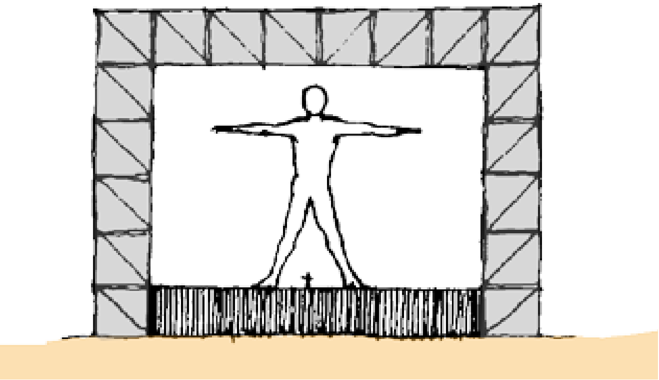
At the Salk Institute the separation of service and servant spaces is taken to the next level by the creation of new floors in which all the pipes and exhaust ducts exist. This results in a layered effect. Although the central courtyard area at the Salk Institute divides places for work, study, science, thought, relaxation and meditation, Kahn's desire for expression can be experienced. Kahn's thin fountain in the courtyard seems to extend into the infinity of the Pacific Ocean and unites with the sky and sea beyond (Fazio, Moffett, Wodehouse & Moffett, 2008: 539).



A division into served spaces with a further division of public and semi-public spaces and servant spaces, which are private spaces, can be seen in this prospective building. The public space from the entrance runs all along the passage on two different levels and mouths into the semi-public spaces of the auditorium, computer laboratory, lecture rooms and library that will be used by students. The private spaces – the mechanical area with the generators, turbines, transformers, pumps, separates and cooling tower – lie on both sides of the public passage. This passage can be described as a display walkway with vision onto the servant spaces which then becomes the point of attraction. The privacy of the offices and the laboratory are hidden from the public eye in the cantilevered area. Although hidden from the public, the feeling of isolation is countered by the use of glass and the louvre system.

9.8 Materials and Texture communicate emotions

In architecture the atmosphere of a space refers to the sensorial qualities of the space. Atmosphere is a physical perception and a person recognises it through emotional sensibility. Spaces are designed and built for people, therefore architects explore space among other things via a haptic experience (Bloomer & Moore, 1977: 57). The point of contact between the building and its audience is vital in building an



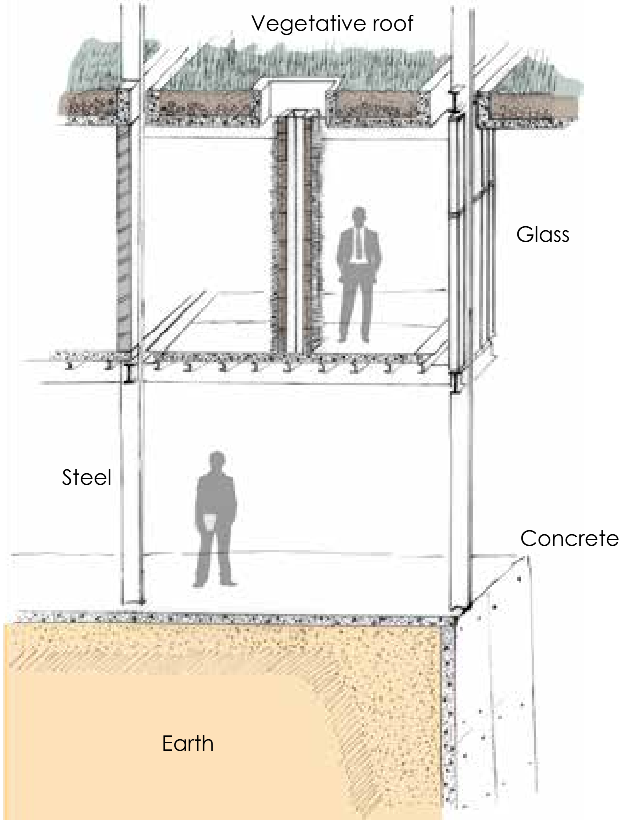
Exploration space via a haptic experience.

affair with architecture. Frampton explains it as follows: "The tactile returns us literally to detail, to handrails and other anthropomorphic elements with which we have intimate contact; to the hypersensitivity of Alvar Aalto, to the coldness of metal and the warmth of wood…" (Frampton, 1996: 519).

Simon Unwin makes us aware of the importance of texture – the way texture can be achieved and how texture can be observed. He further makes the connection between texture and the natural qualities of materials and the ways they can be treated and used. He uses a pathway to show how different spaces are identifiable by the changing of texture (Unwin, 2009: 33, 34).

Materials that hang, bend, tilt or twist, or that are used in an unorthodox way contribute to tension that in itself triggers the effect of motion. The concrete planes of Hadid's fire station in Weil am Rhein intensify the sense of instability as horizontal planes slip over one another (Kroll, 2011: online).

In this proposed building several elements cause tension and strengthen the movement of energy, such as the cantilevered

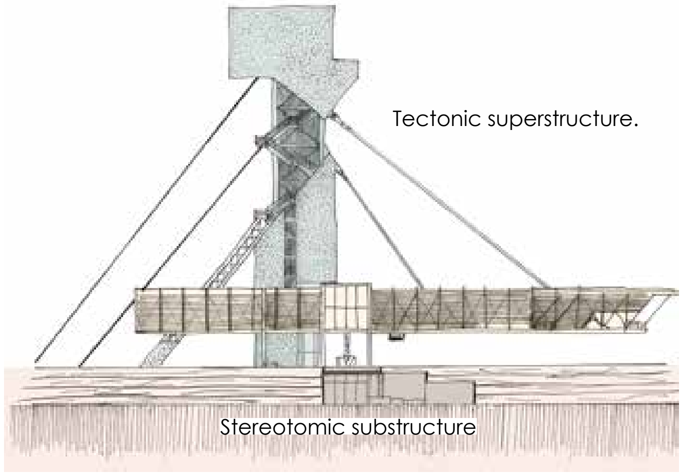


A section through the passage to illustrate the different uses of materials.

section, the crossing of lines, the boxed in atmosphere of the entrance, the contrast of lighter and darker areas, and the positioning of textures. At some point the journey travels over bridges. The glass used for the flooring of these bridges not only lets the visitor observe the geothermal process from above, but also creates a feeling of gravity tension… can I put my foot and weight on the glass?

Over many centuries different materials have been used by architects to describe motion. Francesco Borromini, the master of curved-wall architecture, built the small church San Carlo alle Quattro Fontane out of white concrete (1634). The Spanish Trinitarians who commissioned him had vows of poverty and wanted no display of materials (Francesco Borromini and His Architecture, 2011). Erich Mendehlson created his Potsdamer Einstein Tower in response to new possibilities of reinforced concrete (1920) (Merin, 2013: online). Frank Gehry clad his Guggenheim Museum in Bilbao in titanium to represent the partnership between stillness and motion, order and disorder (1993 – 1997) (Guggenheim Bilbao Museoa, 2014: online).

The materials of steel, glass, concrete, raw earth, rock and mesh not only emphasise a journey with different speeds in this proposed project, but each possesses its own unique quality of relating to industrialism, the mining context, transparency and functionality. The smoothness and coldness of steel lets one move faster. The steel columns appear as thin as possible and are highly reflective to reduce their presence in the space. A steel mesh envelopes the building. At the cantilever section the mesh is moveable to perform as louvres. The mesh on the tower has vertical tubing with a perforated metal mesh on the outside of it to demonstrate that motion can also be expressed in architecture by superimpositioning. Apart from providing shade to the building, the mesh on the outside of the building connects to the idea of transparency and movement. It also creates a curiosity and anticipation of what is happening inside the building. The use of rock and earth underlines the fact that human life is dependent on the earth. The exposure of rock relates to previous mining activities as it reminds the observer of the tunnel walling underground. The transparency of the glass portrays the inclusiveness of the process – of outside and



Stereotomic substructure and tectonic superstructure.

inside, the earth and the sky, and the future into the present. Glass allows the interior process to become part of the public space. Reinforced concrete is the combination of strength and tension. It can be poured into forms and be sculpted to the wishes of the architect. Reinforced concrete is being used both underground and as the floating roof above ground.

Like Kundig's T Bailey Offices, the combination of concrete and steel unites industrialism with urban elegance. The use of concrete blends with the neighbouring industrial area, but it still addresses the sophistication of the nearby CBD.

Detailed texture encourages the history of the site. History is not only conserved by memory, but also by visual and haptic sensations. Pallasmaa argues in his book The Eyes of the Skin that "[a]n old object, polished to perfection by the tool of the craftsman and the assiduous hands of it users, seduces the stroking of the hand" (Pallasmaa, 1996: 41). The history of mining is captured by using the same kind of materials as those which have been used in the past, such as steel and concrete. The face of the tower resembles old mine towers.

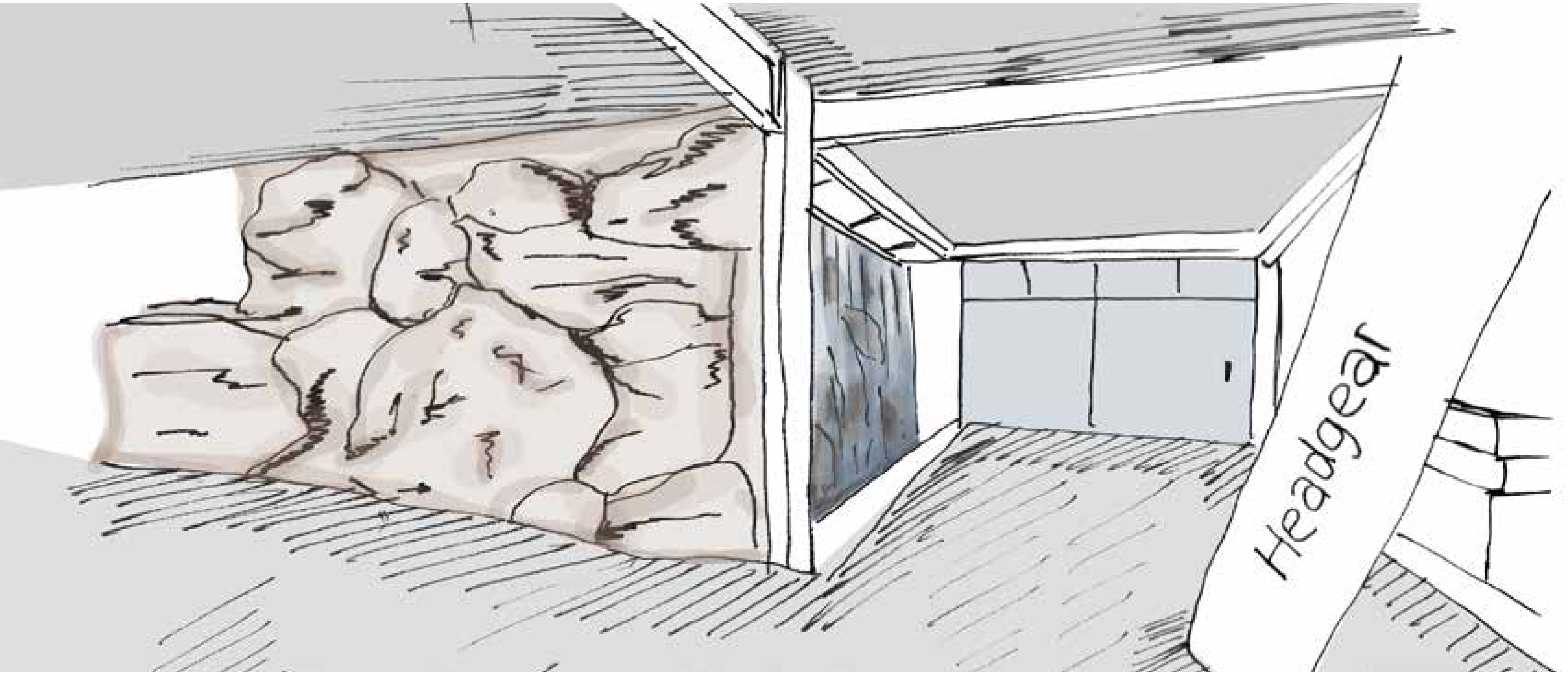
In the geothermal research centre detailed texture is used to create a mental boundary. The length of the concrete passage is finished off with a steel strip to act as an awareness of the borders of the served and servant spaces.

Scarpa used modern materials at Castelvecchio in expressive ways to mediate between authentic and renovated parts. By doing this, Scarpa draws attention to historical facts while at the same time alerting visitors to the fake tales of the Forlati renovation. He places art objects on floating planes to create boundaries between the objects and the architecture. He thus emphasises their removal from other destroyed buildings and their loss of sense of belonging (Buxton, 2013: online).

9.9 Rehabilitation - preserve the past, educate the present, direct the future…

Pistoletto emphasises with his art that man cannot exclude ethics from the aesthetic (IIEA1, 2010). Derrida joins his argument by saying that man should not make a choice between the aesthetic and the ethical, between the one (as found in Modernism where a sense of permanence within the flux of existence can be found) and the many (as flux within Postmodernism), as if one idea is better than the other one (Olivier, 2013: online). Man needs both. Man needs the past to build a sustainable future, just as Scarpa needed the twisted architecture of Forlati to display his authentic story of Castelvecchio (Buxton, 2013: online).

To embark on the architectural journey of form and structure that connects with its users and interacts with its surroundings, a profound understanding of the site is necessary, for it is the site that propels this voyage. The structure of the old headgear of the mine (that was stolen during the year) is a symbol of the history of the rise of Johannesburg. The theft of the headgear led to the realisation that the site was a void for many years.



