THE PRODUCTIVE LANDSCAPE

Wetland Rehabilitation at the Lower Reaches of the Liesbeek River

Preetya Bhikha
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October 2013

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Abstract

This dissertation explores the relationship between architecture, nature and the machine. It aims to investigate the potential for architecture to serve as a catalyst for site regeneration, specifically in a landscape that is undervalued in its current condition. The design, located at the lower reaches of the Liesbeek River, explores wetland rehabilitation and agricultural production, by viewing architecture as a soft machine that becomes a part of dynamic systems in ecological landscapes. The boundary has been selected as the means for architectural engagement, and the layers of the site are explored for their potential to create identity.

The proposed programme comprises of an architecture of inhabited site works, that embodies the process of natural water filtration, using water from the Liesbeek River. Natural ecosystems are restored through the cultivation of endangered wetland plants in controlled growing beds for wetland rehabilitation on the site. Filtered water from the constructed wetlands is then used in hydroponic farming, supported by a water research facility. The conventional typology of landscapes of production is augmented through public interaction, which is facilitated through the provision of public amenities. These include a healthy-food café, public pool and change facilities, as well as a public wetland recreational park.

The dissertation shows that through the creation of a productive landscape that facilitates public interaction, value can be given to an under appreciated site, by establishing identity through activation.

Keywords

Productive landscapes, wetland rehabilitation, water filtration, agricultural production, soft machine

Programme

Scientific facilities include a wetland nursery, agricultural growing beds and a water research laboratory. Public amenities include a café, pool and change facilities. These are accommodated within a wetland recreational park.

Site

The project is located on the Raapenberg dump site at the confluence of the Black and Liesbeek Rivers in Observatory, Cape Town.

Figure 1: Site panorama. The unappreciated landscape at the edge of the Old Liesbeek River (Author, 2013)

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1| An Introduction

The Liesbeek River has long been a point of fascination for me. Growing up in Cape Town resulted in the almost daily acknowledgement of the river, either by crossing it or walking along its banks en route to school. The mysterious and magical atmospheres experienced along the banks of the river in the upper reaches formed the background to many adventures as a child.

Acting as a bio-highway within the suburban matrix of the Southern Suburbs, the Liesbeek River is particularly interesting due to its rich historical, cultural and geographical layers, which have been augmented through influence and time. While it links space, communities, activities and land along its length, it is largely overlooked and undervalued within the spatial terrain of Cape Town.

A variety of interests prompted further investigation within this dissertation:

1) Water filtration systems and wetland ecosystems within stressed environments

2) Constructed landscapes and the potential for architecture to embody machine-like characteristics

3) The ways in which the perceptions of a site that is largely ignored in public consciousness can be changed through spatial activation

With these interests in mind, this dissertation investigates the potential for architecture to serve as a catalyst for the regeneration of a site that is otherwise unappreciated. The architectural inquiry is twofold:

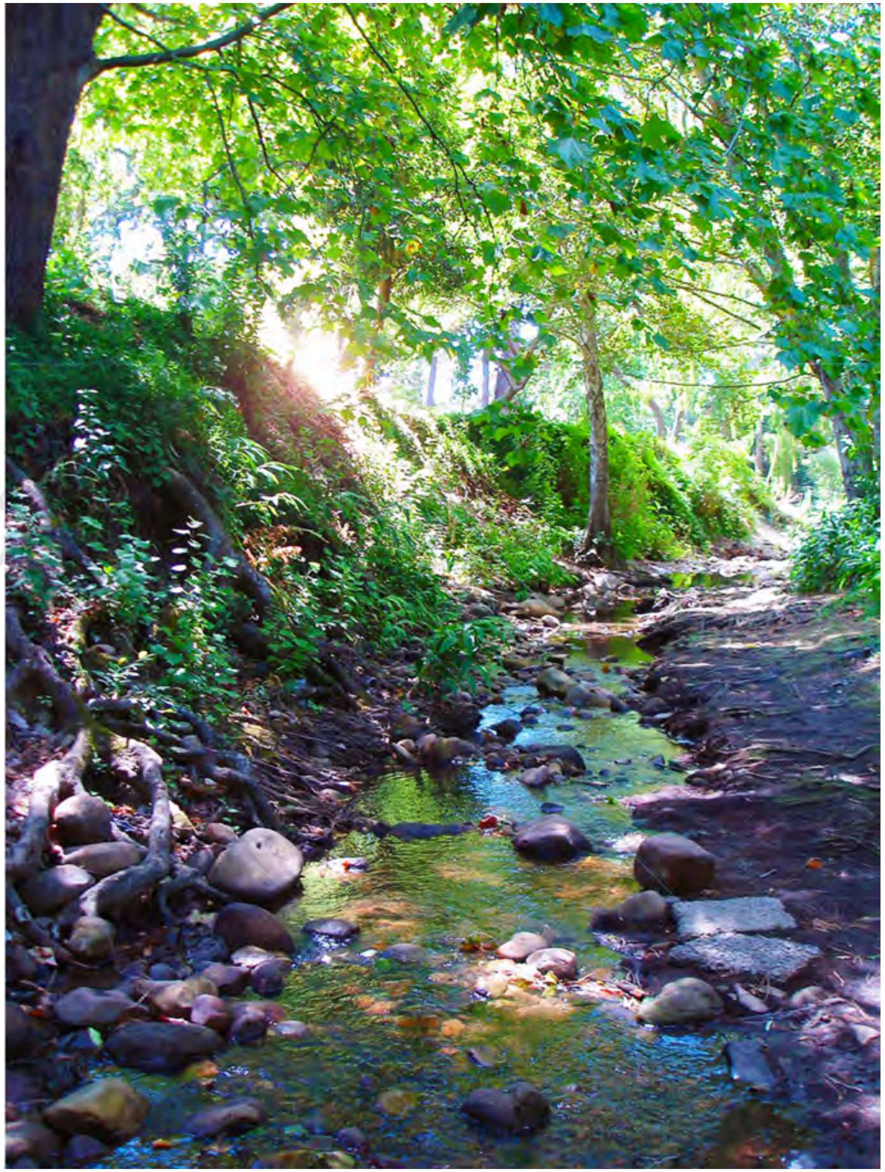


Figure 2: The magical atmosphere created by the different layers of the site in the upper reaches of the Liesbeek River. (Author, 2013)

Firstly, it is driven by an investigation of the boundary as a transitional and flexible zone containing the different layers that constitute the Liesbeek River. By understanding the different layers of the river, the importance of the site within the greater ecological system can be re-established. Landscape is explored as the architectural material that defines identity and adds value by “revealing or concealing the traces of the site’s history” (Reed 2005: 16)

Secondly, the ways in which an architectural intervention can be mediated spatially through the characteristics of the machine, to become part of dynamic processes in natural landscapes is explored. Kronenberg suggests that “technology can contribute to the design of an architecture that is responsive…in a changing world…to create meaningful places” (2001:6) The idea of a productive landscape is developed, which aims to integrate public interaction with scientific processes while highlighting the characteristics of a site in crisis to create polyvalency and identity. This productive landscape will comprise of a soft machine, which embodies both the process of water filtration and narrative thereof. The soft machine augments the idea of a building, both as an extension of landscape and as a network of nested systems.

This report aims to document the design project as a process, which is just as important as the end design solution. An analysis of the Liesbeek River through the lens of boundary allows for the introduction of the site of intervention. The value of wetlands is explored, contextualised by an investigation of existing food and water resources within Cape Town. This introduces the ideas of the soft machine, which is embedded within the productive landscape. The design proposes that the creation of a productive landscape that facilitates public interaction can give value to an under- appreciated site, by establishing identity through activation.

2| Analysing the River through the Lens of *Boundary*

Rivers are ever-changing ecosystems: their shape, texture, form and speed are informed by historical, cultural and urban development. These natural environments of continuous change and cycles are located within boundaries: areas of transitional space between past, present and future conditions. Although the boundary can be seen as a hard, limiting element; Heidegger (1971) develops the notion of an ever-incomplete entity that tends towards another stage of being. He defines the boundary as "not that at which something stops, but… that from which something begins its presencing." (1971:356) Thus, within landscapes, the boundary can be interpreted as a zone in which transitions and interaction can occur, which can be fixed or can allow for change over time. The *boundary* allows for glimpses of something more than what is superficially visible.

In the context of the Liesbeek River, the term *boundary* refers to the multiple layers of history, geography, nature and architecture that form a palimpsest and demonstrate that several activities have contributed to the shaping of the river as a site. Marot calls this anamnesis, or the memories of former histories of a site (1999:50). He suggests that landscapes require a certain degree of incompleteness to allow for the programming of future conditions in the contemporary global context. The restructuring of a landscape can only take place once the different layers of the site are understood in terms of their historical, cultural and social effects.

The exploration of the *boundaries* of the Liesbeek River was conducted both as a means to understand the constituents that have shaped the river, and to search for a suitable site for the proposed intervention. Locating the project proved challenging as the architectural inquiry called for a large area, but the choice was made not to include sites requiring complex social rehabilitation. The Raapenberg dump site was chosen due to its unique site characteristics. Located at the confluence of the Black and Old Liesbeek Rivers, the large site forms the edge of the River Club golf estate and is bordered by the Transnet Railway Workshop, Observatory and the Black River Parkway. (Figure 5) The site was used as a dumping ground for construction materials during the construction of the Black River Parkway, and does not experience complex social pressures. The materials on site are not toxic and consist of rubble and compacted sand, which are formed into mounds on the site. (Figure 3)

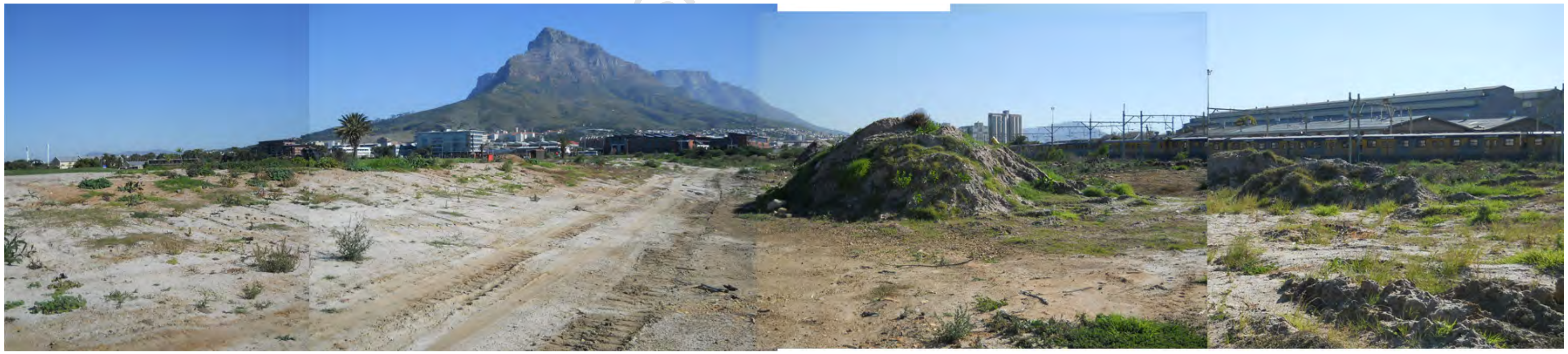


Figure 3: Panorama of site, looking West (Author, 2013)

Figure 4: City context. The site is shown in red on the plan and city section. (Author, 2013)

Salt River Grain Silos (in distance)

Transnet Railway Workshops

Malta Business Park

River Club Golfing Estate

Black River Parkway

Black River Business Park

Figure 5: Locality plan in relation to context markers (Author, 2013)

The Historical Boundary

The pre-colonial landscape consisted of the Salt River Lagoon at the river mouth (now Paarden Eiland) and extended to a large wetland system spanning from the Raapenberg site at the confluence of the Liesbeek and Black Rivers to the river mouth in Table Bay (Figure 6). The river was first settled by Khoi Khoi pastoralists (Pieterse, 2010), who constructed huts along the river banks. The land around the confluence area, including the Raapenberg site, was considered sacred and was used as a location for traditional Khoi Khoi ceremonies.

The arrival of Europeans in the late 1400's and subsequent establishment of a refreshment station by the Dutch East India Company (VOC) in 1652, resulted in development along the Liesbeek River after the first free burghers began farming the land along the riverbanks. Urban densification along with infrastructure such as bridges, roads and railway lines were developed in the early 19th century (Brown et al, 2009). Thereafter, tanning, brewing and milling companies were established. The Raapenberg site was bordered by the Mostert and Jan Reynier farms in 1660, but continued to function as a natural wetland ,until the development of the railway line and Transnet Railway Workshop, when land around the confluence area was built up above the floodplain.

Subsequent urban growth has largely ignored the river, leaving behind traces of historical developments such as the Josephine Mill. (Brown et al, 2009) The original path of the Liesbeek River was shifted in order to gain more land, which results in the sharp form at its confluence with the Black River. (Figure 7) Today, the Old Liesbeek River, which borders the Raapenberg site, contains only water from surface runoff and storm water outlets. The characteristics of the Old Liesbeek and Liesbeek Rivers are therefore different due to their water volumes and natural or man-made edges. The development of land along the river has resulted in a clear spatial boundary through the urban fabric.