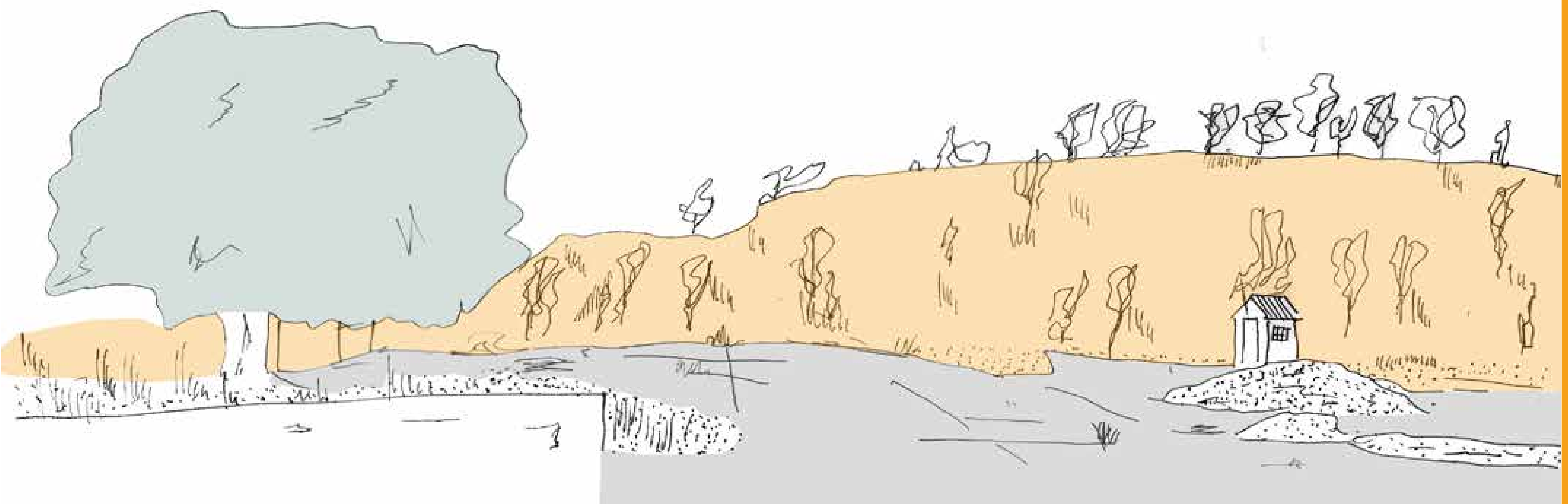
The juxtapostioning of texture where rock and raw earth is used next to the sleek surfaces of steel columns, creates an interior environment of movement. The rough texture of rock also reminds one of the tunnel walling of the old mines.

With the development of the site, it is becoming a place again after 20 years of dormancy. The use of related mining materials is important in sketching an authentic picture to its visitors.

The present is informed by the past. The past is the entrance to a future voyage. It is all around us – in our buildings, in our streets and in our culture. To ignore it will be like walking blindly into the future. The words of Nelson Mandela not only underline the importance of education, but also imply that the past educates the present in order to make better choices (UNESCO, 2014: online): "Education is the most powerful weapon you can use to change the world."

Education is essential to sustainable development. The current knowledge to provide enough solutions for sustainability is inadequate. Education that deals with environment, society, culture and economy matters is crucial. In addressing content, education should take context, global issues and local priorities into account. In achieving this the Geothermal Research and Educational Centre will surely bring hope to the community.

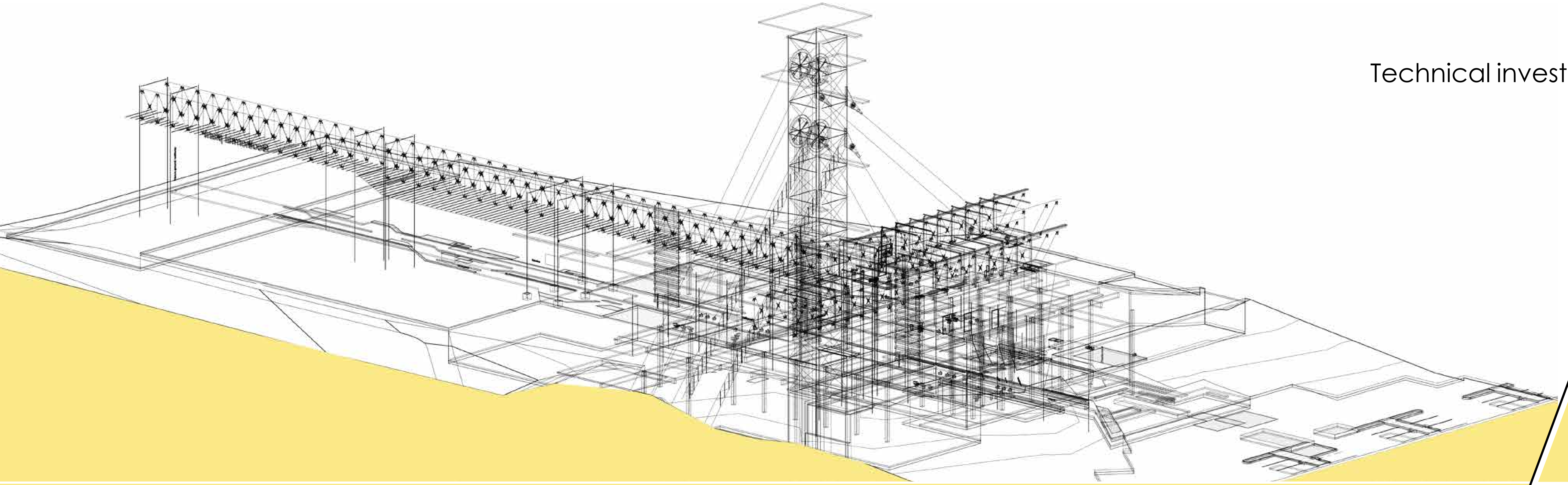
Rehabilitation is a process generally thought of in the reviving of a building or a site to a condition suitable for modern use, habitation and comfort. Beyond this idea of restoration, preservation is also concerned with supporting and creating sustainable, stable communities that are economically viable, safe and attractive. This idea of neighbourhood conservation includes the providing of affordable, reliable and sustainable energy to protect the environment. The Geothermal Research and Educational Centre will rehabilitate an abandoned mine to facilitate the development of a sustainable energy resource. In doing so, it takes an adventurous step towards a sustainable future.



The existing depleted mine site that creates a void within the community.

| Design synthesis

Technical investigation



10

10.1 Sustainability

10.1.1 Climate zone

Sustainable buildings are designed to reduce the impact of the built environment on human health as well as the natural environment. This can be done by making use of:

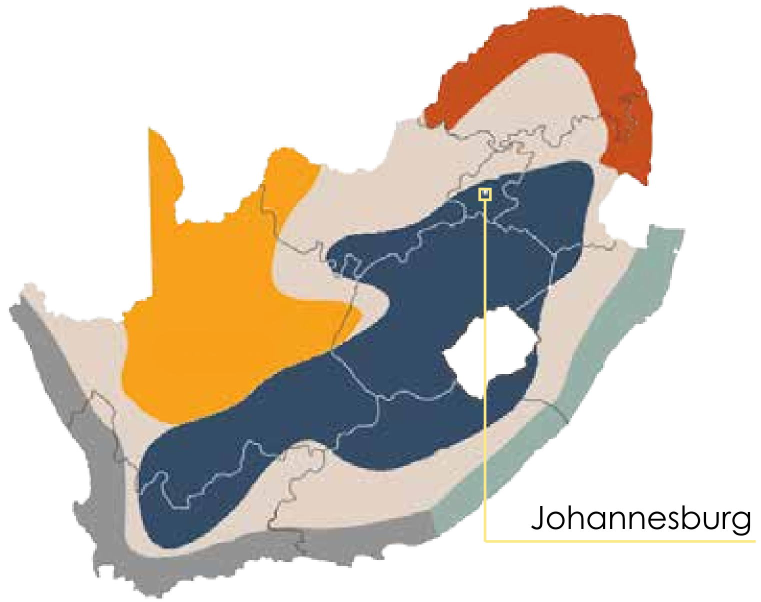
- The efficient usage of energy, water and other resources such as geothermal energy.
- The protection of the health of the occupants of the building and at the same time improve the productivity of the occupants in the building.
- The reduction of waste, pollution and anything that is harmful to the environment.

When thinking of classical building design as a representation of an exemplary standard, these aims actually complement the extension of classical building design into a future of architecture where the understanding of the complex interaction between humans and their environment emerges.

In order to achieve this, the architect should know in which climate zone the proposed project lies, the requirements of a building and how the building is going to be used.

South Africa is divided into 6 climate zones. These climate zones are indicated on the following map (Schmidt, S. 2013: 104).

Climate responsive design contributes to human thermal comfort which in the end leads to the reduction of energy consumption due to less mechanical and electrical usage. The geothermal research centre lies in the coldest climate zone where low humidity, a big range of daily temperatures, the experience of four different seasons during the year with cold winters and a summer rainfall are the main characteristics. A thorough site analysis is also important to consider the specific micro-climate of the site.



Zone	Climatic conditions
1.	Cold interior
2.	Temperate interior
3.	Hot interior
4.	Temperate coastal
5.	Sub-tropical coastal
6.	Arid Interior

10.1.2 Landscaping

Landscaping forms a large part of the rehabilitation of the site. If it forms part of a larger integrated site design, landscape architecture can dramatically reduce energy costs over the long term on the site while also creating a healthy environment for the occupants of the site for example, a green roof system can significantly reduce heating and cooling costs of a building.

In this site the contours were taken in consideration for controlling storm water and to form a dam of fresh water that can be used in the geothermal plant as well as recreation. Rather than getting rid of storm water possible via sewers, other strategies can be implemented to create a system of managing water that mimic nature's capacity of water management. The dam also contributes to the effect of evaporative cooling. As water evaporates, energy is lost from the air and reduces the temperature. Healthy soil and vegetation are the foundation of ecosystems. Healthy soils allow rainwater to penetrate the surface of the earth. It prevents excess runoff, sedimentation, erosion, and floods. Healthy soils also help clean, store, and recharge groundwater. An analysis of the indigenous flora of the area supports biodiversity, reduce pesticide use, and conserve water. The preservation of existing trees on the site improves the built environment and restores natural resources. Mature trees are significant community resources because of their cultural, aesthetic and historic relevance (Sustainablesites.org, 2014: online).

10.1.3 Geothermal: Renewable Energy Resource

All sources of energy have environmental advantages and disadvantages. Some types of energy are more expensive to produce than others and some have more detrimental effects on the environment. All of these factors must be weighed when deciding which energy source to use today and which to invest in for tomorrow.

Of all renewable energy resources geothermal development activities result in lower long-term land disturbance. The Bureau of Land Management (BLM) of the United States reported in its 2008 Programmatic Environmental Impact Statement that the total surface disturbance for a geothermal power plant, depending on the size of the plant, ranges from 11 - 129 hectares. This covers all activities such as exploration, drilling, and construction. Much of this land is reclaimed after the exploration, drilling, and construction phases of the development. In comparison to other energy sources the BLM gives the following thirty year land use comparison (Geo-energy.org, 2014: online).

Water is a critical component in a geothermal plant. The amount of water used in geothermal processes varies, based on the type of resource, the of type plant and the type of cooling system. In a conventional system, water comes from the earth and is reinjected back into the reservoir to maintain reservoir pressure and prevent reservoir depletion. Reinjection keeps the mineral-rich saline water found in geothermal systems separate from fresh groundwater sources to avoid contamination. Injection wells are encased by thick borehole pipes and are surrounded by cement. In the geothermal reservoir, the water is reheated by the heat of the rocks. Findings from Argonne National Laboratory in Chicago on water consumption for lifetime energy output are as follows:

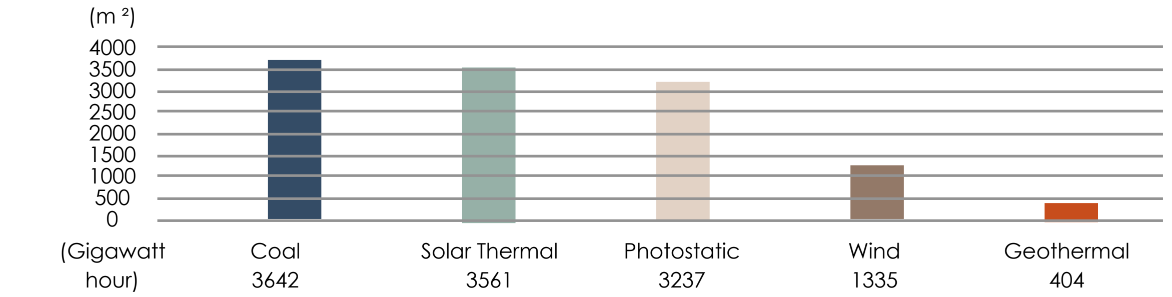
- flash geothermal plants consume 0.38 l/kWh
- binary geothermal plants consume 0.26 - 0.98 l/kWh
- EGS projects consume between 1.14 -2.76 l/kWh
- Coal plants between 0.98 - 5.52 l/kWh
- Nuclear plants between 0.98 – 3.75 l/ kWh
- Hydro electrical plants 17.03 l/ kWh
- Wind plants 0.38 l/kWh
- Solar plants between 0.26 – 0.72 l/kWh

Additional studies from Argonne National Laboratory show that condensate at some geothermal plants could potentially be used as drinking water, but no existing geothermal plant incorporates this method. Being a research centre this could be investigated together with the method of making fertilizer from acid water (Geo-energy.org, 2014: online).

The science of predicting acid mine drainage (AMD) is still far from conclusive. The gap between the theoretical tests and the real world dynamics provides reason for caution before permission to mines are granted. On Carte Blanche on the 6th of March 2011, some possible solutions were shown to viewers of how to clean up the acid mine drainage problem in South Africa. Richard Doyle from the company Earth said that the mine water problem is a salt problem and not a water problem. The biggest obstacle Doyle argued is to find a usage for the amount of salts that acid water produces. Doyle's company is turning the salts into fertiliser and explosives and attracting a lot of interest from overseas. Being a test centre, research can be operated from here (Watersafe.co.za, 2014: online).

At geothermal power plants, the "smoke" seen rising from cooling towers are composed of water vapour or steam caused by the evaporative cooling system. It is not burned fuel or smoke emissions. The resource temperature and type of power plant will have an effect on the amount of gasses released into the atmosphere. A binary or flash/ binary geothermal plant produces nearly zero air emissions. Air emission levels at dry steam plants are considered to be slightly higher. In summary, though, geothermal technology is considered environmentally friendly and any emissions are negligible when compared with using technologies that involve combustion of fossil fuels (Geo-energy.org, 2014: online).