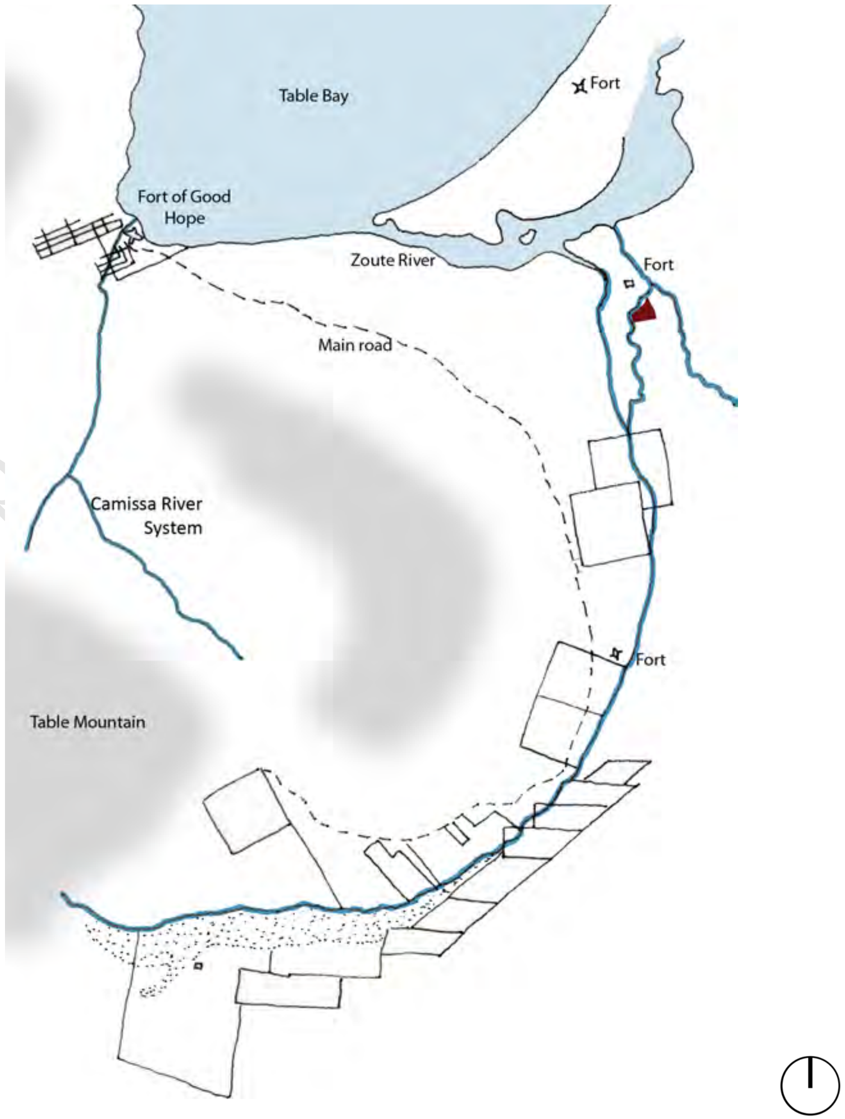


Figure 6: Historical map to show the original course of the Liesbeek River in 1660. The approximate location of the Raapenberg site is shown in red. Not to scale (NTS). (Author, 2013. Adapted from Brown et al, 2009)

Figure 7: Urban development along the river through time. The site is shown in red, while the changes in the river course are mapped by the blue dotted line. NTS. (Author, 2013)

The Architectural Boundary

Mills, pumps, bridges and canals are key architectural features of the Liesbeek River. These man-made constructs serve as markers in the landscape that define the edge of the Liesbeek as a place of doing: either as part of the process of making (brewing and milling) or for movement (bridges and canals). Both wind and water mills were erected along the river, which were used to mill flour obtained from wheat harvests along the river. Bridges that cross the Liesbeek were constructed primarily for motorised transport, with few pedestrian bridges along the river's length.

Canalisation has had the greatest impact on the spatial fabric of Cape Town. (Figure 9 a) Through attempting to control the river's seasonal flow, physical limits have been put in place on an element that undergoes constant transformation. Despite these control measures, the Liesbeek is predisposed to flooding due to high winter rainfalls, surface hardening along the river's edge and storm water surges. (Brown et al, 2009)

When dealing with similar issues in Mumbai, landscape architects Anuradha Mathur and Dilip da Cunha (2009) proposed transforming the landscape to allow for seasonal flooding. "Wet theory" is explored, where hard, man-made edges are softened to allow for change, impermanence and flux (Mathur and da Cunha, 2009). Land is allowed to hold water through absorption and is designed for resilience using the section as a tool, creating a flexible boundary zone (Figure 8).

The banks of both the Black and Old Liesbeek Rivers bordering the Raapenberg site have been mechanically altered. Earth is annually compressed at the water's edge in order to create steep slopes that prevent flooding. For most of the year, the Old Liesbeek channels very little water from the Liesbeek River. Although the river water input is higher in winter, the Old Liesbeek does not experience the severe flooding that occurs in the Liesbeek River due to its lower volume and velocity. An analysis of the "1 in 5", "1 in 10" and "1 in 50" floodplains shows the site will become an island during these different flood events, making it an ideal location for an architectural intervention that can allow for constant change (Figure 9 b-d).

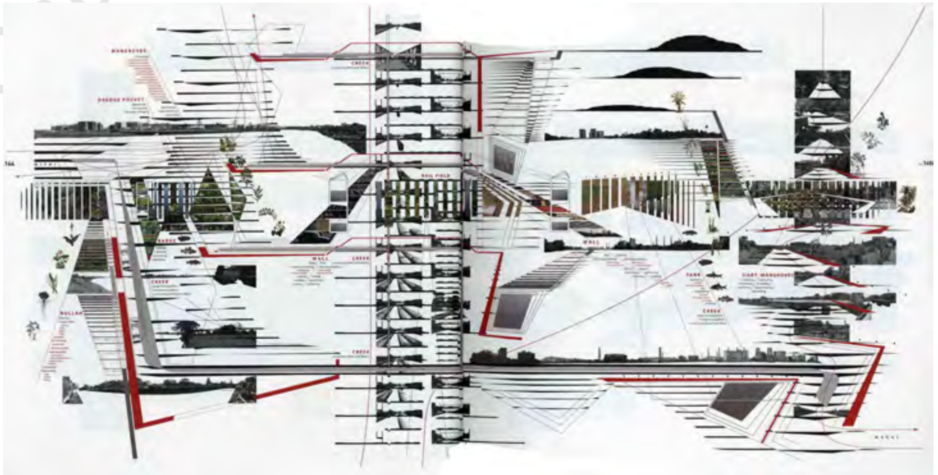


Figure 8: Landscape architects Mathur and da Cunha work through section to re-imagine open space in Mumbai. Land is able to absorb monsoon rains, preventing flooding. (Mathur and da Cunha, 2009)

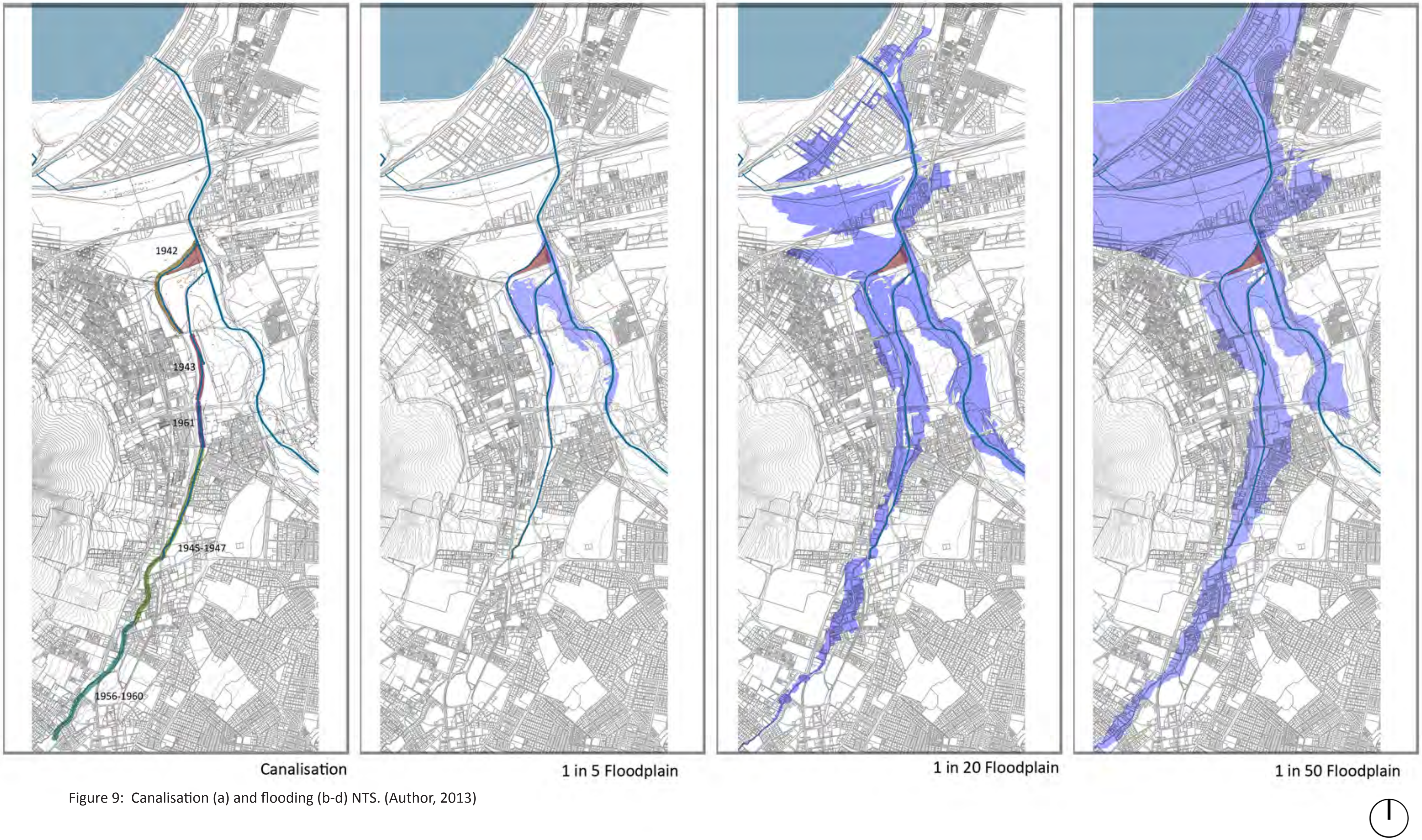


Figure 9: Canalisation (a) and flooding (b-d) NTS. (Author, 2013)

The Natural Boundary

The Liesbeek River possesses a variety of indigenous and alien riparian conditions along its course. These consist of different layers of fauna, flora and geographical characteristics, each distinctive of the river's maturity.

Table Mountain, Kirstenbosch and Bishopscourt form the upper reaches of the river, where the natural boundary consists of indigenous riparian conditions (Brown et al, 2009). The middle reaches are mostly canalised, enabling the invasion of alien flora in portions along Rosebank, Mowbray and Observatory. (Figure 10)

Figure 10: A canalised portion of the middle reaches of the river in Mowbray (Author, 2013)

The lower reaches of the river includes the Raapenberg Nature Reserve in Observatory, which is a conserved area for natural riparian conditions and is situated at the confluence of the polluted Black and Liesbeek Rivers. (Figure 11) After converging with the Black River, the heavily polluted water travels through Paarden Eiland in the Salt River Canal to the river mouth in Table Bay. (Figure 12) Fertiliser from domestic use

Figure 11: The Raapenberg Nature Reserve adjacent to the proposed site. (Author, 2013)

Figure 12: The polluted Salt River Canal in Paarden Eiland, just before the water enters Table Bay. (Author, 2013)

and natural debris add excess nutrients to the water and fuel the growth of unwanted fauna and flora along the way.

In the middle to lower reaches, the spaces left around the canalised river are grassed, open and undefined. This transitional zone is meant to act as a buffer against urban development along the river, but also represents the fragile relationship between urban development and landscape through the seasonal event of flooding.

The Raapenberg site, which is situated within the Two Rivers Urban Park (TRUP), is an important location within the existing biodiversity corridor. Containing heritage buildings, important institutions and "unique ecological systems and habitats" (CoCT, 2012), the TRUP has been recognised by the City of Cape Town as an environmentally, culturally and historically important precinct along the Salt River system, and is earmarked for environmentally-responsible development. This includes the development of mixed-use precincts, recreational space, wetland conservation projects and the reintroduction of urban agriculture, specifically in the Maitland Garden Village (CoCT, 2012). Additionally, the area contains endangered riparian vegetation. Natural wetland vegetation has been retained in parts along the banks of the Old Liesbeek River, which helps with the filtration of pollutants and retention of water during flooding (Figure 13).