Land Use Comparison



Estimated Emission levels by pollutant and energy source of Power plants

Lbs / Mwh	Dry Steam	Flash	Natural gas	Coal
CO_2	59.82	396.3	861.1	2200
CH_4	0	0	0.0168	0.2523
$PM_{2.5}$	-	-	0.11	0.59
PM_{10}	-	-	0.12	0.72
SO_2	0.0002	0.35	0.0043	18.75
N_2O	0	0	0.0017	0.0367

10.2 Structure & Passive design Strategies

| Technical investigation

10.2.1 Applying Passive Design

The proposed building will largely be self-sufficient where energy consumption is concerned. As a geothermal research centre, energy will be generated that will be used in the building itself for heating and cooling purposes and also in small quantities in the usage for lighting. Surplus energy can be sold to the Johannesburg Fresh Produce Market and in that way costs can be recovered.

As a research centre in sustainable energy, the geothermal plant must provide guidance on the level of sustainability in such a way that it functions like a living organism. Following the ant concept, thermoregulation and ventilation is of the utmost importance. Ventilation is an important factor for maintaining acceptable indoor air quality. Ventilation not only includes the exchange of air to the outside, but it also the circulation of fresh air within the building and the removal of unpleasant smells. When thinking of energy efficiency, passive ventilation strategies such as naturally occurring air-flow patterns and the use of fans can be applied in the heating and cooling of a building. Following these strategies turn out to be more cost effective than the of use air- conditioning systems. Controlling a constant temperature in a substructure turns out to be an easy option and for this reason most of the building lies underground. Architectural features such as the building shape also influences air flow. The building shape also plays a role with the distribution of natural light. With a long narrow building daylight can penetrate the building more effectively and the sun can heat more of the building during winter.

The following orientation is being implemented to achieve a constant temperature in the building:

- The construction of an underground area where the wrapping of the soil assist in temperature regulation.
- The usage of a mechanical louvre system above ground.
- The functionality of specific areas determined the orientation of that space e.g.
    1. The orientation of the offices to the north for more sunlight.
    2. The use of film equipment in classrooms and the auditorium result in placing these spaces underground.
    3. The aggravation of simultaneous heating and cooling in laboratories due to reheating of equipment. This variation can increase energy use in laboratories. To solve this problem careful consideration is paid to orientate laboratories on the south side of the building.

The TIASA guide to Energy Efficiency defines thermal mass as the ability of building materials to store heat (Schmidt, S. 2013: 118). Materials with a higher thermal mass can absorb heat, store it and at a later stage release the heat.

Buffer spaces is an alternative way of regulate the temperature of a building and providing shade onto a building (Schmidt, S. 2013: 114). The louvre system on the tectonic superstructure not only provides shade, but forms a buffer space between the louvre and the glass. The louvre system is a mechanical system which improves the energy performance of the building. Another buffer space can be found in the stereotomic substructure. The geothermal plant forms a buffer zone around the public walkway where the most constant temperature will be experienced.

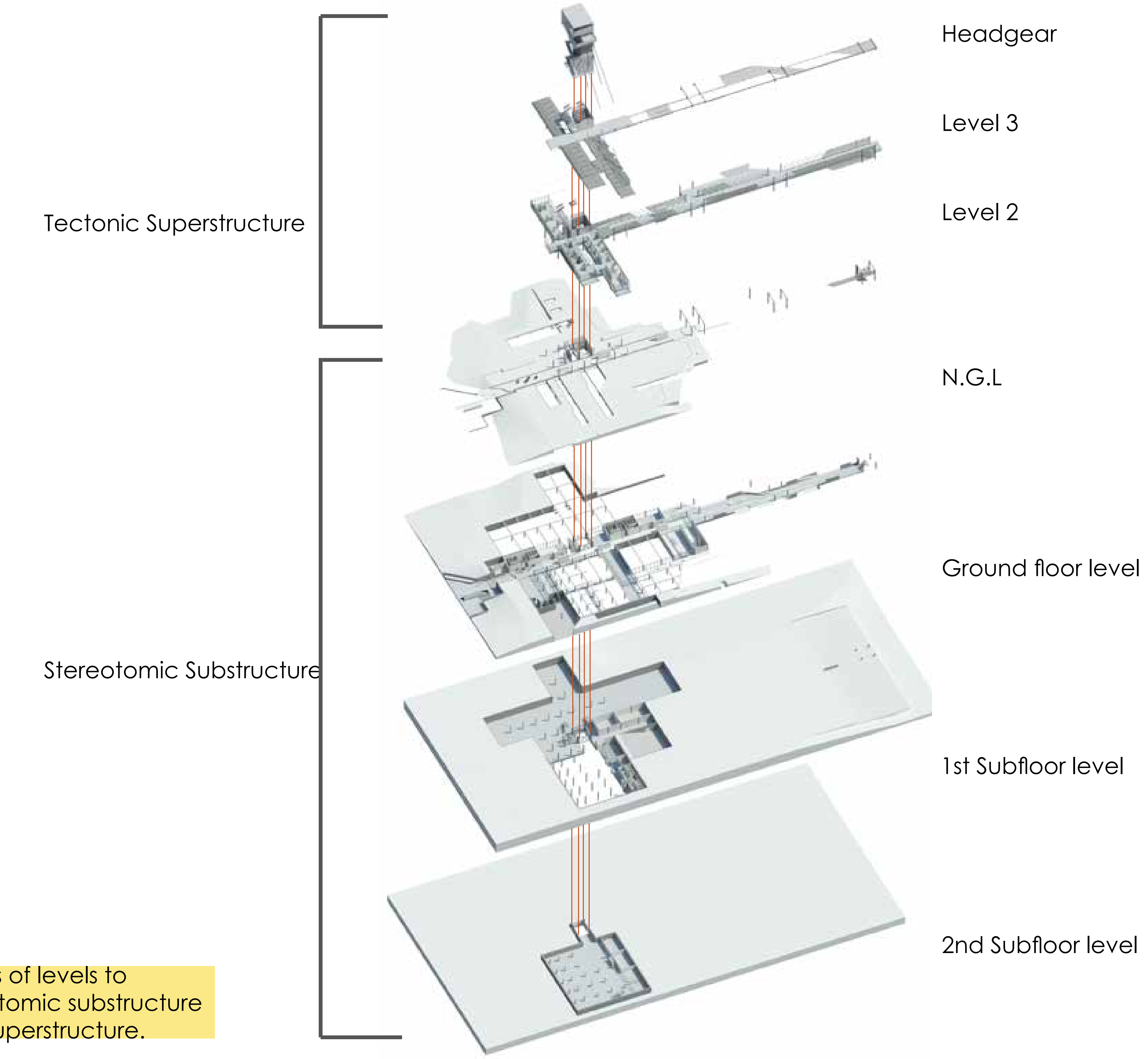
10.2.2 Stereotomic Substructure and Tectonic Superstructure

The Oxford dictionary defines the word tectonic as a relation to building or construction (Oxforddictionaries. com, 2014: online). This term includes the structural aspect of the building, the use of materials as well as the poetic design of the construction. The word is derived from the Latin word tectonicus and from Greek tektonikos that means "belonging to carpentry and from the Greek word tektōn meaning a builder" (Dictionary. com, 2014: online).

In architecture the word tectonic has a second meaning. It relates to the differences in construction elements regarding their stability. The structural investigation of the proposed geothermal centre refers to the theoretical work of Gottfried Semper, a German architect (1803 – 1879) who explores the tectonic relationship of architectural materiality. He moves away from Vitruvius's idea from utilitas, formitas en venustas by dividing construction elements in two categories namely stereotomic that defines the solidity of the structure and tectonic that relates to dematerialisation (Semper, 1989: 3).

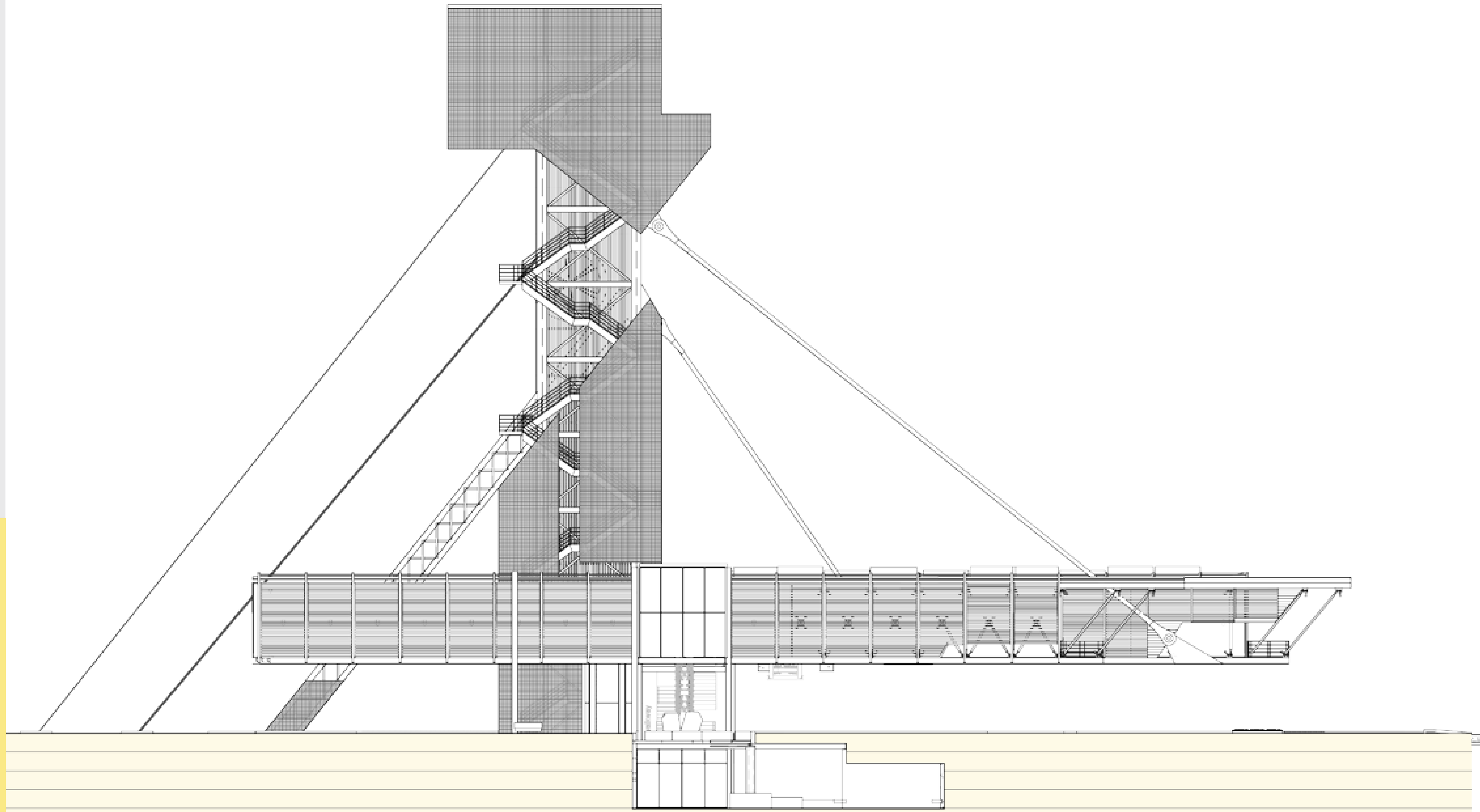
Kenneth Frampton argues that these inherent opposites provide the whole human body - and not just memory - to unite with the structure, because the specific qualities of both elements are recognised and valued. The human body understands these qualities and can relate to it (Frampton, 1996: 517). This comparison reminds Frampton of the identification theory of Heidegger and it emphasizes the fact that a soulless structure can evoke a presence (Bloomer & Moore, 1977: 78). Viollet-le-Duc also recognized the value of tectonic and stereotomic elements and referred to it as the honest use of material (Hearn, 1990: 170).

It is within this theoretical premise that the relationship of the stereotomic underground substructure and the tectonic superstructure above ground is technically handled and resolved in rehabilitating the depleted Village Main mine.