Figure 13: The limited network of existing wetlands along the Liesbeek River. Through the Metropolitan Open Space System (MOSS), these spaces are to be linked to create a ecological network across the city, facilitating conservation and recreation (Author, 2013)

The TRUP forms part of the Metropolitan Open Space System (MOSS), which aims to facilitate conservation and recreation by linking green open space across the city (Figure 14). Though MOSS, the city aims to improve the Salt River System by rehabilitating wetlands and riparian vegetation for flood control, improve water quality, de-canalise rivers, and deal with industrial effluent. (CoCT, 2009)

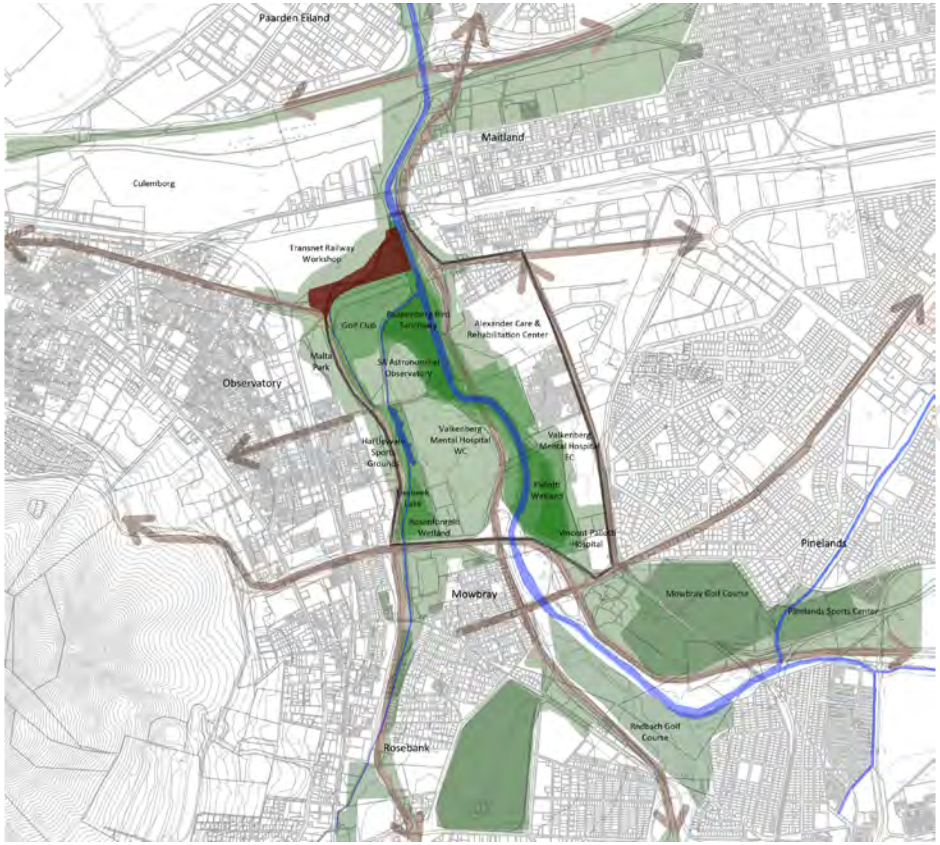


Figure 14: The MOSS system across the city. The extents of the TRUP is shown in black. Areas of conservation priority are highlighted in green, along with major traffic movement routes. NTS. (Author 2013. Adapted from CoCT, 2012)

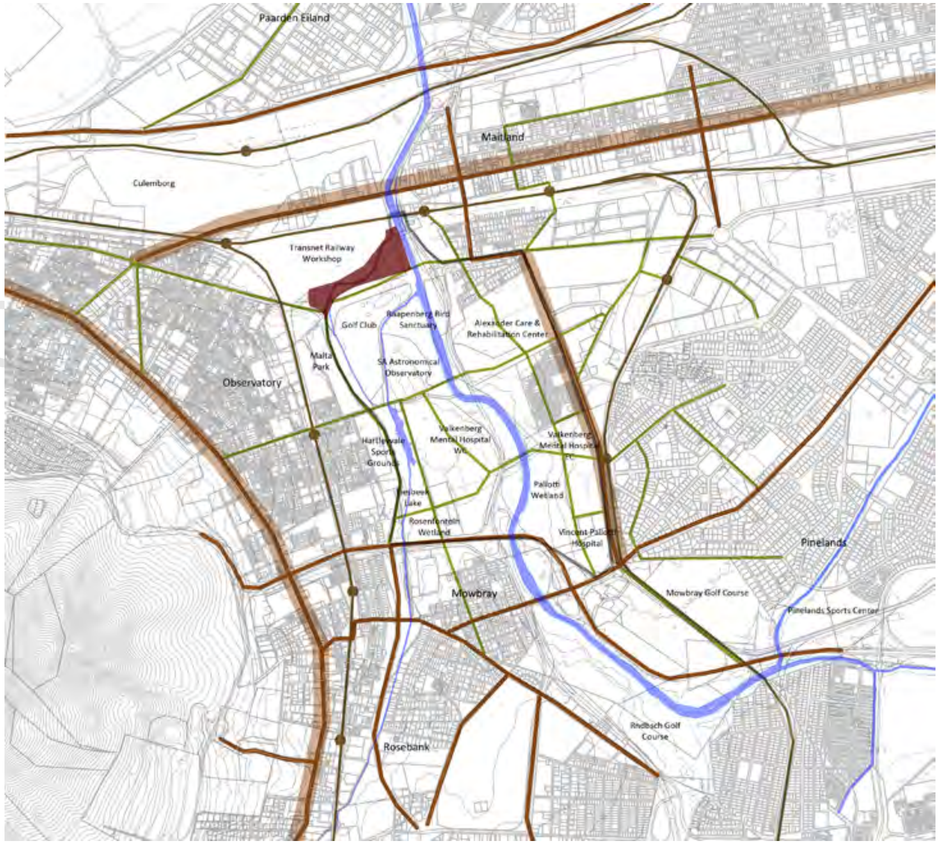


Figure 15: Proposed movement routes prioritising public transport in the TRUP. These include rail, bus and road intensity networks. NTS. (Author 2013. Adapted from CoCT, 2012)

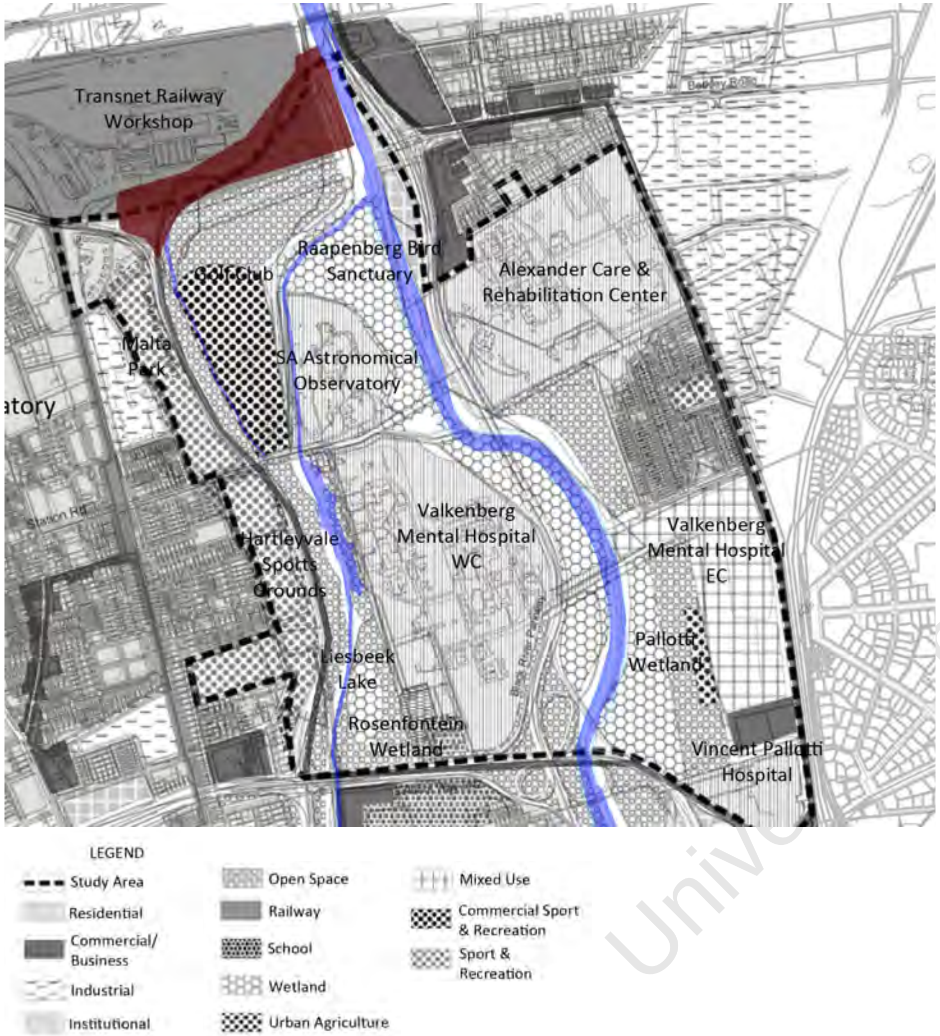


Figure 16: Current zoning of uses. NTS. (Author 2013. Adapted from CoCT, 2012)

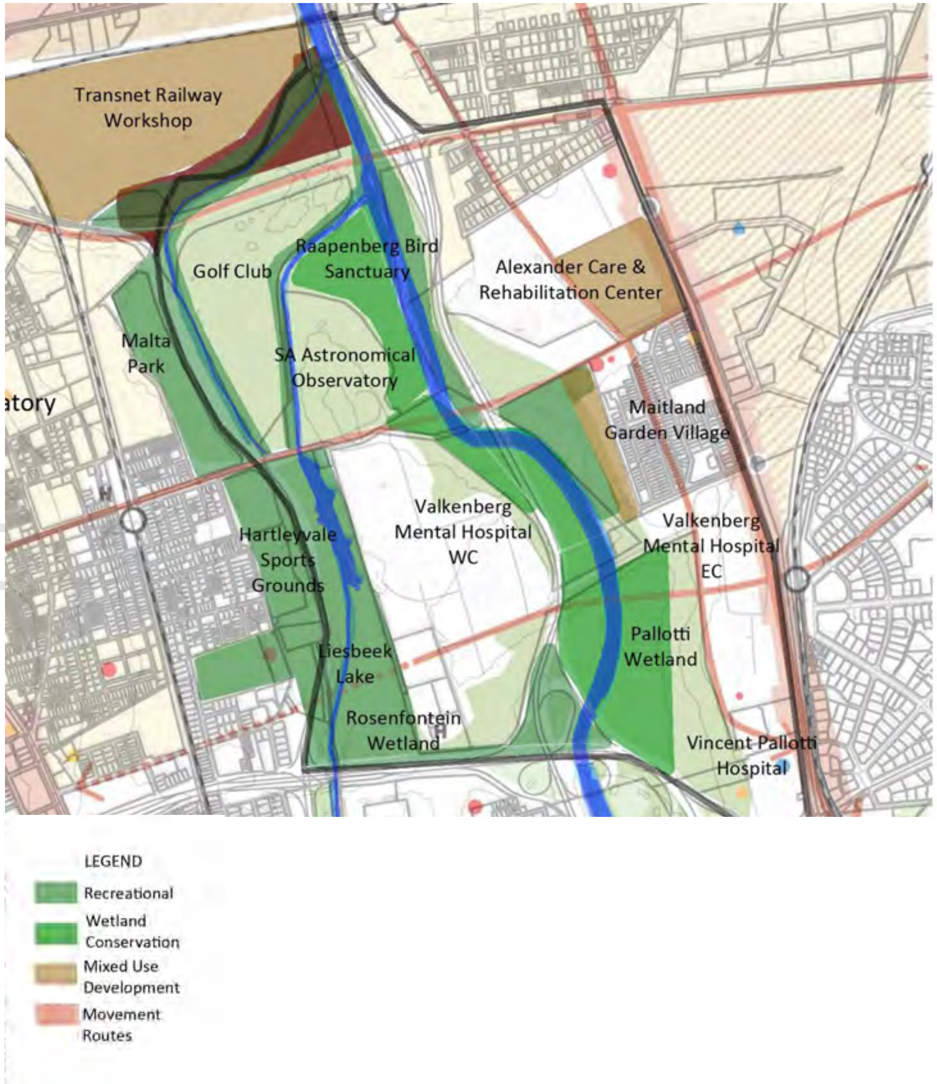
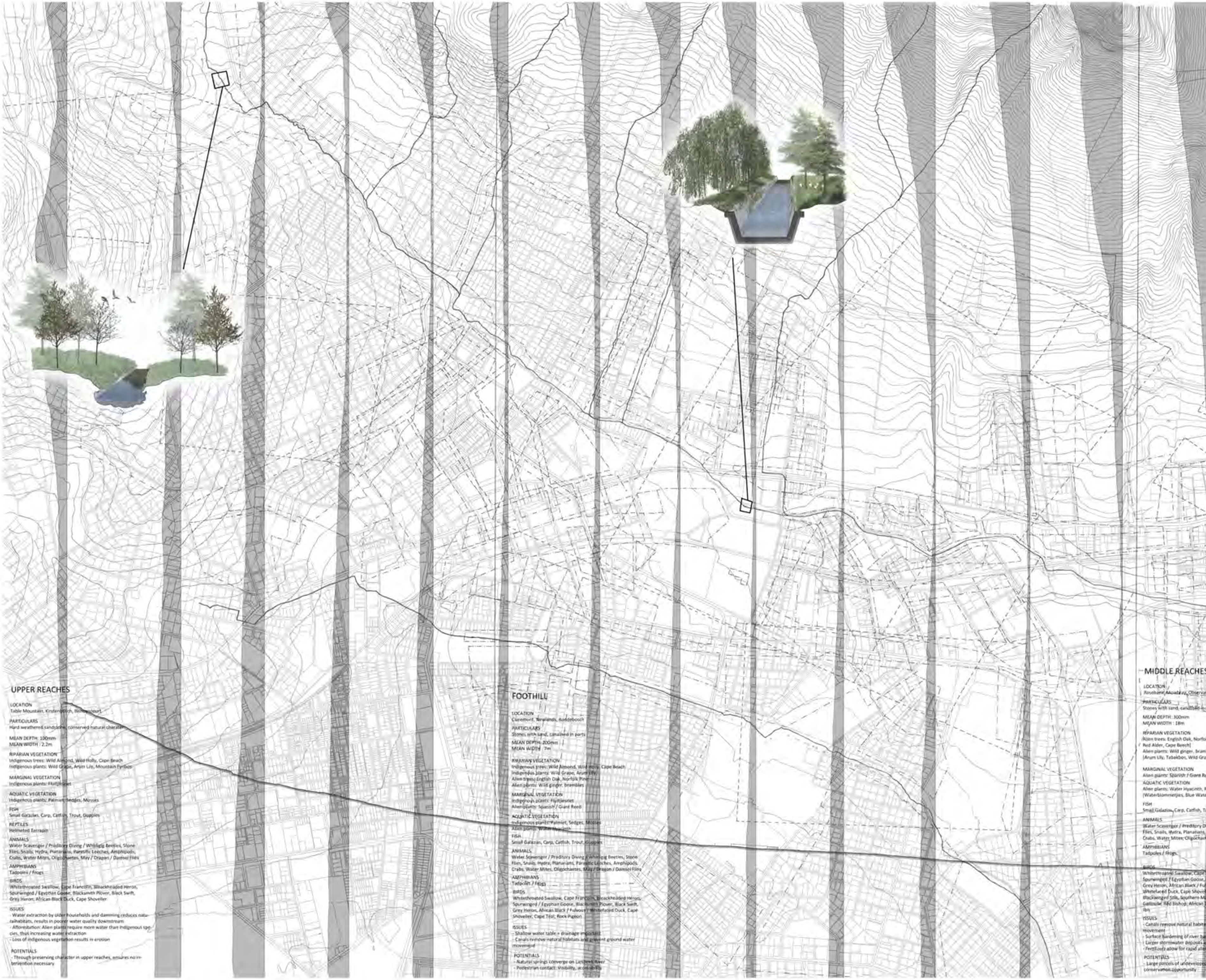