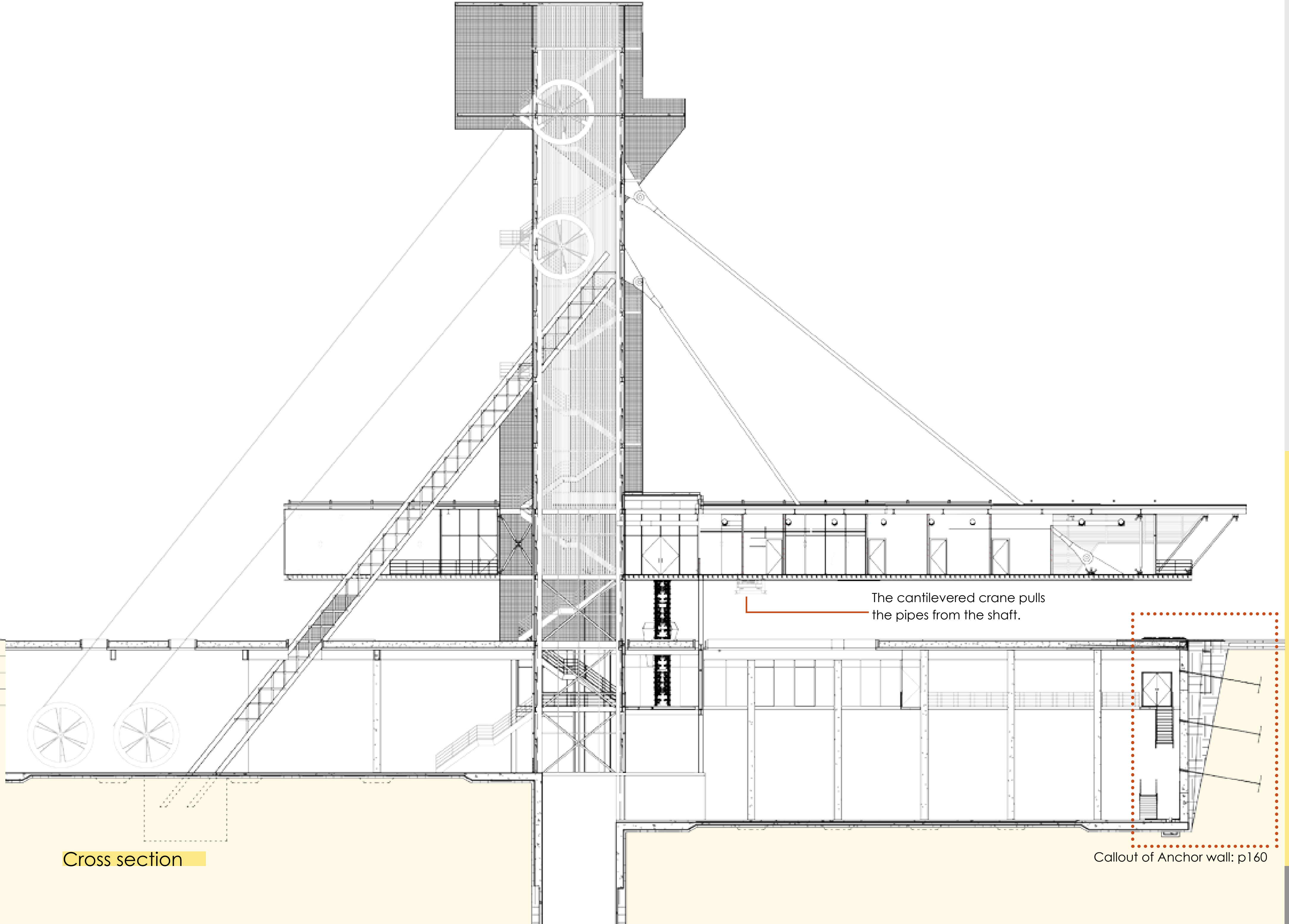
Exploded views of levels to indicate stereotomic substructure and tectonic superstructure.

| Technical investigation



The tectonic superstructure can be viewed from outside. The stereotomic substructure reveals itself only from below ground level.

South elevation

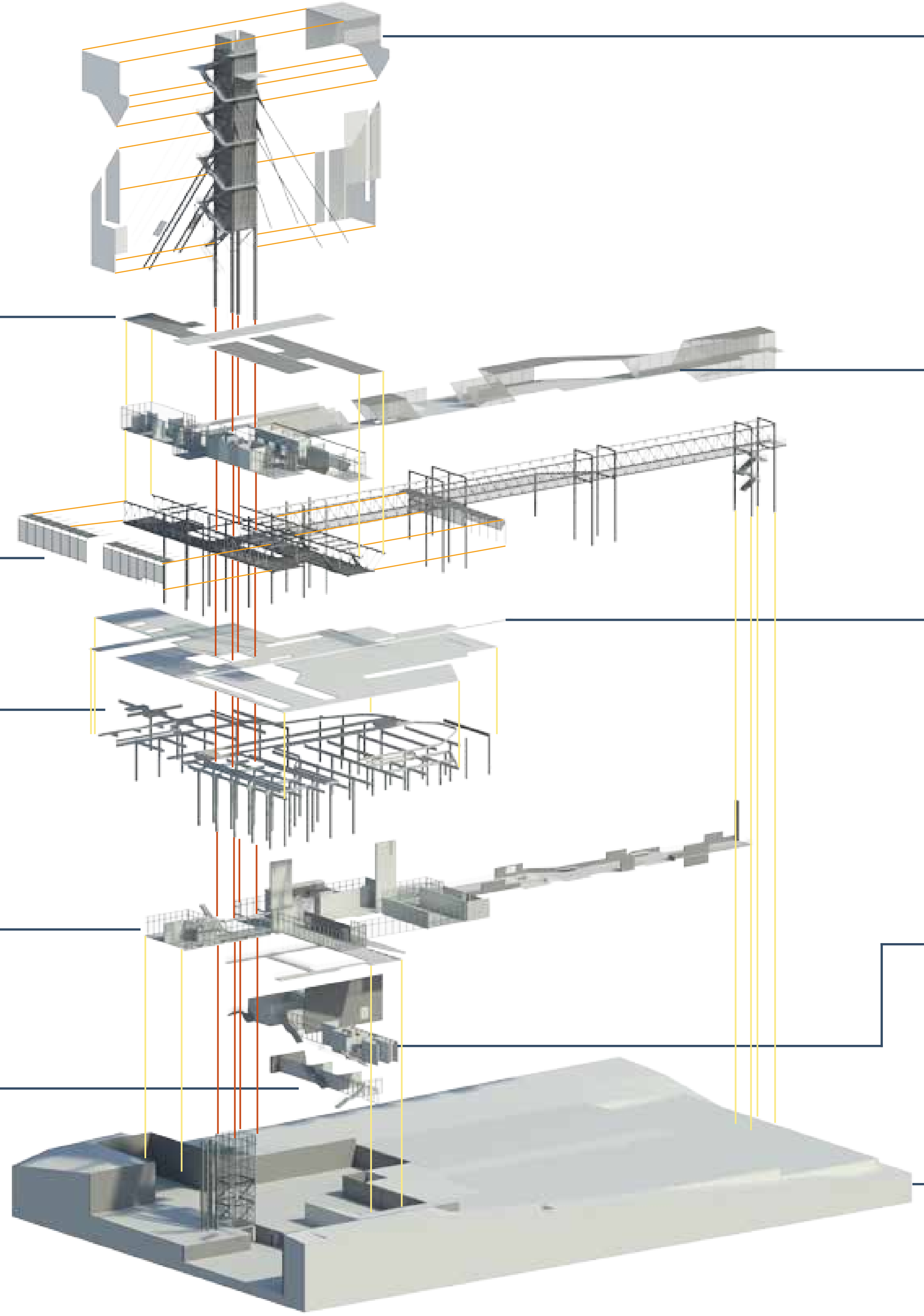


Cross section

An explanation of the stereotomic substructure and the tectonic superstructure in an exploded view.

The main structure of the stereotomic substructure consists of a reinforced concrete column and beam structure with masonry infill work and anchor walls. This structure supports the green roof. Visitors view the geothermal process through a glass curtain wall.

The tectonic superstructure is a steel framework consisting of steel columns and beams with cross bracing. The infill work consists of light steel frame walls to keep the structure light. Offices and laboratories have a view onto the surroundings via a glass curtain wall.



Level 2 - Roof

0,5mm Concealed Fix Klip-Lok 700 Roofsheeting @ 1° slope.
fixed to 150x75x20 m/s lipchannel. Space at 1000mm C.C

Level 2 - Steel framework

305x305x97 H Column

180 IPE I Beam

150 x 75 x 20 mm Lip channel

2500 x 2500 x 50ø mm Galvanised hollow circular steel cross bracing, attached with M22 sleeve nuts to 5mm clevis plate

Column and beam concrete system

600 x 300 mm reinforced concrete beam to structural engineer's specifications

450x 300 reinforced concrete to structural engineer's specifications

Ground floor level

230mm Brick wall

230mm Brick wall

200mm Reinforced concrete wall

Custom made curtain wall with 10mm glazed glass

2nd Subfloor level

230mm Brick wall

230mm Brick wall

200mm Reinforced concrete wall

Custom made curtain wall with 10mm glazed glass

Headgear

2mm Galvanised steel (SANS 121) with 40mm x 40mm square perforations

500x500 H Column with 180 IPE I Beam 4000mm CC with 100x100x12 Angle iron (Equal leg) cross brasing

60x40x2.5 Rectangular Hollow section

102Ø Parallel Wire Strand (TATA steel) to structural engineer's specifications

Mine Shaft: Spiral Strand 57mm Ø Spiral strand to structural mine engineer's specifications

Level 2

230mm Light steel frame wall

120mm Light steel frame wall

Custom made curtain wall with 10mm glazed glass

30 x10x2.5 Rectangular Hollow aluminum grid section

Reinforced concrete green roof

150mm Thick reinforced concrete roof to structural engineer's specifications

30mm Thick (lowest point) cement screed to fall

Derbigum SP 40 torch on water proofing membrane, fullbore outlet to be counter flashed, overlappings of min. 100mm

Min of 50mm thick layer coarse engineerd soil with vegetation

Min of 50mm thick layer coarse gravel

1nd Subfloor level

230mm Brick wall

230mm Brick wall

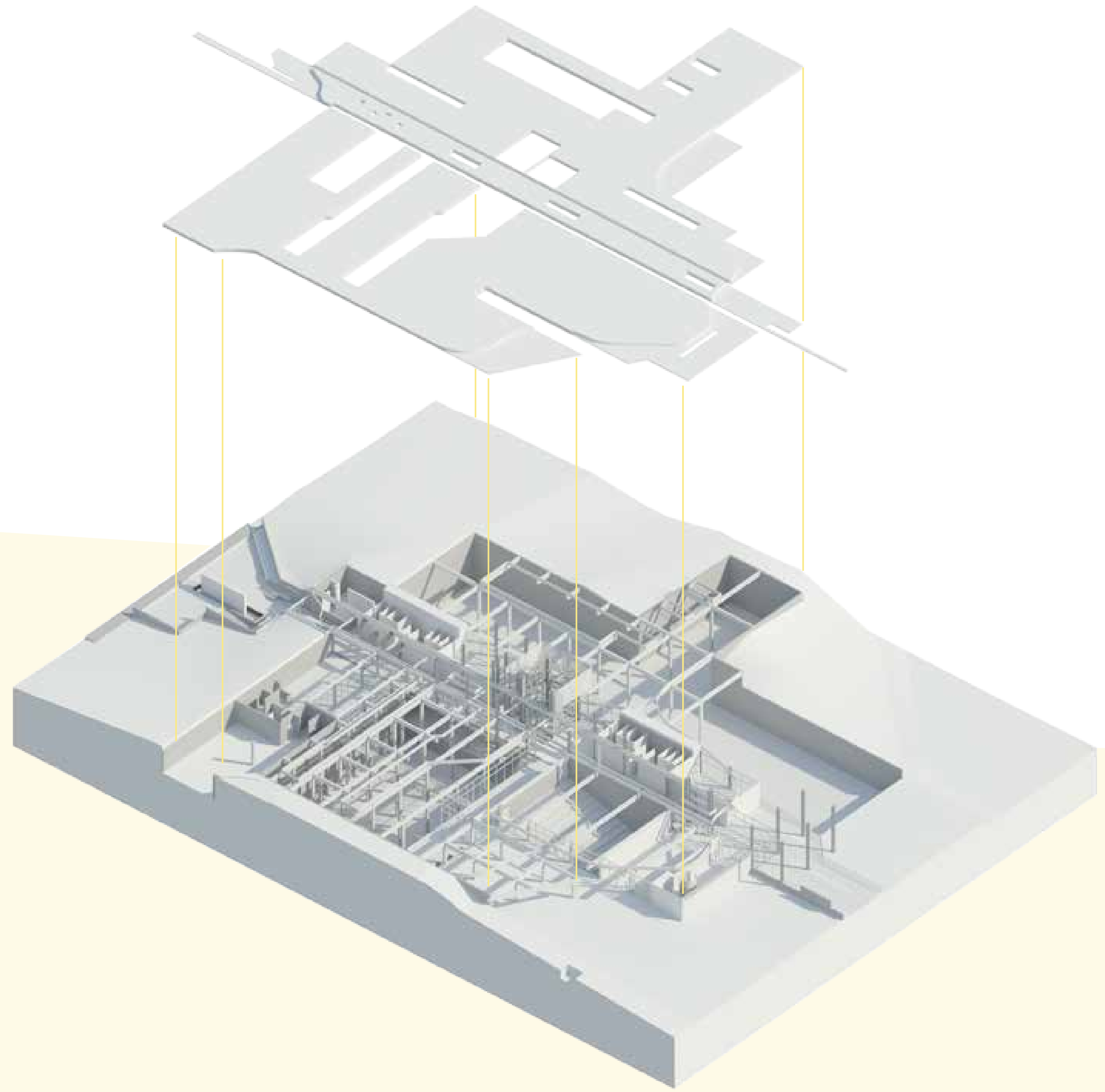
200mm Reinforced concrete wall

Custom made curtain wall with 10mm glazed glass

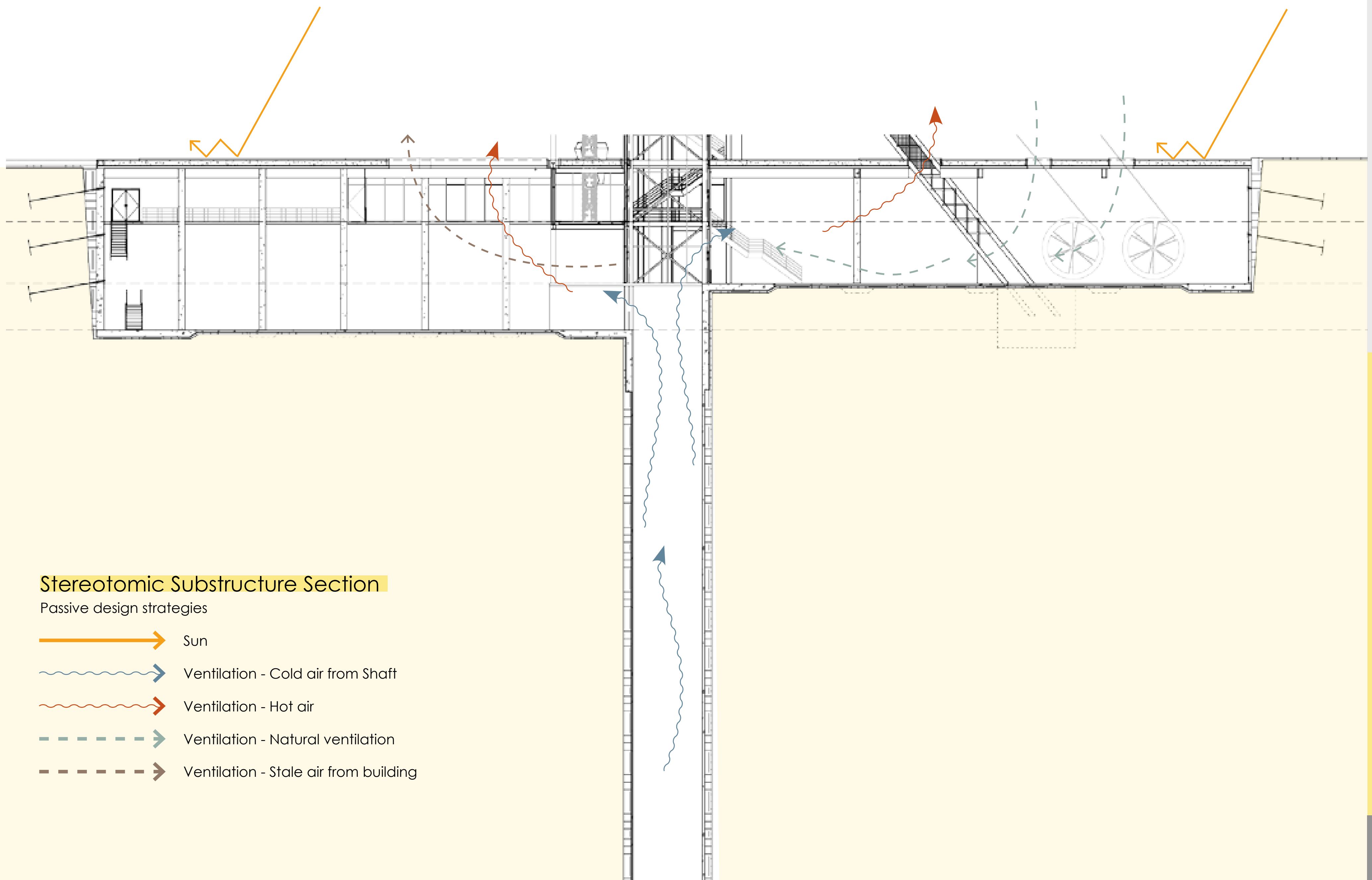
Earth cut and fill

0.25mm polyolefin Damp Proof Membrane underneath surface bed, laid on top of selected approved backfill compacted in 150mm layers

10.2.2.1 Stereotomic Substructure

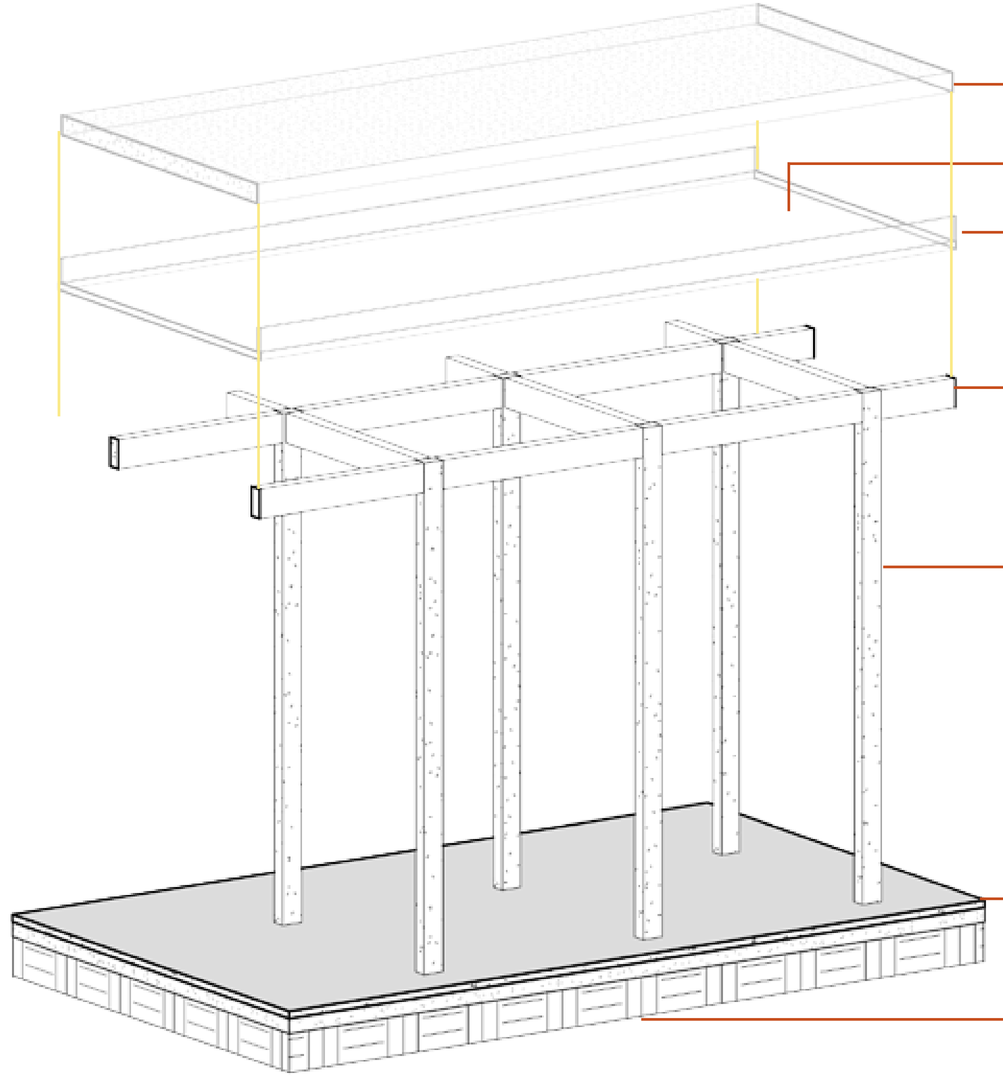


Extracted roof from Stereotomic Substructure

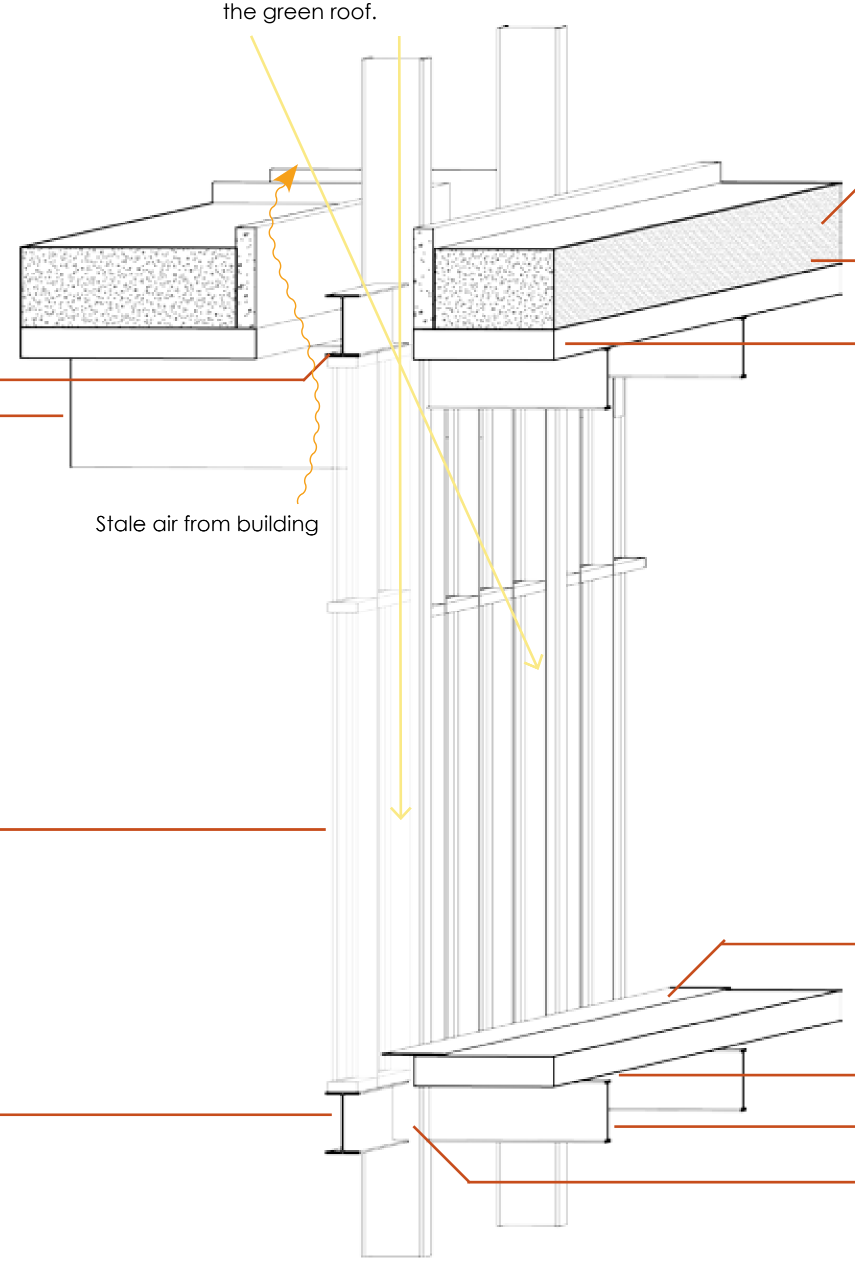


Stereotomic Substructure Section

Passive design strategies

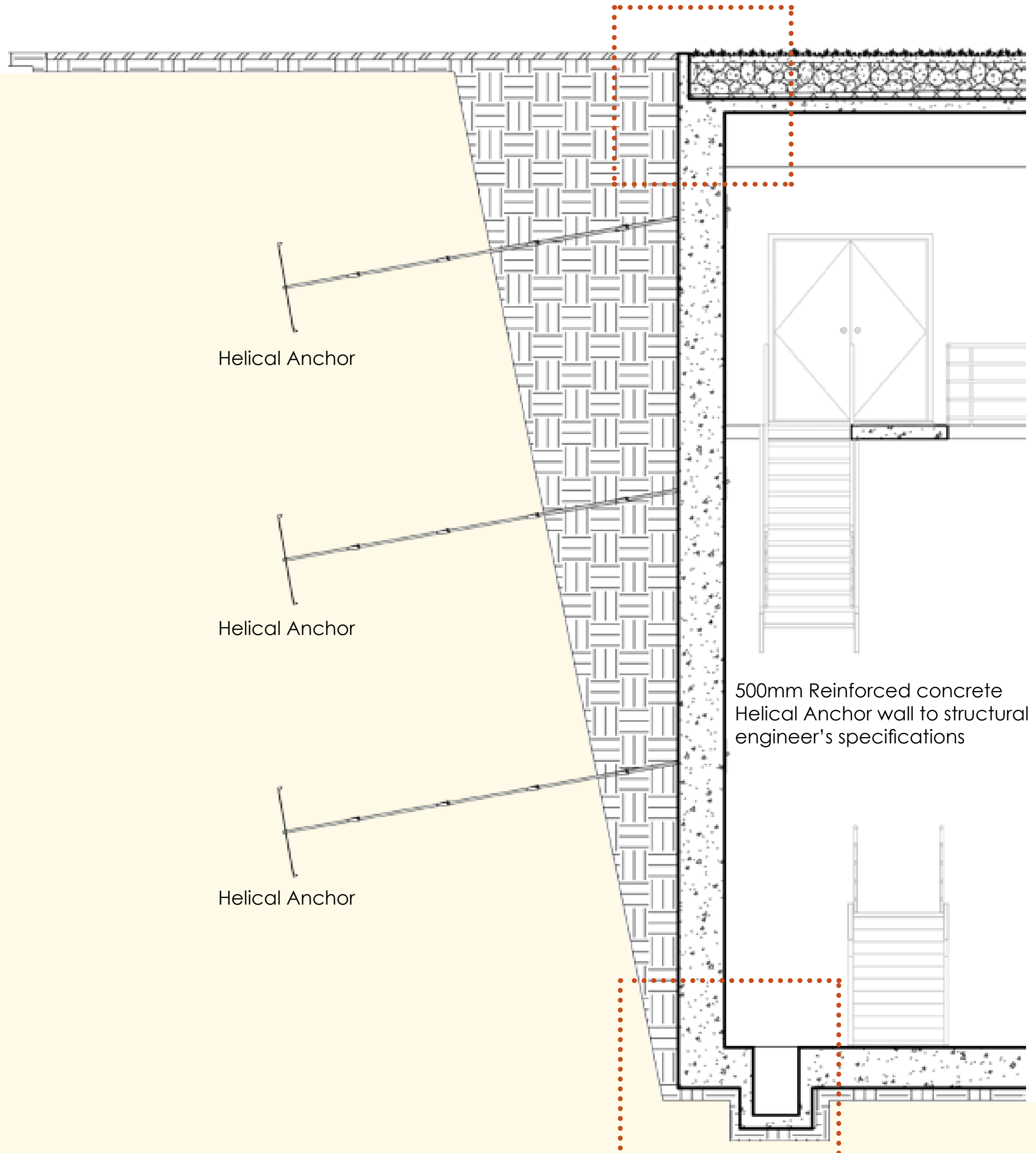


Concrete column and beam structure.