Figure 17: Proposed zoning of uses and urban integration. NTS. (Author 2013. Adapted from CoCT, 2012)


UPPER REACHES
LOCATION
Table Mountain, Kirstenbosch
PARTICULARS
Hard weathered sandstone, conserved natural character
MEAN DEPTH: 100mm
MEAN WIDTH : 2.2m
RIPARIAN VEGETATION
Indigenous trees: Wild Almond, Wild Holly, Cape Beach
Indigenous plants: Wild Grape, Arum Lily, Mountain Fynbos
MARGINAL VEGETATION
Indigenous plants:
AQUATIC VEGETATION
Indigenous plants: Palmiet, Sedges, Mosses
FISH
Small Galazias, Carp, Catfish, Trout, Guppies
REPTILES
Helmeted Terrapin
ANIMALS
Water Scavenger / Predatory Diving / Whirligig Beetles, Stone Flies, Snails, Hydra, Planarians, Parasitic Leeches, Amphipods, Crabs, Water Mites, Oligochaetes, May / Dragon / Damsel Flies
AMPHIBIANS
Tadpoles / Frogs
BIRDS
Whitethroated Swallow, Cape Francolin, Blackheaded Heron, Spurwinged / Egyptian Goose, Blacksmith Plover, Black Swift, Grey Heron, African Black Duck, Cape Shoveller
ISSUES
- Water extraction by older households and damming reduces natural habitats, results in poorer water quality downstream
- Afforestation: Alien plants require more water than indigenous species, thus increasing water extraction
- Loss of indigenous vegetation results in erosion
POTENTIALS
- Through preserving character in upper reaches, ensures no intervention necessary
FOOTHILL
LOCATION
Claremont, Newlands, Rondebosch
PARTICULARS
Stones with sand, canalised in parts
MEAN DEPTH: 200mm
MEAN WIDTH : 7m
RIPARIAN VEGETATION
Indigenous trees: Wild Almond, Wild Holly, Cape Beach
Indigenous plants: Wild Grape, Arum Lily
Alien trees: English Oak, Norfolk Pine
Alien plants: Wild ginger, brambles
MARGINAL VEGETATION
Indigenous plants:
Alien plants: Spanish / Giant Reed
AQUATIC VEGETATION
Indigenous plants: Palmiet, Sedges, Mosses
Alien plants: Water Hyacinth
FISH
Small Galazias, Carp, Catfish, Trout, Guppies
ANIMALS
Water Scavenger / Preditory Diving / Whirligig Beetles, Stone Flies, Snails, Hydra, Planarians, Parasitic Leeches, Amphipods, Crabs, Water Mites, Oligochaetes, May / Dragon / Damsel Flies
AMPHIBIANS
Tadpoles / Frogs
BIRDS
Whitethroated Swallow, Cape Francolin, Blackheaded Heron, Spurwinged / Egyptian Goose, Blacksmith Plover, Black Swift, Grey Heron, African Black / Fulvous / Whitefaced Duck, Cape Shoveller, Cape Teal, Rock Pigeon
ISSUES
- Shallow water table = drainage important
- Canals remove natural habitats and prevent ground water movement
POTENTIALS
- Natural springs converge on Liesbeek River
- Pedestrian contact: Visibility, accessibility
MIDDLE REACHES
LOCATION
PARTICULARS
MEAN DEPTH : 300mm
MEAN WIDTH : 18m
RIPARIAN VEGETATION
MARGINAL VEGETATION
AQUATIC VEGETATION
FISH
ANIMALS
AMPHIBIANS
Tadpoles / Frogs
BIRDS
ISSUES
POTENTIALS
conservation opportunity

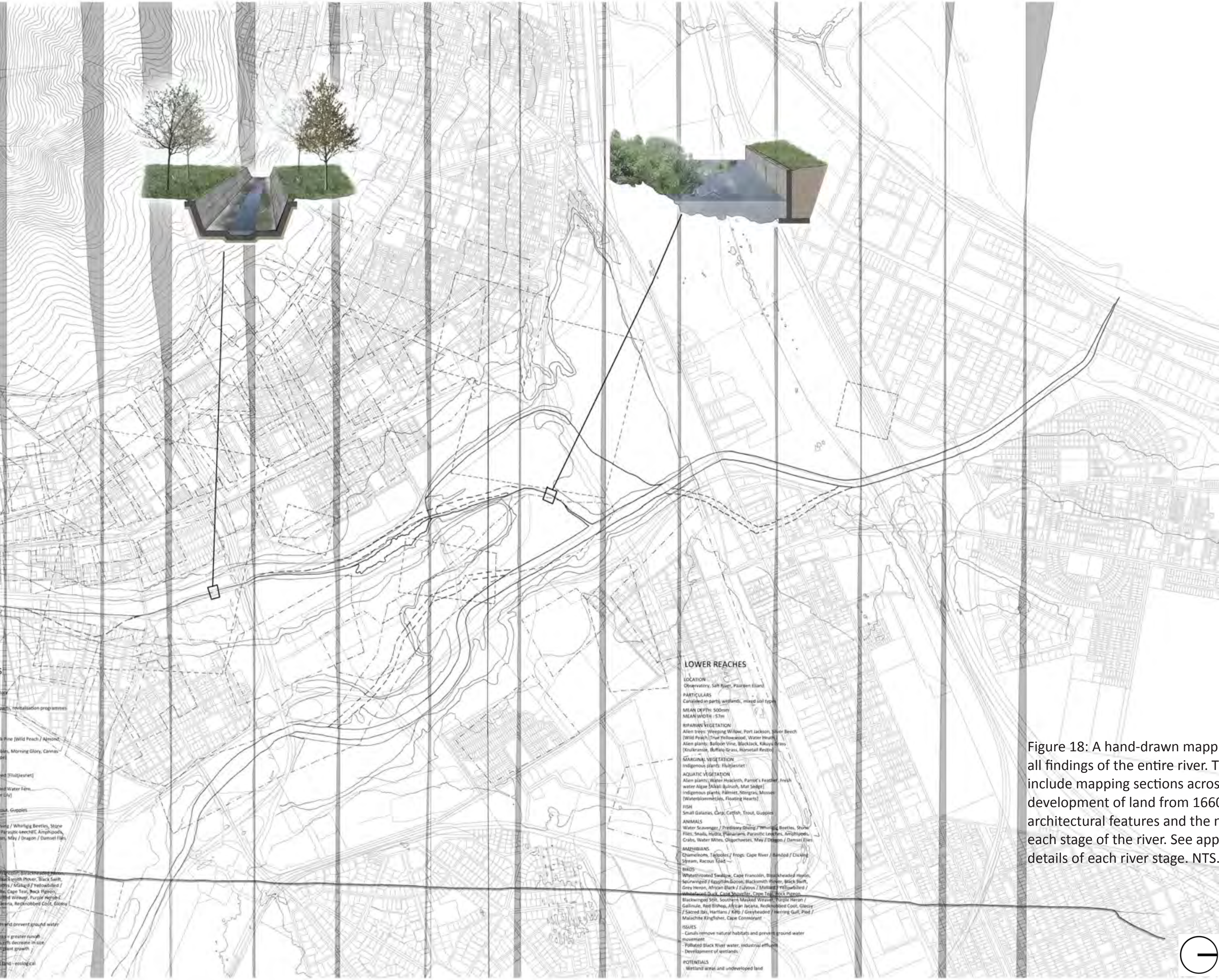


Figure 18: A hand-drawn mapping summarising all findings of the entire river. The layers include mapping sections across the course, development of land from 1660-2013, key architectural features and the natural qualities of each stage of the river. See appendix for further details of each river stage. NTS. (Author, 2013)

Wetland Processes

After understanding the layers of the Liesbeek, a key issue that arises is the degradation of naturally-occurring wetland vegetation. Development along the Liesbeek River has resulted in building within and over floodplains and wetlands, which normally retain flood waters and therefore mitigate the effects of flooding. (Brown, et al. 2009) This damaged ecosystem is unable to cope with heavy rains, causing seasonal flooding when the river water overflows its canals. Further, canalisation prevents the regeneration of groundwater; which leads to stagnation, an infestation of nutrient-withdrawing alien plants, and inhibiting the potential habitats of indigenous small creatures and plants within the river system.

Wetlands act as natural engines by slowing down the flow of water in order to trap pollutants in vegetation and allow suspended solids to settle out (US EPA, 2004). Excess nutrients are taken up by plants and micro-organisms, as well as through sorption[1] by surrounding wetland soils and organic litter. Other pollutants are transformed into less soluble forms and taken up by plants and micro-organisms, which remove the polluting material from the water (US EPA, 2004). Wetlands provide rich habitats for fauna and flora species, especially in Cape Town where unique indigenous species of fish, frogs and plants occur. Due to the ability to retain water in permeable soils, wetlands act as sponges during the wet winters and prevent flooding from occurring.

Constructed wetlands are created artificially and can be used for the treatment of storm water and as part of waste water treatment systems. Constructed wetlands are made up of free water surface systems (FWS) with shallow depths, which slow the flow of water to allow for settlements and aeration in settlement basins and detention ponds (EPA, 1988).

1 A situation where both adsorption and absorption occur within the same process. See glossary.

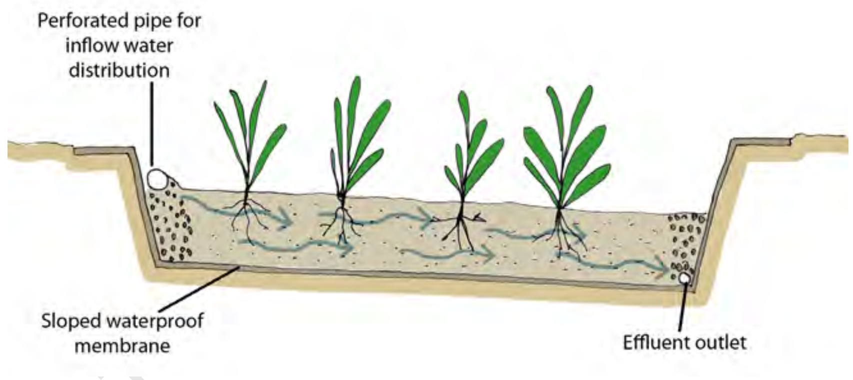


Figure 19: A sub-surface flow system. (Author, 2013. Adapted from PUB, 2009)

Sub-surface flow systems (SFS) involve the horizontal flow of water through sand or gravel, which acts as a filtration machine (Figure 19). These include bio-retention swales and basins, which contain bio- retention systems at their base. These elements allow for the retention of water for settlement, biological uptake and filtration of fine pollutant particles. Bio-retention elements can accommodate micro-organisms that degrade polluting matter in areas planted with wetlands plants on beds of nutrient poor substrates (Figure 20).

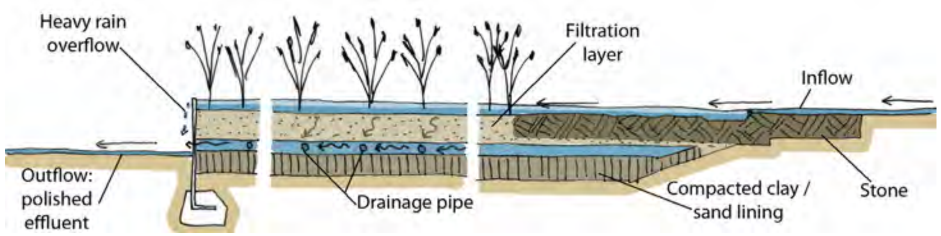


Figure 20: The bio – retention system. (Author, 2013. Adapted from PUB, 2009)

Aquatic plant systems are a series of ponds containing floating and submerged plants, which assist in the filtration and adsorption of excess nutrients. Pathogens carried within the water are subjected to predation by micro-organisms, absorption and a clean (and therefore unfavourable) environment. These shallow vegetated areas contain an inert zone (a sedimentation basin); macrophyte zone (heavily vegetated but shallow area) and high flow bypass channels to accommodate sudden increases in water volume (PUB, 2009).

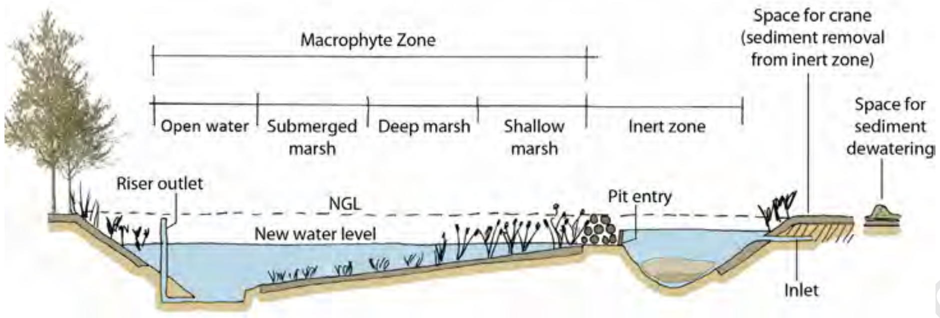


Figure 21: The layout of a constructed wetland, with the free water surface system located in the macrophyte zone. (Author, 2013. Adapted from PUB, 2009)

Sedimentation basins filter out coarse to medium- sized pollutants, by reducing water velocity in ponds that temporality retain water (Figure 22). Polluting material naturally floats or sinks within the water solution (Pescod, 1992).

Systems of biological water filtration unrelated to the wetland process itself include the vegetated swale, which filters coarse soil particles and slows down the surface water flow. Swales can be used for the conveyance of water across land as they protect downstream water treatment elements from erosion and allow for the settlement and retention of pollutants (PUB, 2009).

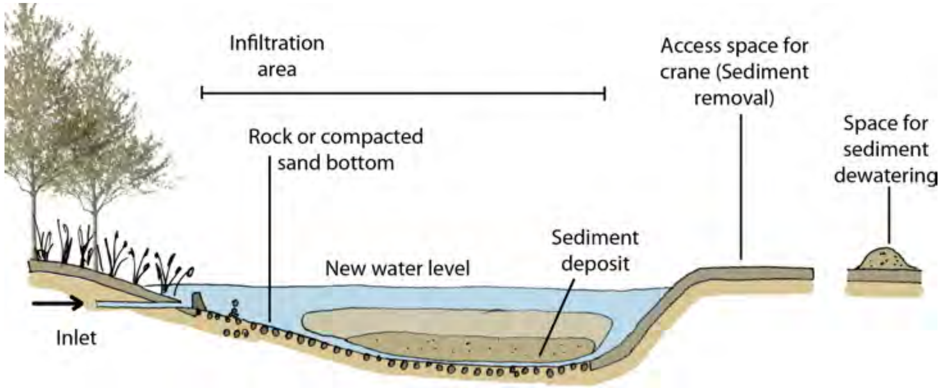


Figure 22: Components of a sedimentation basin. (Author, 2013. Adapted from PUB, 2009)

Bio-engineered canal walls involve "greening" concrete canal walls by inserting outlet pipes into the surrounding soil and adding gabion walls to accommodate wetland planting and organism habitats (Figure 23).

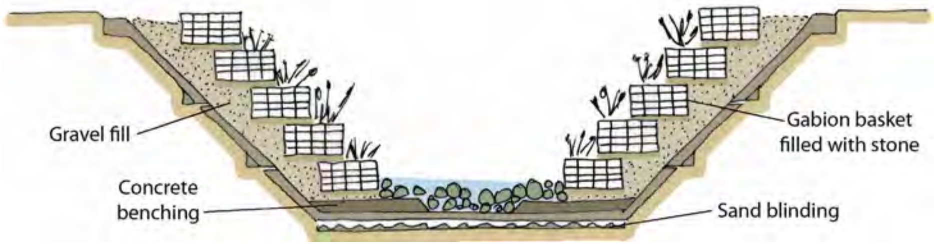


Figure 23: A retro-fitted bio-engineered wall uses gabion baskets to accommodate fauna and flora. (Author, 2013. Adapted from PUB, 2009)

Through understanding the layers of the site as well as wetland processes, it becomes clear that an ideal means of responding to the complexities of the Raapenberg site would be to restore natural wetlands on the land, thereby re-establishing the sites' role within greater ecological systems across the city.

3| The Productive Landscape

Historically, the Liesbeek River acted as a water resource for agricultural production. Value was given to the land through its productive potential and present urban development is a direct result of this agricultural heritage.

Agricultural production is directly linked to the availability of water, but Cape Town is expected to experience water stress brought about by unsustainable urban developmental practices (Pieterse, 2010). Natural water systems have become polluted and are hidden to accommodate for sprawling city development; there is a limited supply of potable water and food production cannot meet an ever-growing demand. (Pieterse et al, 2010) Contaminated storm water is discharged into river systems and combined with canalisation, produce flash floods during the rainy season (CoCT, 2002).

The conventional agricultural process makes use of 70% of available potable water in the Western Cape (Pieterse, 2010). Contaminates are introduced into the water, which is channelled into the sea. Sediment runoff occurs after heavy rains and an excess of soil particles produce turbulence in the water, inhibiting the functioning of organisms and natural filtration processes (Geyer et al, 2011). Nutrient runoff is by far the most damaging pollutant, as an excess of nitrogen and phosphorus in the water from manure and other fertilizers inhibit the growth of desirable fauna and flora, while allowing the rapid growth of alien plants such as the water hyacinth. There is clearly a need to review current water and food provision strategies for a sustainable future (CoCT, 2012).

Figure 24: The growing demand for land has pushed agriculture towards the outskirts of Cape Town. Transportation issues and excessive water use results in an unsustainable method of food production. (Author, 2013)

Pieterse (2010) suggests that a sustainable and holistic reconceptualisation of current practices, will help to counteract the existing poorly-designed infrastructural networks in Cape Town. The conditions of these sustainable living systems need to be cyclic, indicating a balance between resource extraction and waste generation within the spatial confines of the city. This creates a need for productive landscapes, where food and water can be generated with minimal effort and result in no wasted resources (7 Group and Reed, 2009).

In the context of the Raapenberg site, agriculture presents a unique opportunity to give value and identity to the site, by creating a productive landscape that facilitates public interaction while still achieving functional aims. River water is readily available, and the cultivation of wetland plants for site rehabilitation produces a by-product of filtered water.

Within the design, agricultural production is a small component of the greater site works. The objective is not to address food shortages in Cape Town, but to test alternative food production methods. Produce will be used for consumption on site, and excess stock may be sold to vendors, thereby generating income for the site.

Through reintroducing the lost component of agriculture, the inhabited site works becomes a constantly changing landscape based on the seasonal production of both agriculture and wetland plants. This natural landscape therefore acts as a marker of time, creating a dialogue with the histories of the site. The objective of the design is not to create a building in the conventional sense, but rather an architecture that can facilitate this productive landscape. By merging ideas of architecture and the machine, the relationship between technology, landscape and man can be amplified through layering the land.

Breaking the Boundary

The dualities of the “physical / scientific, emotional / cultural, collective / personal, static / dynamic” (Shannon, 2012:625) are all contained within natural environments that continually transform through the passage of time. By shifting to accommodate their broader social, economic, environmental, cultural and infrastructural systems; landscape can facilitate interaction with the natural environment while amplifying existing characteristics, as well as initiate a change from homogenous to heterogeneous urban environments. Shannon argues for a “precise openness” (2012: 629), where limits and boundaries are dissolved in order to emphasise the different layers of a site that supports both fixed and shifting activities within the urban landscape.

> Through the careful reading of layered contested territories, existing logics can be recognised at different scales and connected to new infrastructures. Specific logics from the junkyard of existing landscapes can be stressed and new interventions with structural capabilities could reformulate reality.
>
> (Shannon, 2012:637)

The landscape becomes a storybook where the surface literally unfolds as events through time, and is simultaneously responsive and dynamic. (Wall, 1999:232)

The Raapenberg site embodies the idea of the boundary: it is isolated yet connected to the urban fabric of Cape Town. It can accommodate the private and the collective entity due to dualities of the landscape. The site is both barren and fertile, and the prime location for wetland rehabilitation at a key point along the Liesbeek.

Although both the Black and Liesbeek Rivers border the site, an early decision was made to focus only on water from the Old Liesbeek. Several site generators prompted the decision: The water from the Old Liesbeek River comprises of storm water and runoff from the golf course, and so is not heavily polluted. The water flows past the bulk of the site, and its seasonal fluctuations are not as varied as that of the Black

River. The land on Black River boundary consists of wetland vegetation, and it seemed obvious to rehabilitate this edge fully so as to cope with a constantly changing water threshold.

The design does not aim to rehabilitate polluted river water in any way, including that of the heavily compromised Black River. Instead, the search is for the ways in which an otherwise wasted resource can be used to cultivate plants to regenerate a site, thereby passively helping to rehabilitate river water over a period of time.

The site makes allowances for constant changes in water levels and becomes part of a functioning ecological network through wetland rehabilitation. The unique geometry of the land presents exciting design opportunities, and the lack of prior activities on the site allows for a new version of tabula rasa to be created.

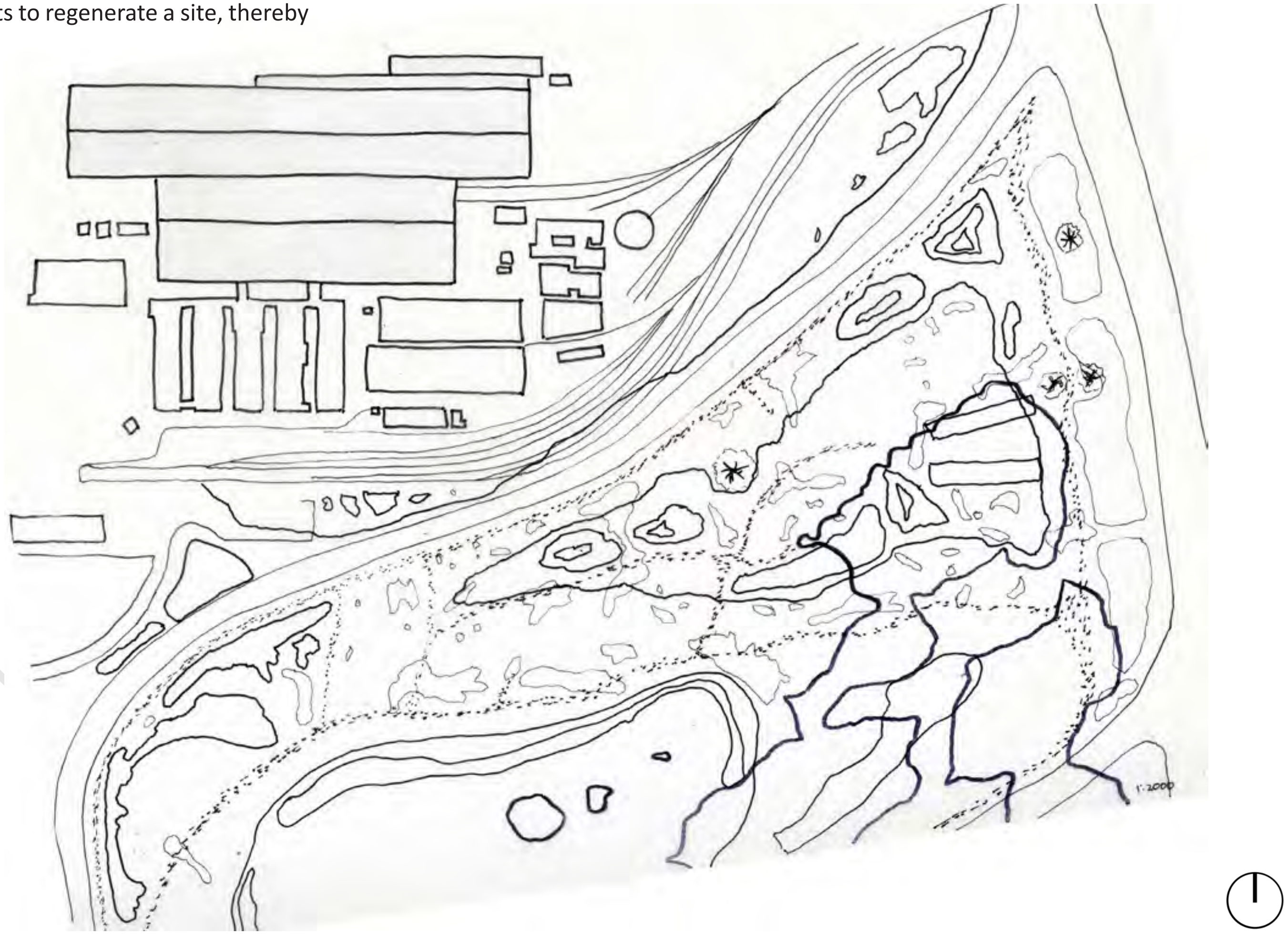


Figure 25: Several mappings were done both on and off - site in order to uncover layers of the landscape. These mappings were used as design cues for siting the soft machine within the landscape, which will be discussed later. The above drawing explores the topographical layers of the site within the factual limits of the land. Fixed contours were layered with the perceived contours of the site, building an idea of the undulating landscape. NTS. (Author, 2013)

Girot (1999) identifies four concepts within landscape design which deal with layering the site. Through *grounding*, the visible and invisible layers of a location become apparent and allow for an orientation within and a pull towards the site through an understanding of the multifaceted readings of different boundaries. *Landing* implies touching the ground plane, yet still reaching for that which is not known. The unknown can be interpreted as the different ephemeral layers of history, society and culture embedded within a site. These impermanent or permanent traces may be fleeting or be physically manifested, and are identified through *finding*. By bringing in new elements in *founding*, the legacy of a site can be extended to allow for a resilient and loose place that accommodates for change over time. These result in the restructuring of a site in terms of both its physical experience and the imaginative sense of place (Descombes, 1999:80). These concepts were used as a design tool and will be discussed in the design process.

However, as much as the research argues for a polyvalent site that is a result of complex permeable and adjustable boundary layers, the simple beauty of a landscape arises when the visitor is made aware of the quiet aesthetics of everyday life. (Regionalverband Ruhr, 2010:11) Weilacher (2010) explains:

> In terms of cultural responsibility, ...it is not a question of spectacular event landscapes, but of the ordinary cultural landscapes of the future, designed in terms of a beauty that has been created from the function and that accomplishes its own function through beauty.
>
> (Regionalverband Ruhr, 2010:11)

This dissertation therefore aims for a gentle, empathetic and poetic approach to landscapes embedded with multiple qualities. Through the understanding and engagement with the transient qualities and layers of a site, architecture can change the perceptions of a site that is largely ignored in public consciousness. The boundaries of the different layers should be stretched to allow for adaptability of a site in order to accommodate polyvalent functions over time, thereby adding value to the urban public landscape by giving a sense of place and identity.