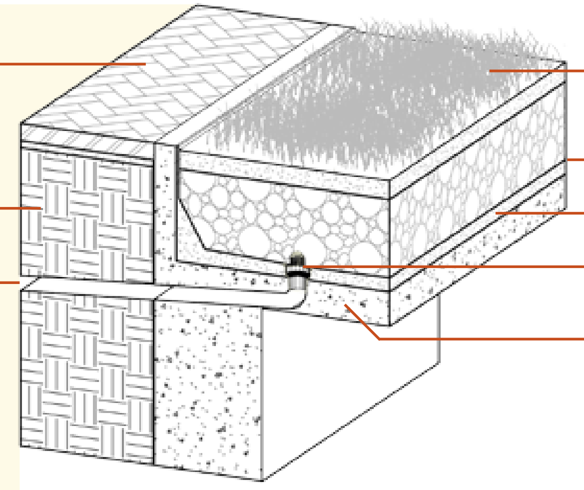
Curtain wall detail

Callout of drainage of green roof: p161

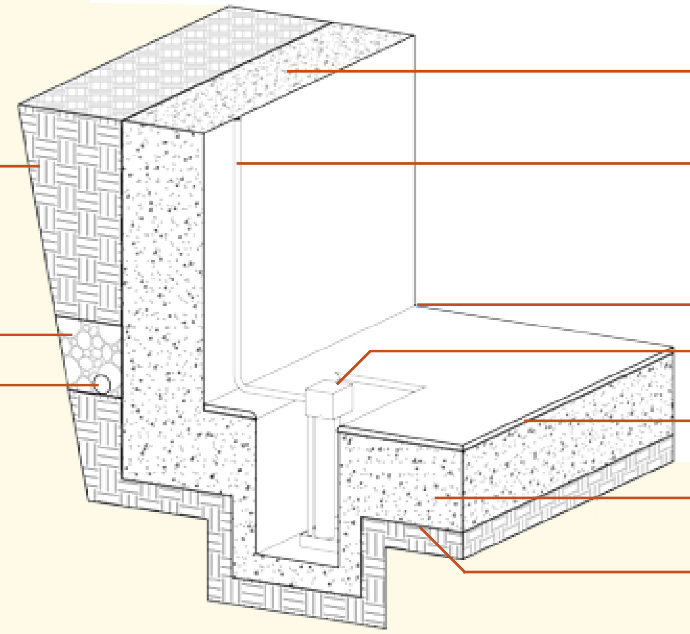


Callout of drainage of stereotomic substructure: p161

Anchor wall



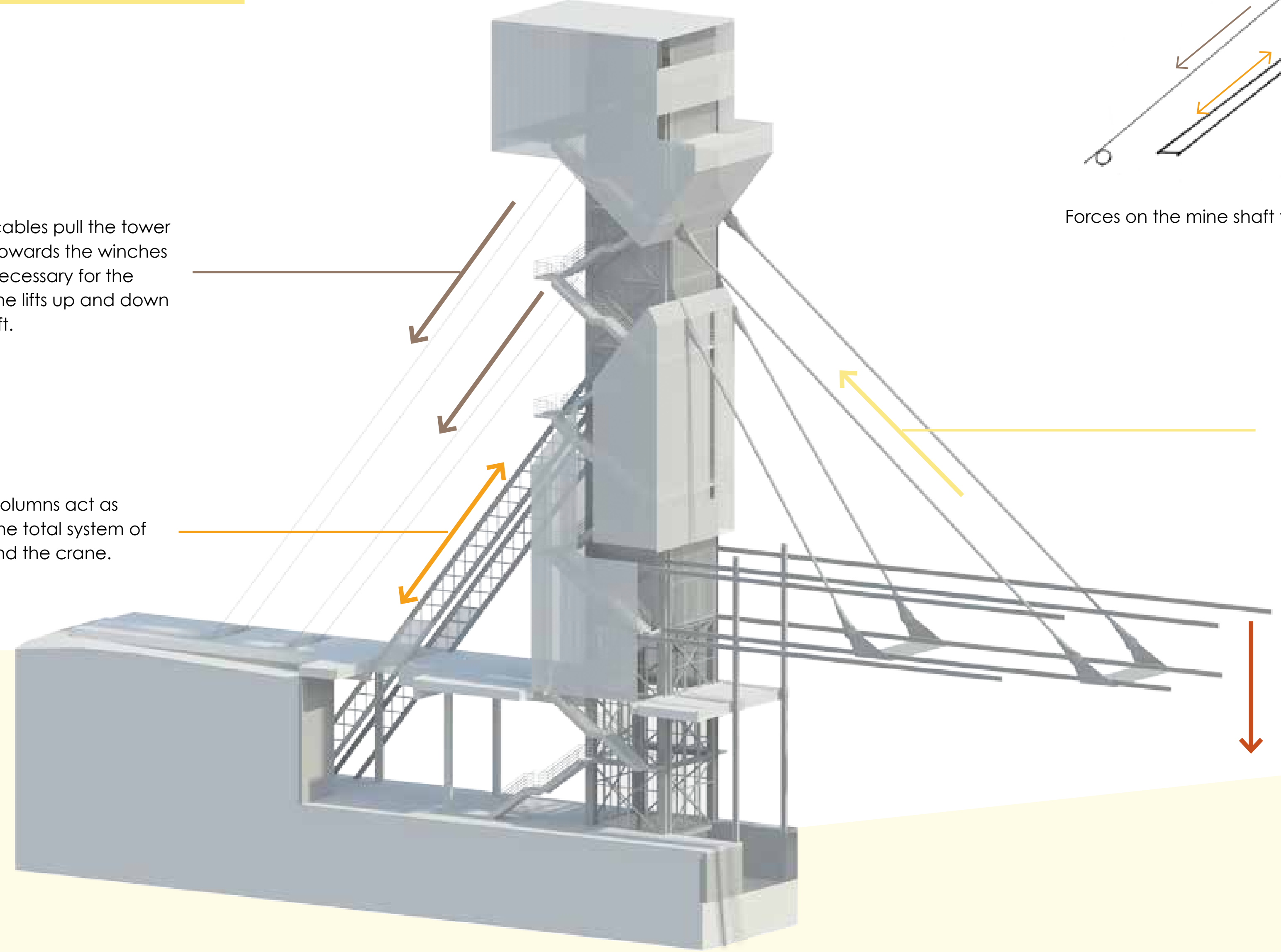
Drainage of green roof



Drainage of stereotomic substructure

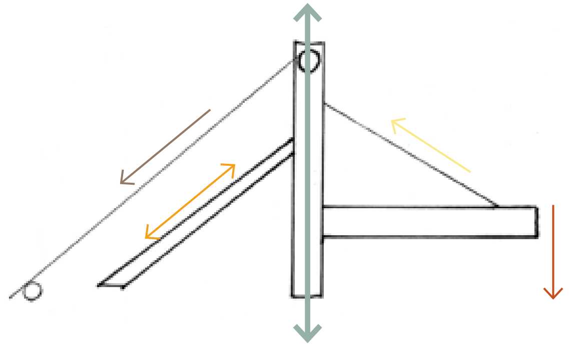
10.2.2.2 Tectonic Superstructure

Forces on mine shaft tower



Mine shaft cables pull the tower backward towards the winches which are necessary for the moving of the lifts up and down into the shaft.

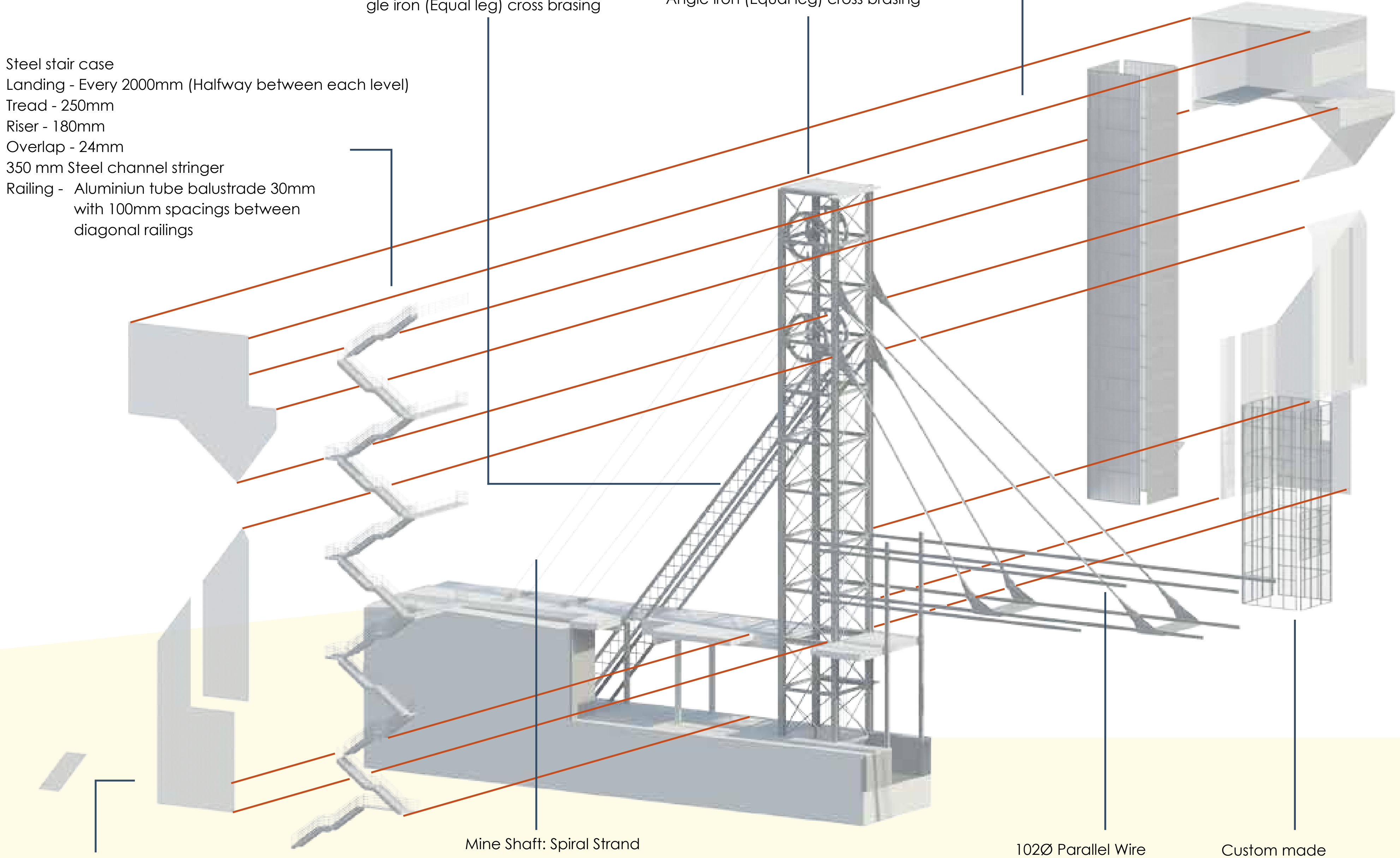
Mine shaft columns act as anchor for the total system of the tower and the crane.



Forces on the mine shaft tower

The cables between the tower and the crane pull the crane towards the tower.

Crane (cantilevered offices) pulls the tower in the opposite direction of the mine shaft winch.



305 x 165 x 46 I section (Parallel Flange) with 70 x 70 x 8 mm Angle iron (Equal leg) cross brasing

500x500 H Column with 180 IPE I Beam 4000mm CC with 100x100x12 Angle iron (Equal leg) cross brasing

60x40x2.5 Rectangular Hollow section

2mm Galvanised steel (SANS 121) with 40mm x 40mm square perforations

Steel stair case
Landing - Every 2000mm (Halfway between each level)
Tread - 250mm
Riser - 180mm
Overlap - 24mm
350 mm Steel channel stringer
Railing - Aluminiun tube balustrade 30mm with 100mm spacings between diagonal railings

2mm Galvanised steel (SANS 121) with 40mm x 40mm square perforations

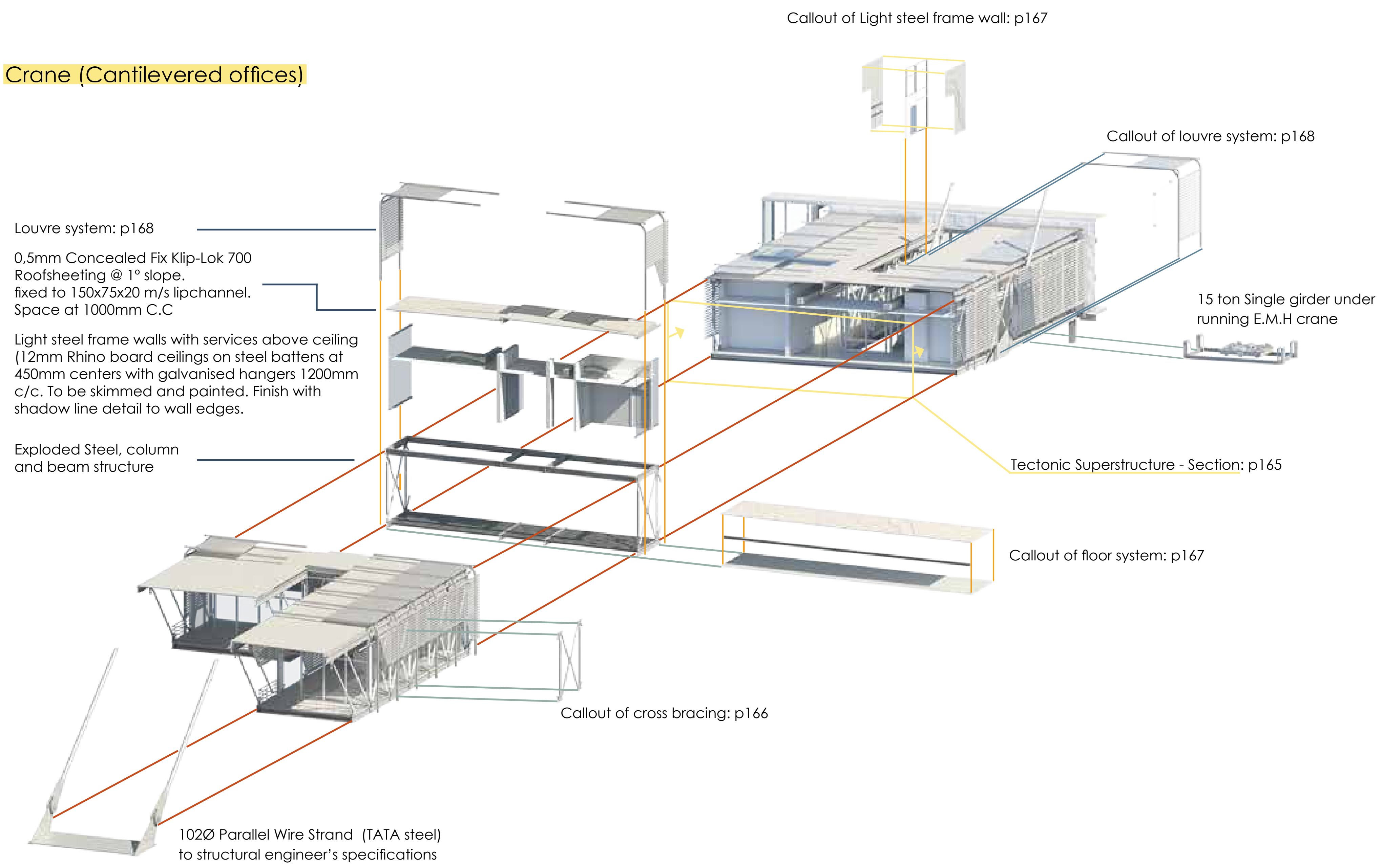
Mine Shaft: Spiral Strand 57mm Ø Spiral strand to structural mine engineer's specifications

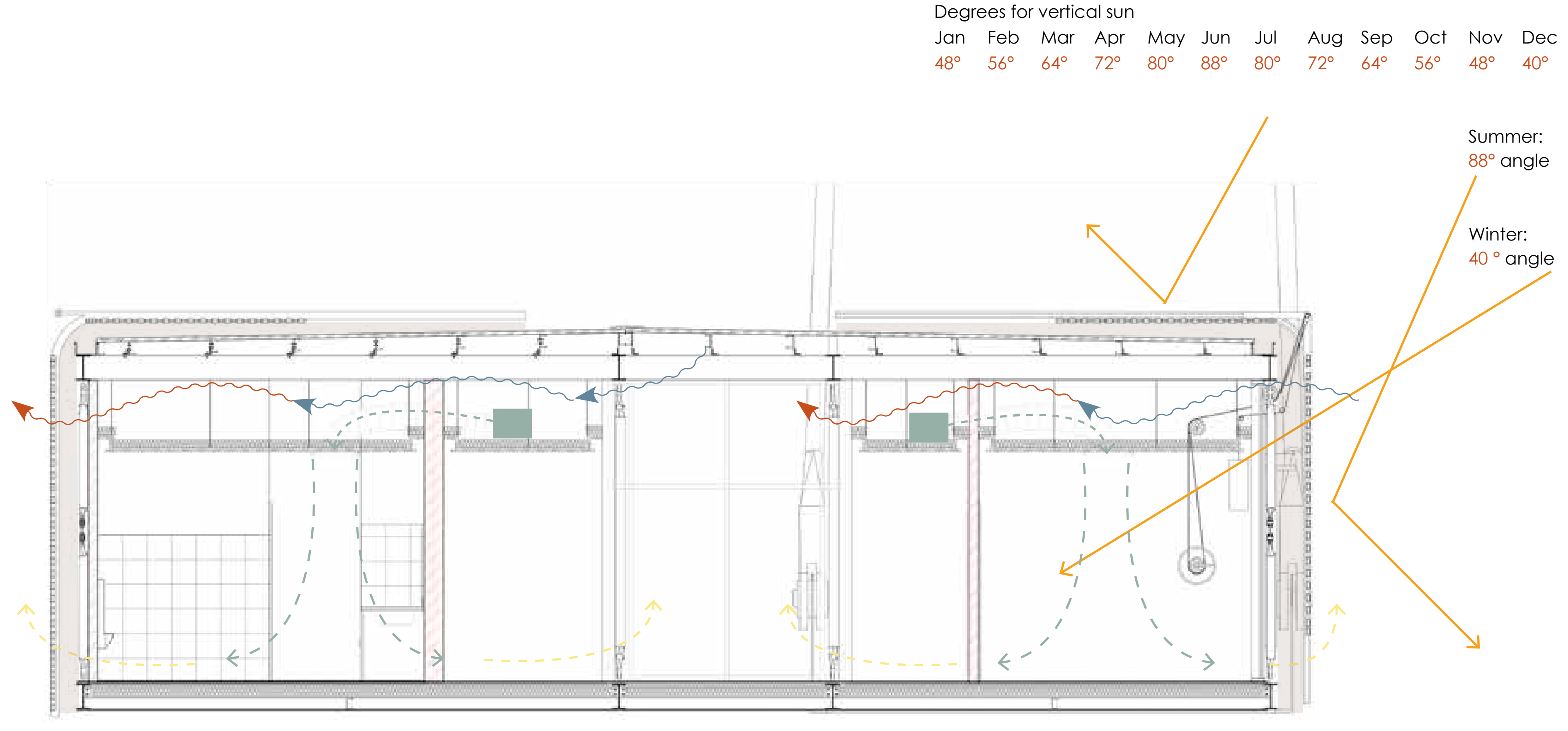
102Ø Parallel Wire Strand (TATA steel) to structural engineer's specifications

Custom made curtain wall with 10mm glazed glass

| Technical investigation

Crane (Cantilevered offices)

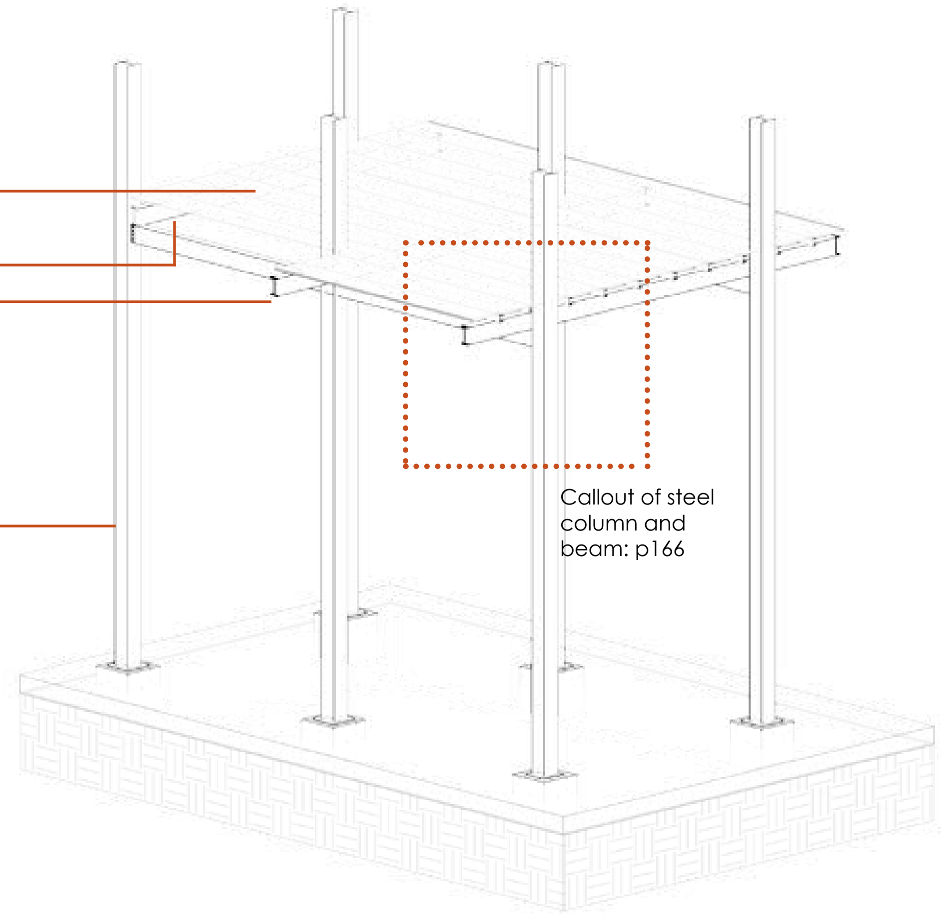




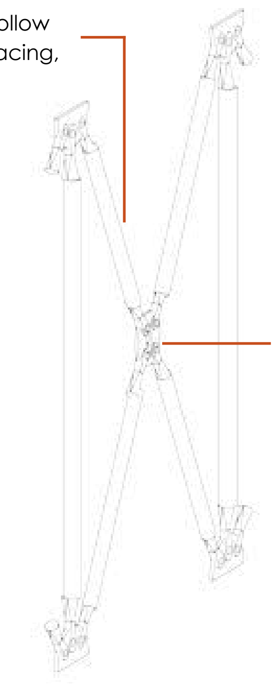
Tectonic Superstructure Section

Passive design Strategies

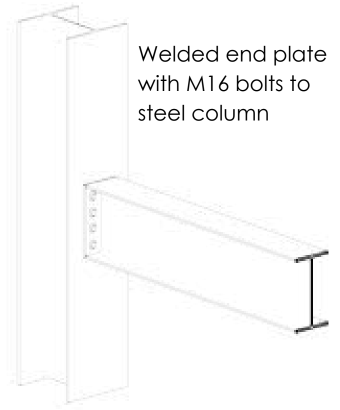
- Northern sun
- Ventilation - Cold air from out side
- Ventilation - Hot air above ceiling
- Clean controlled air from Geothermal plant
- Stale air
- Clean controlled air ducting - Supply from Geothermal plant
- Buffer zone