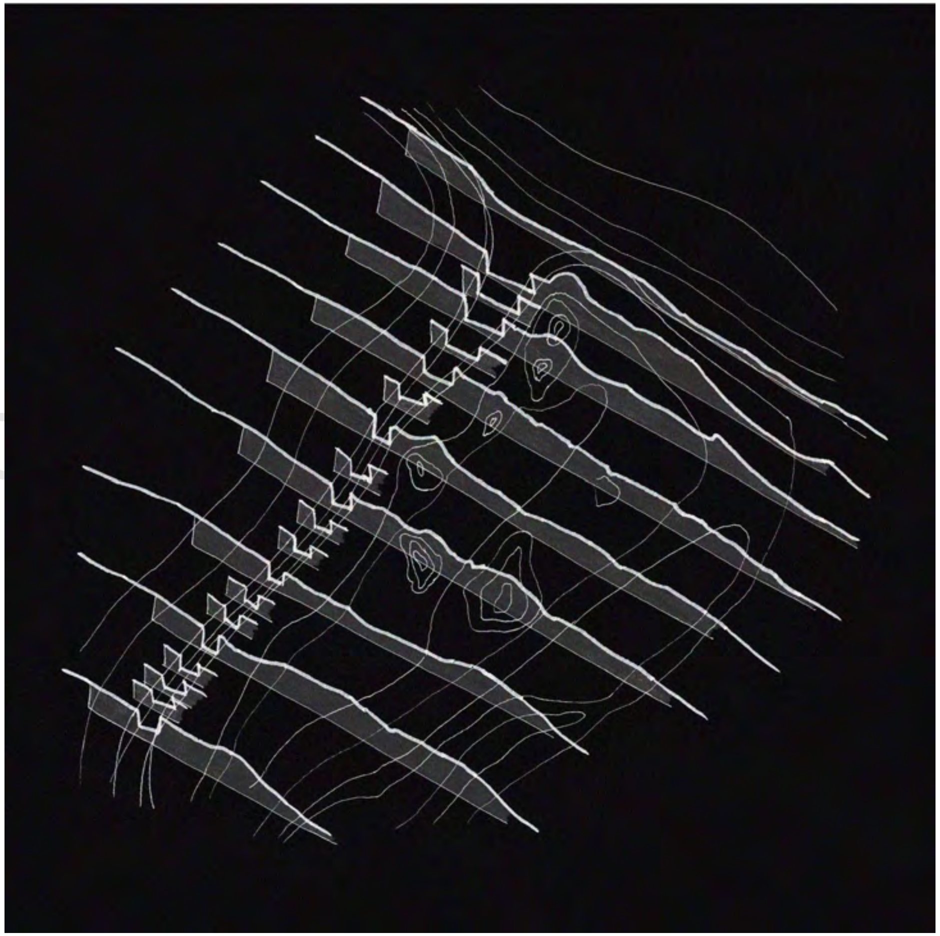


Figure 26: A sectional exploration of the site exaggerates existing site topographies in order to understand the landscape. The land undulates between 1 and 5 meters across the site. Dumped material on site radically alters the surface depth. (Author, 2013)

4| Introducing the Soft Machine

An early interest within this project was an inquiry into the relationship between architecture and the machine. In “Spirit of the Machine”, Kronenburg argues that like a machine, contemporary architecture is expected to be “flexible, responsive, sustainable; represent our relationship with the world and express our cultural ambitions” (2001:5). The idea of the machine can therefore be used as inspiration for the building - not in terms of creating a machine aesthetic, but rather a building that embodies the machine -like characteristics of adaptability, movement, process and systems.

The wetland can be viewed as a natural machine, where systems of activities are required for water filtration. This prompted the idea of the soft machine: a living machine that merges architecture and landscape as a single entity, which embodies nested systems of process for the filtration of water for agricultural production. The challenge is to create an architecture of inhabited site works that functions as a machine within the productive landscape, yet does not have machine-like aesthetic qualities.

There exists an inherent contradiction between ideas of the ‘machine’ and the ‘soft landscape’. The intention here is to augment the traditional perception of a machine as an object in space to that of the very process embodied within the productive landscape. As a result, the architecture-as-the-machine becomes the essence of the mystery, complexity and rhythm of the site.

However, there needs to be a balance between the purely scientific functions of the building and its social responsibility towards its context. The soft machine therefore needs to facilitate a diverse community and deal with public interaction as a collective entity. It allows for the layering of various systems of activities across the site through integrating social and ecological processes. The landscape must reference the urban whole, but its limits must be undefined, oscillating and multiple. As future pressures on the site can only be predicted but are not a certainty, the building needs to be able to function both with and without public participation to accommodate for change over time. Like the machine that is always in a state of change according to its’ surroundings, the building becomes a constant element within the continually fluctuating landscape, creating resilience. Through activation by public participation and purpose, the soft machine becomes the identity of the site.

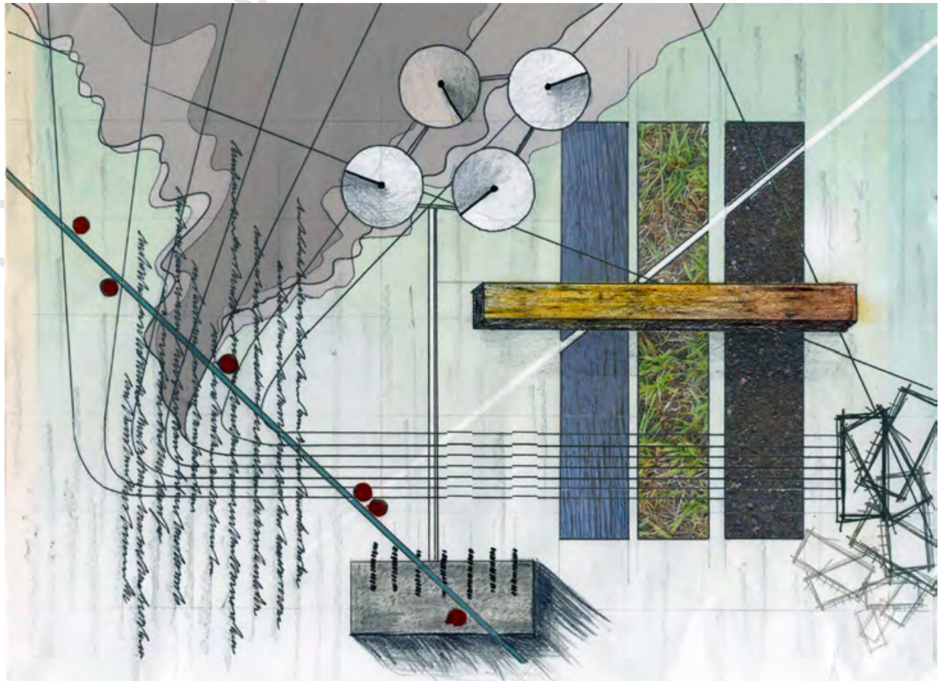


Figure 27: An interpretation of the soft machine, containing the various biological filtration processes. (Author, 2013)

Hydroponics

As noted previously, hydroponics has been selected as the medium for agricultural production on site and was investigated as part of the technical research earlier in the year. This method of growing plants without soil using mineral nutrient water solutions is a more technologically advanced one compared to conventional production, and extends the dissertation interest of mechanical processes. Additionally, conventional crop production would not be viable on the site due to the soil quality, which consists of saturated Cape Flats sand and building rubble. While the soil conditions are not toxic and are conducive for the cultivation of wetland plants, it is not suitable for produce to be consumed. The project specifically aims for a low maintenance system, and conventional production requires large amounts of labour for maintenance, irrigation and harvesting of crops.

Hydroponically-grown agricultural yields are higher, of a better quality and more stable than that of traditional processes, as produce can be grown year-round (Roberto, 1994). The harvesting process is simple as there is easy access to the plants within a confined area. Plants have access to exactly the amount of water and nutrients that they require, while roots have continuous access to oxygen as needed (Jenson, 1997). Unsuitable land can be used for production, and water feeds can be mechanised and regulated.

Disadvantages include the initial cost of construction of hydroponic cells, which is mitigated by the long-term low running costs of the system. Some technical knowledge is required to monitor the water and nutrient feed systems, but this is to be controlled by scientists on site in the soft machine.

Different types of hydroponics were evaluated for use within the project, as the programme of the building involves research into production methods. In solution culture, plants are grown without any substrate and only the roots are exposed to the nutrient solution. Solution culture is the standard method of growing plants for research and teaching. Continuous flow solution culture produces high quality large yields. The nutrient solution flows constantly past plant roots while still allowing for sufficient aeration. In the soft machine, this system is designed as removable trays containing the different plants (Figure 28).

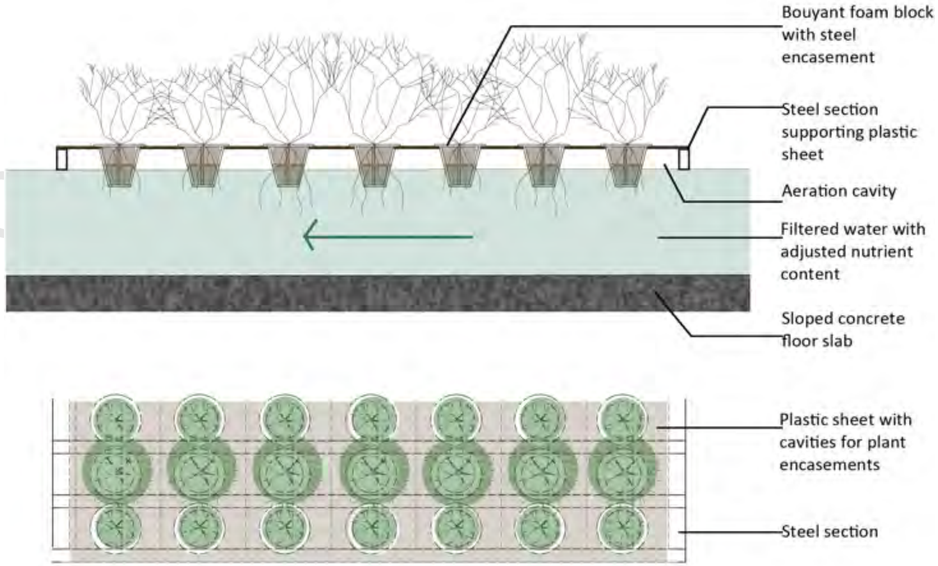


Figure 28: Design for a continuous flow solution culture system for use in the soft machine. (Author, 2013)

Medium culture requires an inert substrate structure for the roots of the plants to grow on, and is named after the particular substrate used (Roberto, 1994). Passive sub irrigation involves the transfer of the nutrient solution (housed in a separate tank) to the plant by the particular substrate through capillary action (Figure 29). Substrates prevent root rot caused by moist conditions, and include grow stones, coir, rice hulls, expanded clay aggregate, pumice, vermiculite, gravel, sand, brick shards, sheep wool, wood fibre and polystyrene packing peanuts.

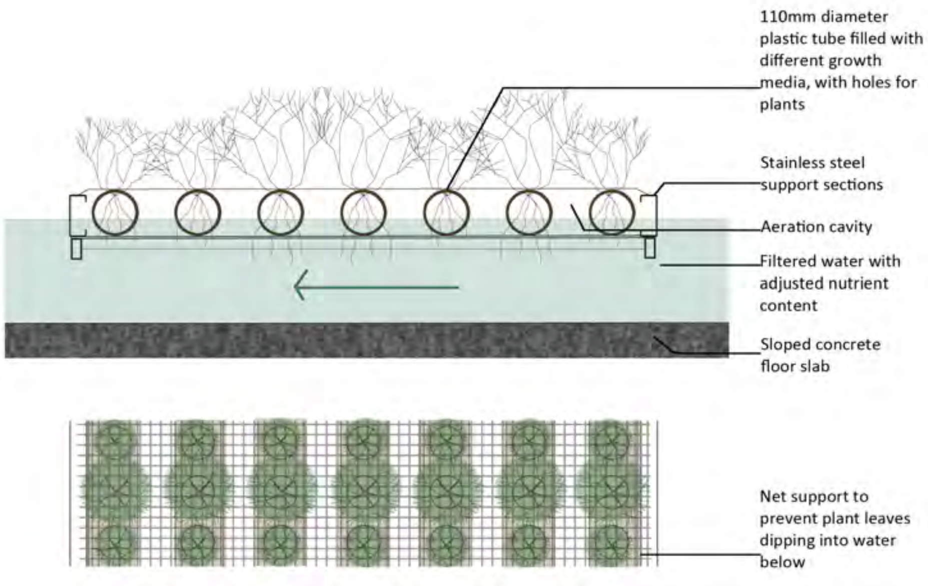


Figure 29: A possible design for a medium culture system for use in the soft machine.(Author, 2013)

A variety of vegetables were selected for production based on their nutritional content, ease of production and resilience. The table below shows the different characteristics of the selected produce. The yield factor refers to the amount of vegetables that can be harvested relative to conventional farming. The nutrient values are measured in milligrams.

	Beans / sprouts	Beetroot	Lettuce	Peas	Pepper	Radish	Tomato
Crops per year	26	6	8	6	5	12	4
Yield factor	2-3	3-6	4-8	2-3	2-5	2-3	2-4
Protein	7	7	2	7	3	0	2
Carbohydrates	13	16	5	16	12	13	9
Sodium	13	111	21		9	6	50
Potassium	338	708	359	544	441	529	470
Calcium	31	25	43	95	12	50	17
Iron	2.0	1.4	1.1	4.5	2.8	1.3	1.1

(Author 2013, Adapted from Willis 2013)

5| Generating Programme: The Soft Machine

The programme for the dissertation was generated early on, weaving the various interests within the initial inquiry to create a complex network of activities on site. The driving force behind this was the creation of the soft machine of the productive landscape, and the development of an architecture of inhabited site works that can achieve this. The brief calls for landscape and architecture to be merged as a large-scale living machine, that can treat contaminated river water for use in crop production (Figure 30).

The programme that resulted from the initial explorations comprises of

1) A wetland nursery and hydroponic growing beds:

Endangered wetland plants are to be cultivated in the nursery for on-site rehabilitation. These plants serve as an educational tool for the public, as well as a field for scientific exploration. Excess plants can be used for the rehabilitation of other wetlands in Cape Town. Hydroponic cells are used for the cultivation of vegetables for scientific testing and for consumption on and off- site. Possible plants for wetland cultivation are listed in the appendix.