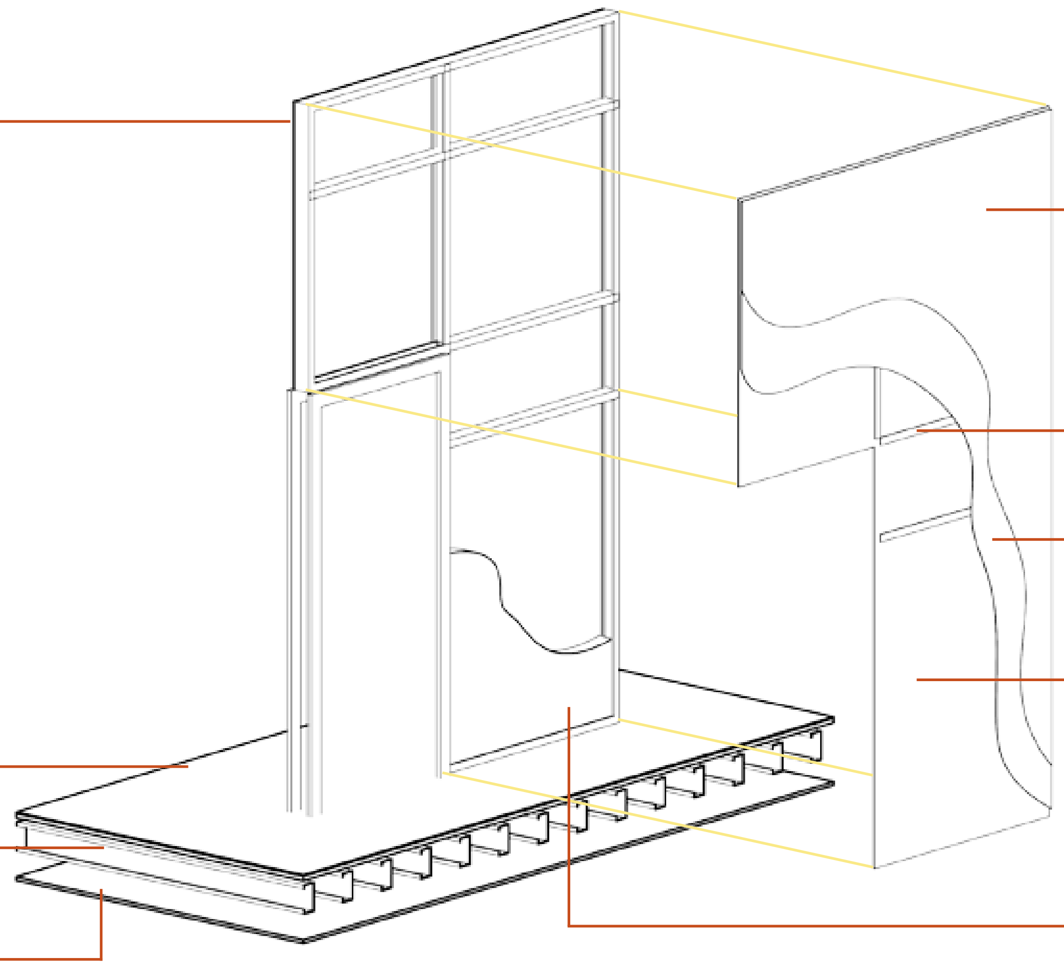
Steel, column and beam structure



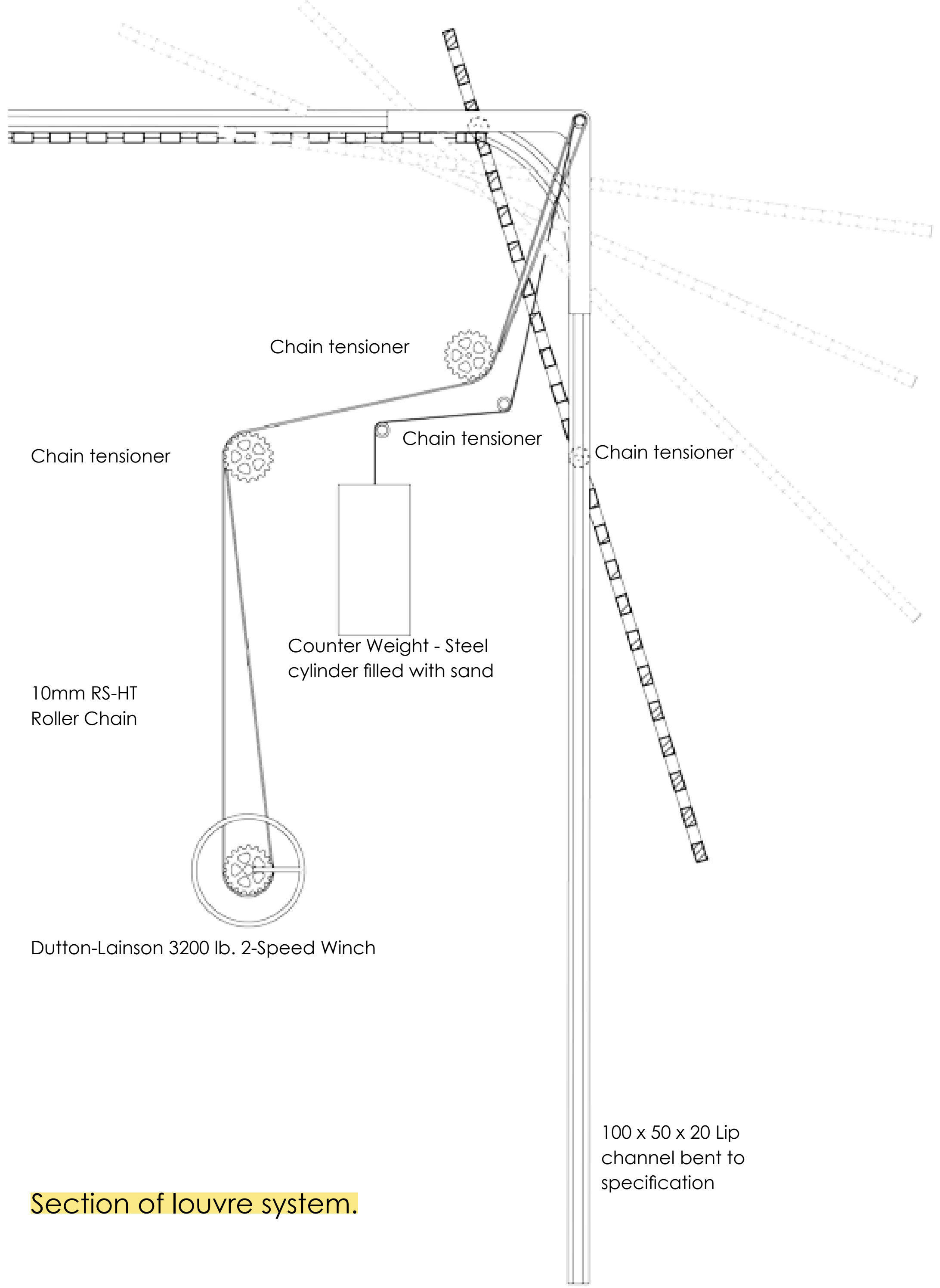
Cross bracing



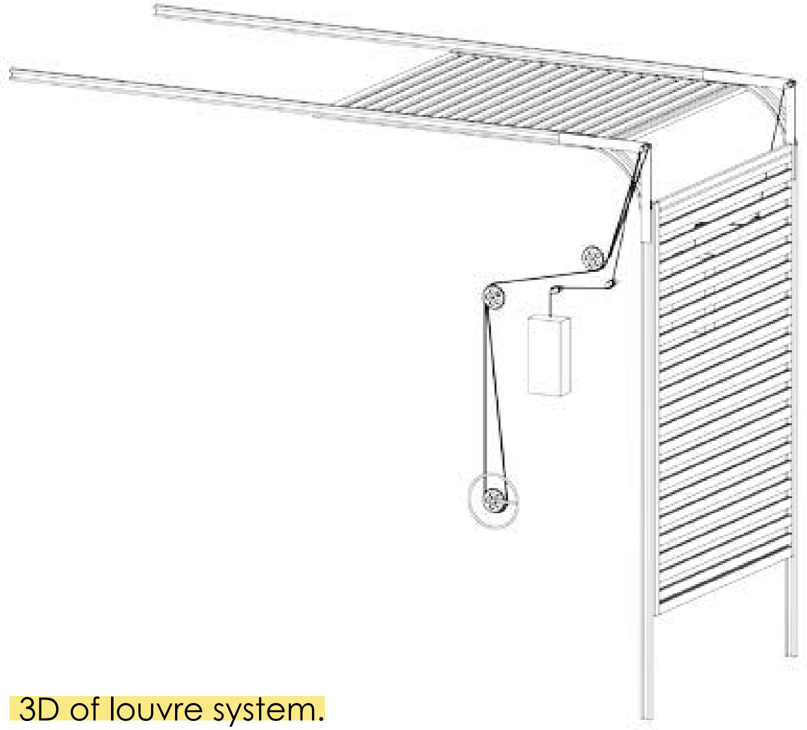
Connection detail of steel column and beam.



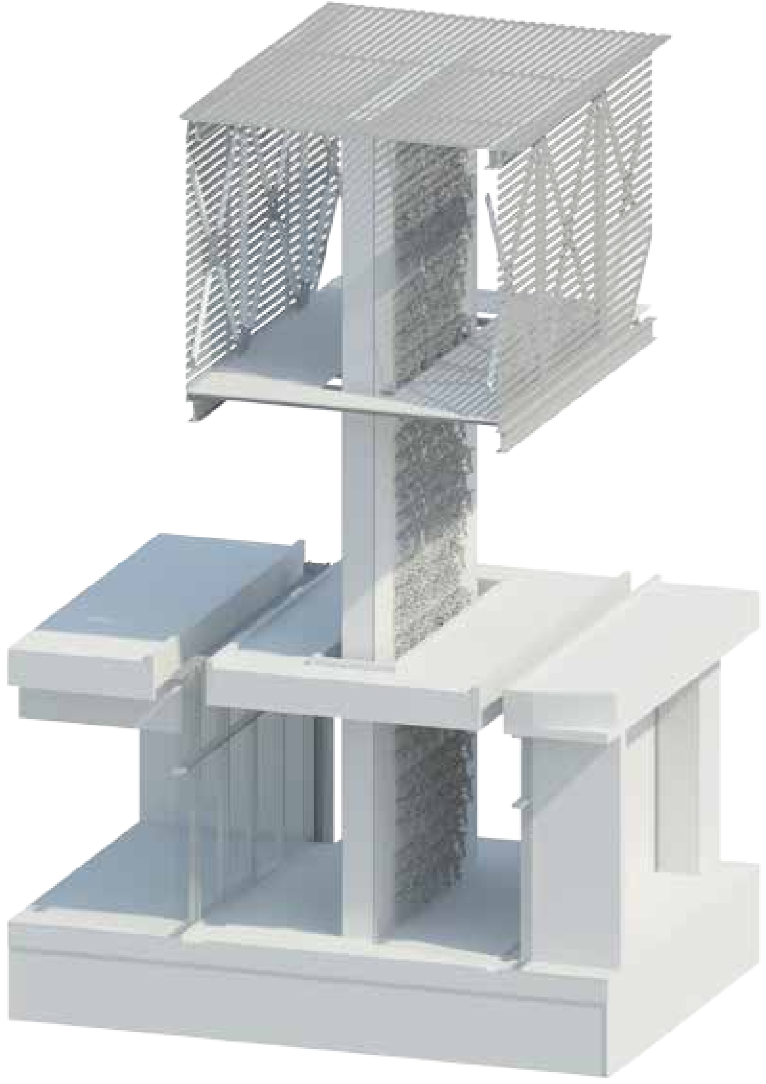
Light steel frame wall supported on tectonic steel beam floor



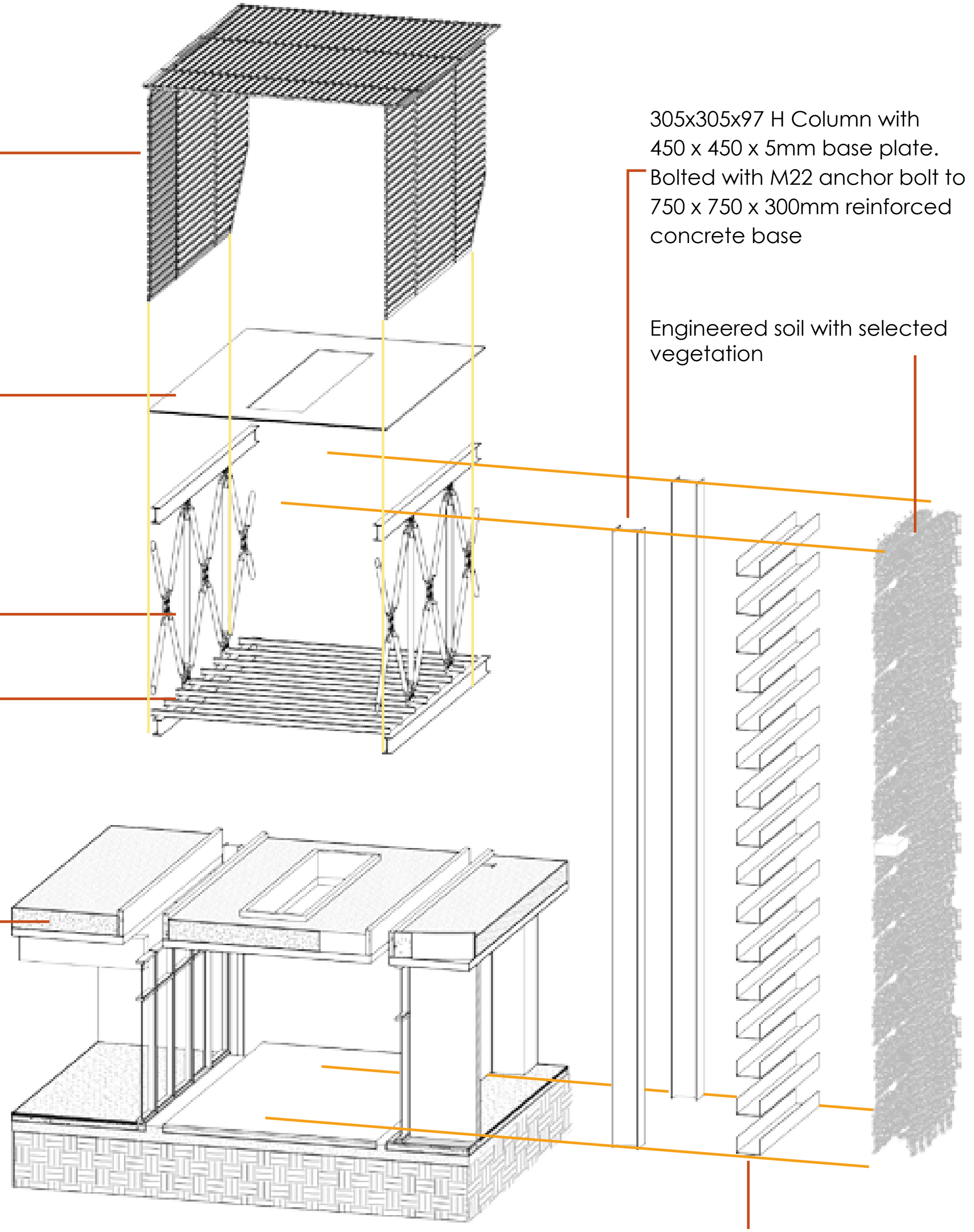
Section of louvre system.



3D of louvre system.



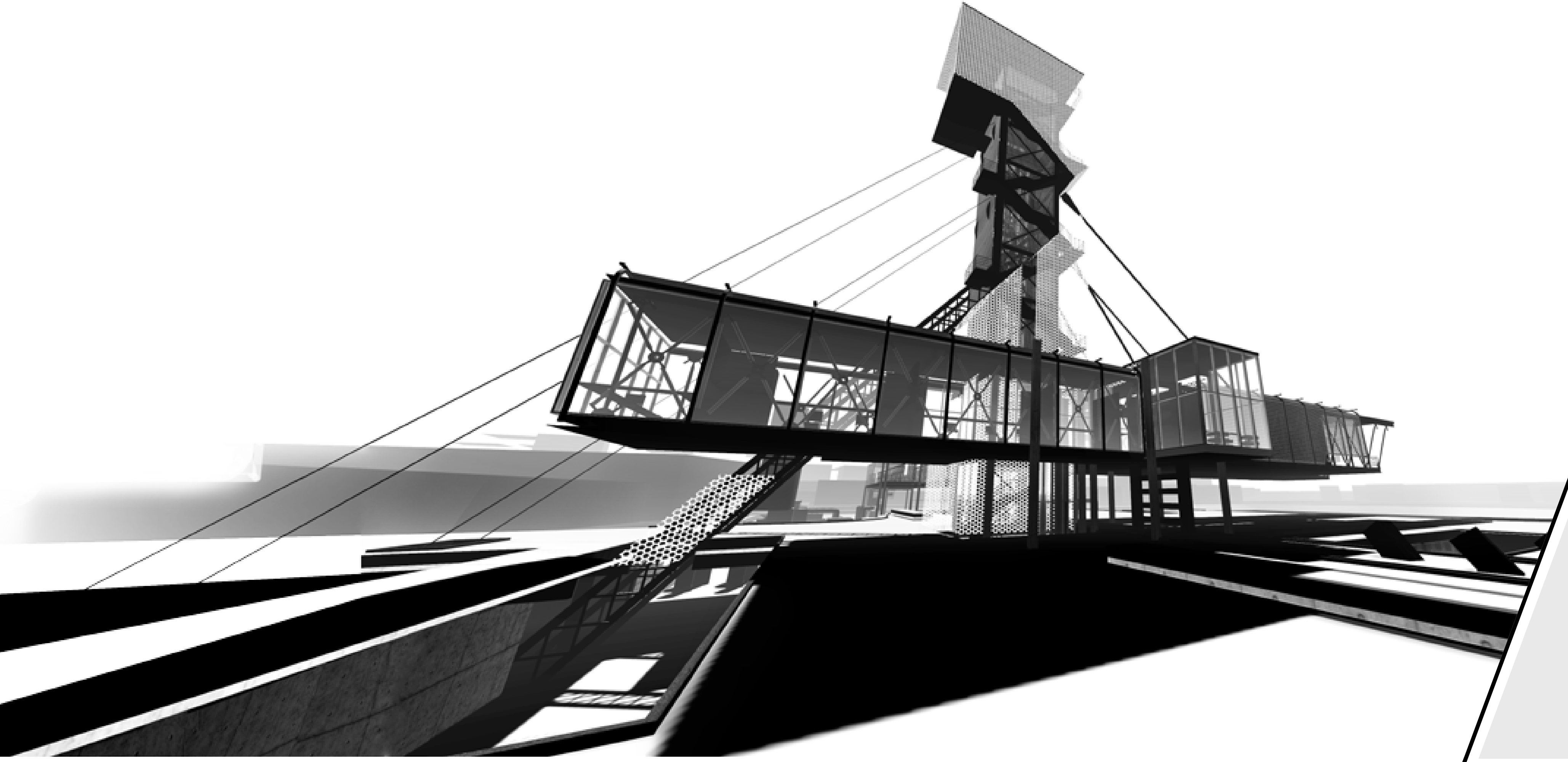
Green wall



Exploded view of green wall

Conclusion

Building construction can have comprehensive direct and indirect impacts on the environment, society and economy. In the field of architecture sustainable design seeks to balance the needs of these above areas by using an integrated approach to harmonise everybody's needs and to create design solutions with benefits for everybody. This project is a contribution to find a way into a journey of sustainable living.



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