2) Hydro-agricultural testing laboratory:

This includes the associated facilities consisting of a reception, workstations, ablutions, kitchenette and meeting rooms that can be hired for public use.

3) Transitional public spaces:

These consist of a café and public change rooms, a promenade, wetland park and public pool. This boundary allows for the scientific and public realms to merge on site. By doing so, the purely functional soft machine gains another social dimension, creating a fully productive landscape.

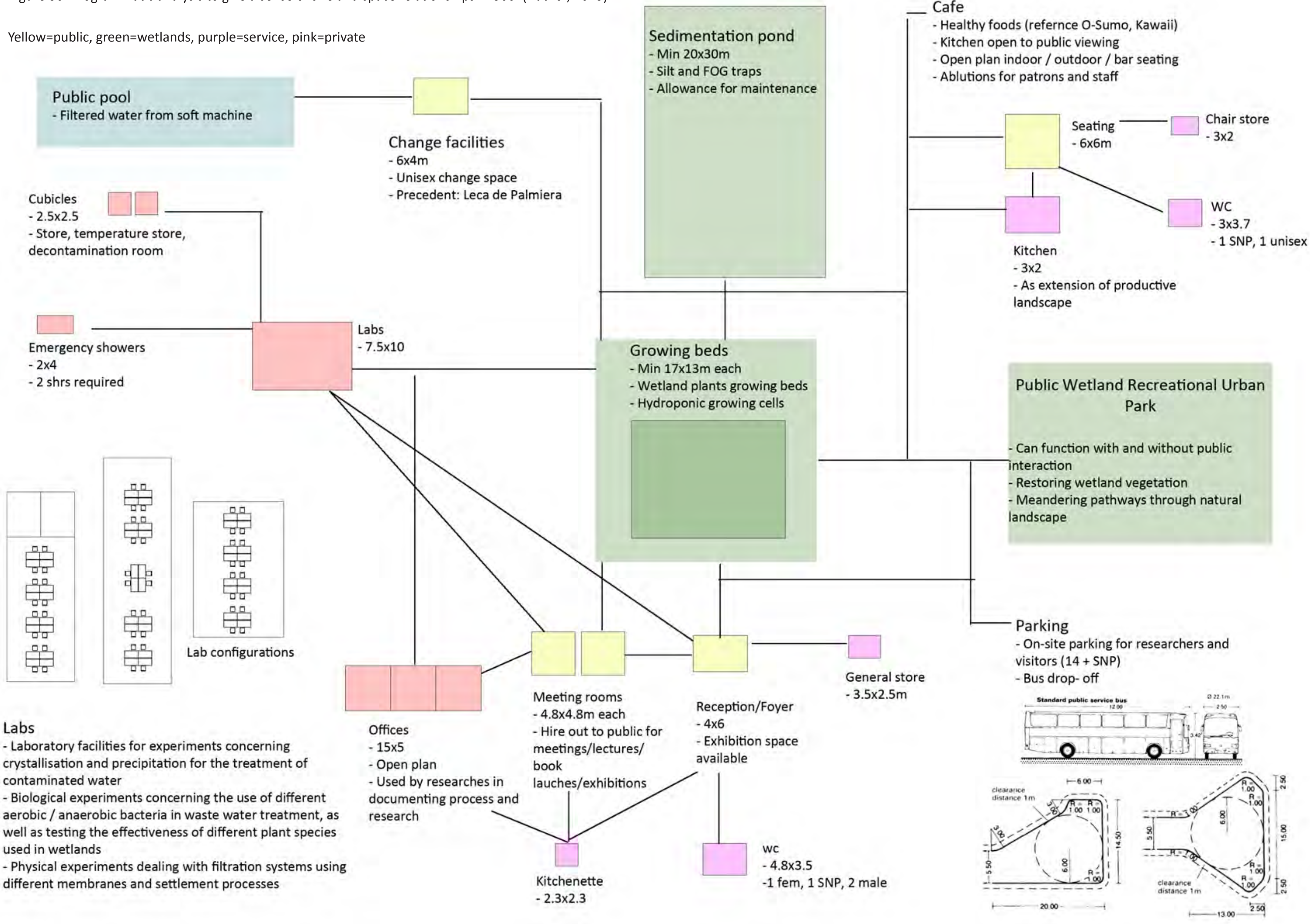
4) Event stations which mark moments along the system, which animate and create events out of the process of water filtration.

These aim to be points for interest for the public and facilitate involvement with the water filtration process. Scientists going about their work become performers in the landscape, and the public is able to move through the rowing beds in a journey of quiet reflection, education and discovery.

Through an analysis of programme and understanding of the processes that will be required on site, a formal system can be established for the site works (Figure 31). Water will need to be pumped onto the site for storage in a sedimentation pond, before being channelled to wetland cells for filtration. The filtered water is used for hydroponic agricultural production before entering the public pool. Considerations include solar energy panels, and a dry sanitation system for the ablutions on site.

Figure 30: Programmatic analysis to give a sense of size and space relationships. 1:500. (Author, 2013)

Yellow=public, green=wetlands, purple=service, pink=private



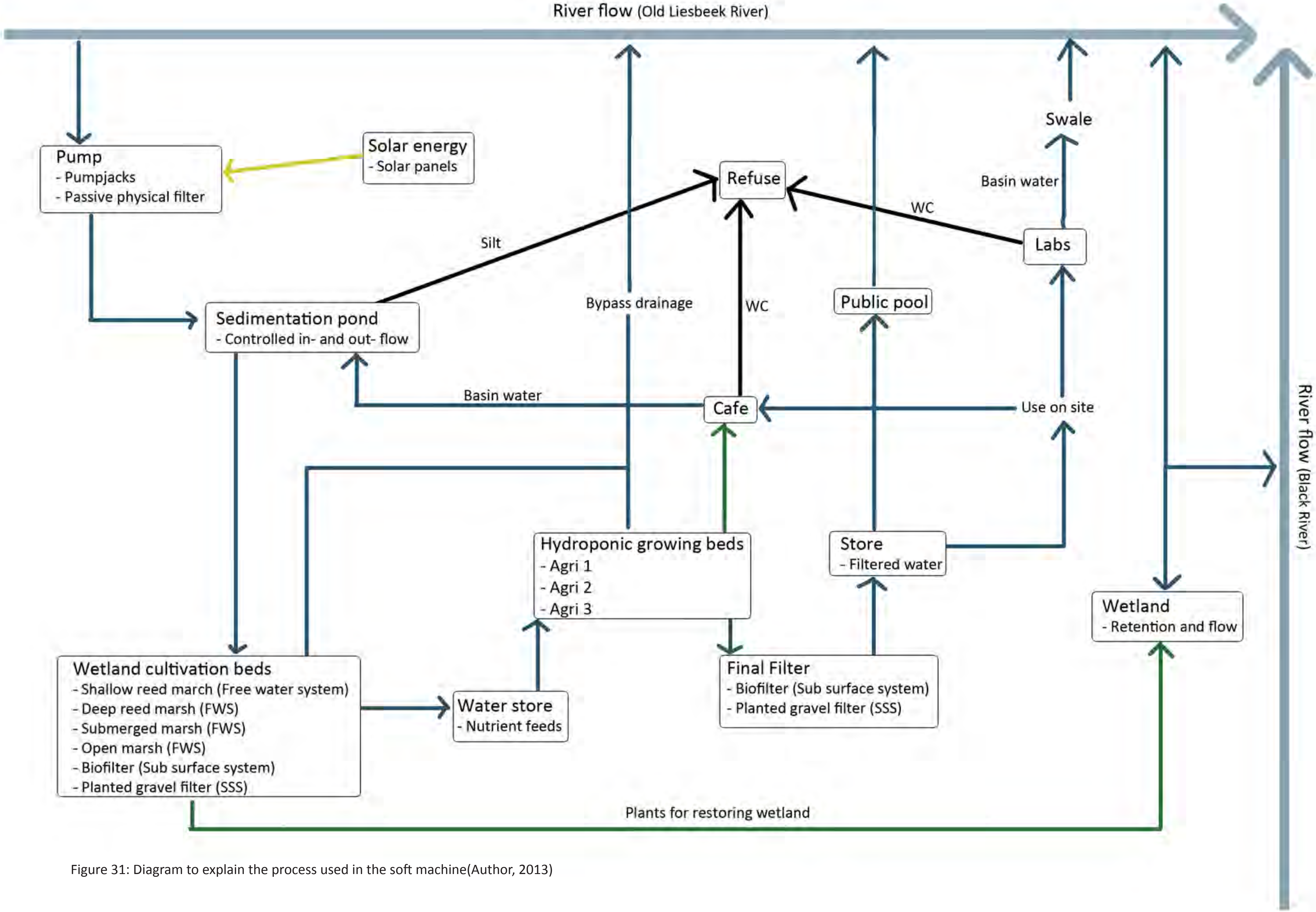


Figure 31: Diagram to explain the process used in the soft machine(Author, 2013)

6| Design Process

Urban proposal

Three different scales were focused on during the design process. The urban scale was informed by the initial investigation of the river as a whole. Although the Liesbeek River is the cleanest river in Cape Town, it still contains pollutants from surface run-off and storm water outlets. Along with the development of the Raapenberg site, a number of urban interventions are proposed as a system for river rehabilitation and public interaction. These will allow for the passive rehabilitation of the whole river, as well as augment existing boundaries to facilitate the interaction between the public and nature (Figure 32).

Locality Proposal

The locality scale was informed by the proposed development plans of TRUP. The site is designed to accommodate the 1 in 5, 10 and 50 year floodplains, with the building preventing water penetration where required. Its boundaries become dynamic, with folding surfaces and fixed and shifting activities. A dialogue with nature is created, dealing with the questions of when the site is truly an island and when it becomes connected to the city fabric. The Transnet Railway Park, as the most prominent link to the site, is designed to accommodate different future plans. Currently, the city is engaged with plans for the mass upgrade of the workshop plant, resulting in a large occupancy level. An alternate plan proposes a large scale mixed-use precinct, including light industrial, residential and office development. Both scenarios are accommodated for and were developed along with the site itself. The summary of the proposed programme is shown in Figures 33-35.

Figure 32: (Following page) The urban proposal envisions the future rehabilitation of key sites along the Liesbeek. (Author, 2013)

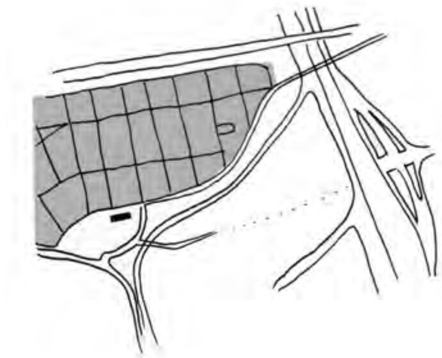


Figure 33: The design needs to accommodate for the Transnet Railway Workshop land as is, or developed as a mixed- use precinct.

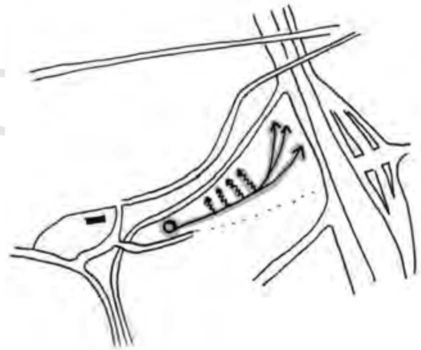
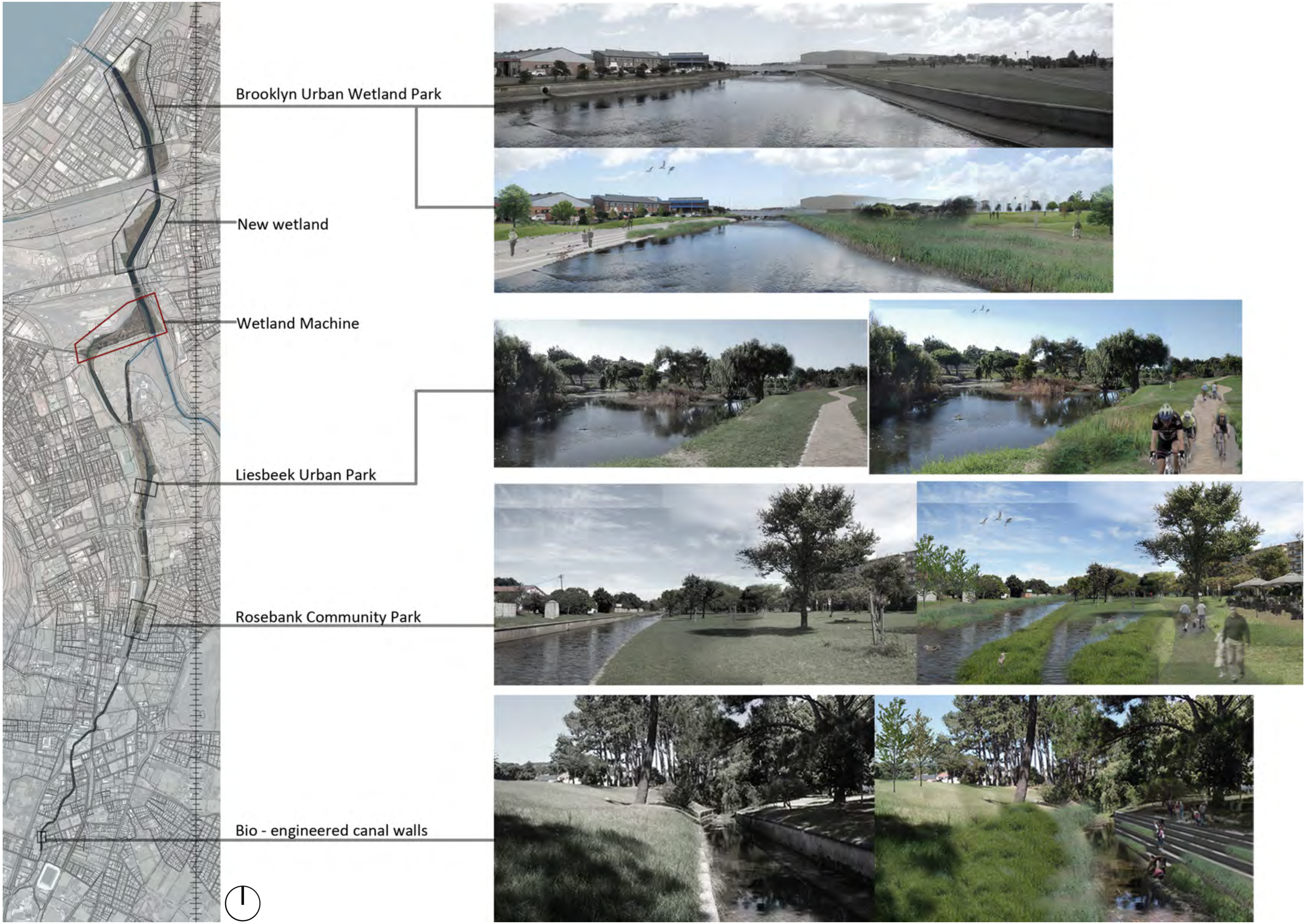


Figure 34: Water filtration occurs across the site.

Figure 35: The site becomes a new place of recreation, linking to the surrounding sporting activities.


Brooklyn Urban Wetland Park
New wetland
Wetland Machine
Liesbeek Urban Park
Rosebank Community Park
Bio - engineered canal walls

Mapping the Site

Key aspects of the site needed to be taken into consideration for the design of the project (Figures 36-41). Particularly important was the understanding of site sections, which would be used for designing the permeable and fixed edges of the soft machine. (Figure 42)

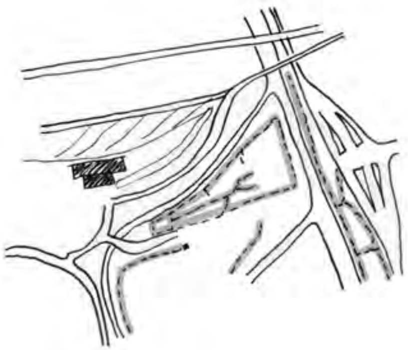


Figure 36: Movement routes on site. Definite pathways have been etched into the land by construction vehicles driving on the site.

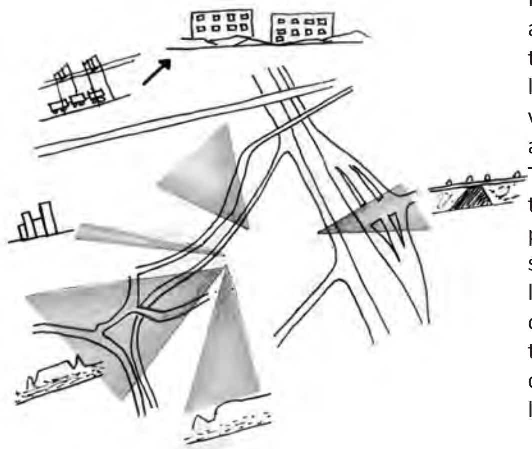


Figure 37: Sight lines. The site effectively acts as an island with distant visual links to the city, despite its proximity and central location. Atmospheres on site leave the visitor feeling relaxed and at peace within a quiet and oasis-like detached landscape. The design aims to capture this feeling through the creation of meandering pathways across the natural wetland on site, celebrating the quiet beauty of the land. These qualities present an ideal opportunity for a space of regeneration that is activated through public use, yet can still function independently of this layer.

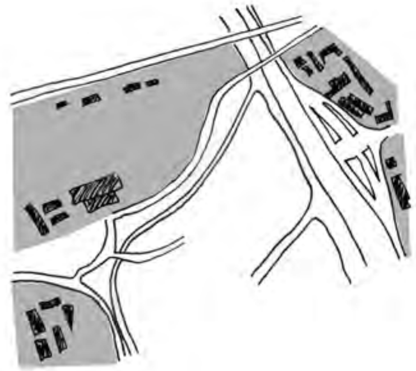


Figure 38: Places of business within the precinct. The site can provide green relief for workers in the surrounding areas, particularly for those on the Transnet land. The expected increase of workers within the Railway Workshops would create a need for recreational space. The proposed mixed-use development of the site would also require a public park.

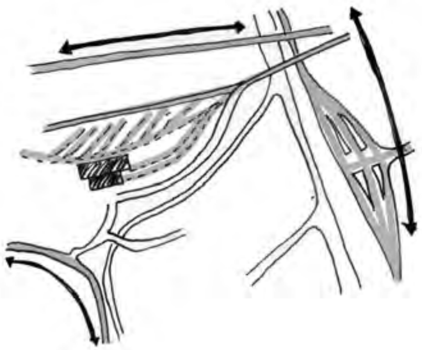


Figure 39: Transport infrastructure. This is comprised of the busy Black River and Liesbeek Parkways, as well as the rail network at the top of the precinct. Public transport to the site should be facilitated, but must not have a large impact of the land.

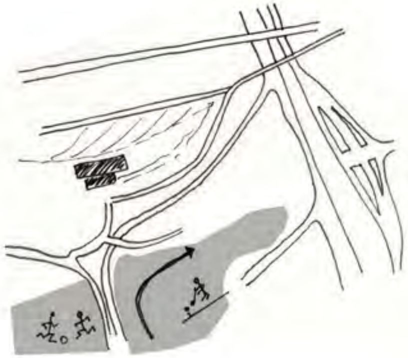


Figure 40: Recreation. The site is an ideal location for a recreational area, with a catchment of the surrounding suburbs of Observatory, Mowbray and Salt River. This allows for a continuation of the network of recreation, containing the Malta and Hartleyvale sports precincts and the commercialised River Club Golf Estate

(All by author, 2013)

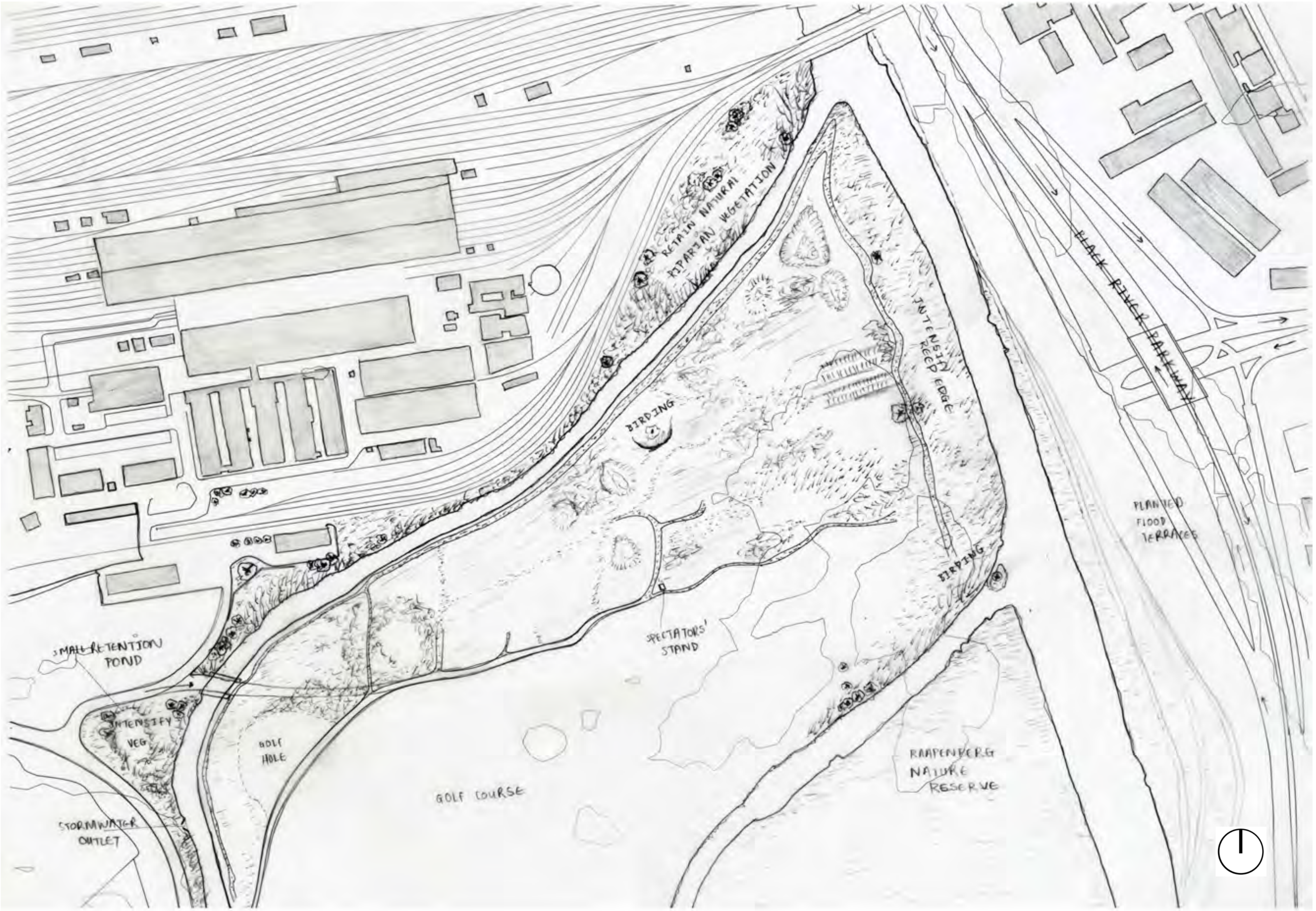
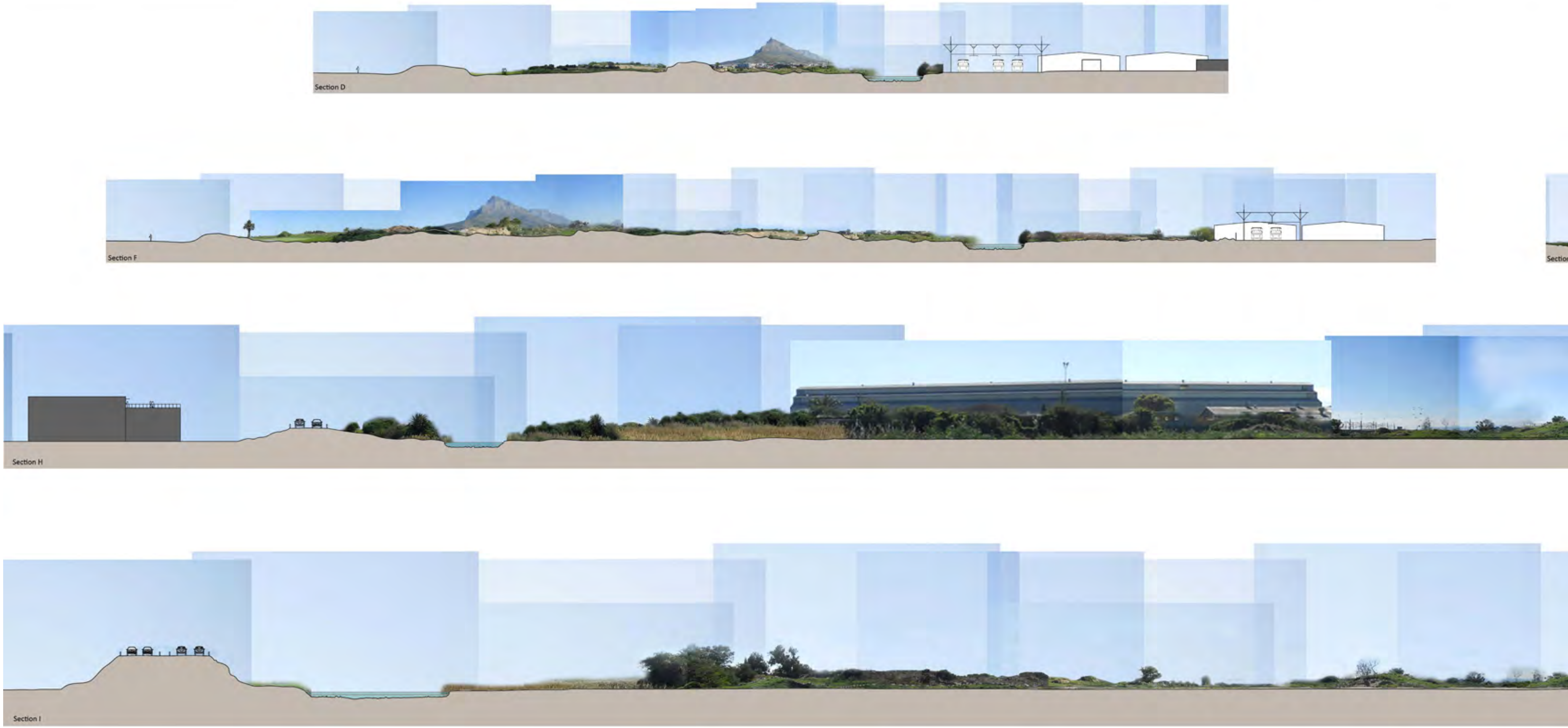


Figure 41: Existing site conditions, focusing on natural vegetation. It was decided to retain the existing vegetation as far as possible, building on the wetland edges of the site. (Author, 2013)

Figure 42: Site panoramas and sections. The large site has height fluctuations of between 1 and 5 meters. (Author, 2013)



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Shaping the Site

The sketch design considered contextual analysis and theoretical underpinnings of the project. Initial intuitive attempts to draw process directly out of the land were explored on site and developed into the site diagram (Figure 43).

After initial struggles in dealing with a large site, a design strategy was adopted to guide the development of the site works. Existing movement patterns and contours were abstracted in an attempt to rationalise the site (Figure 44). This allowed for the physical traces of the site to guide the design, augmented by the programmatic requirements.

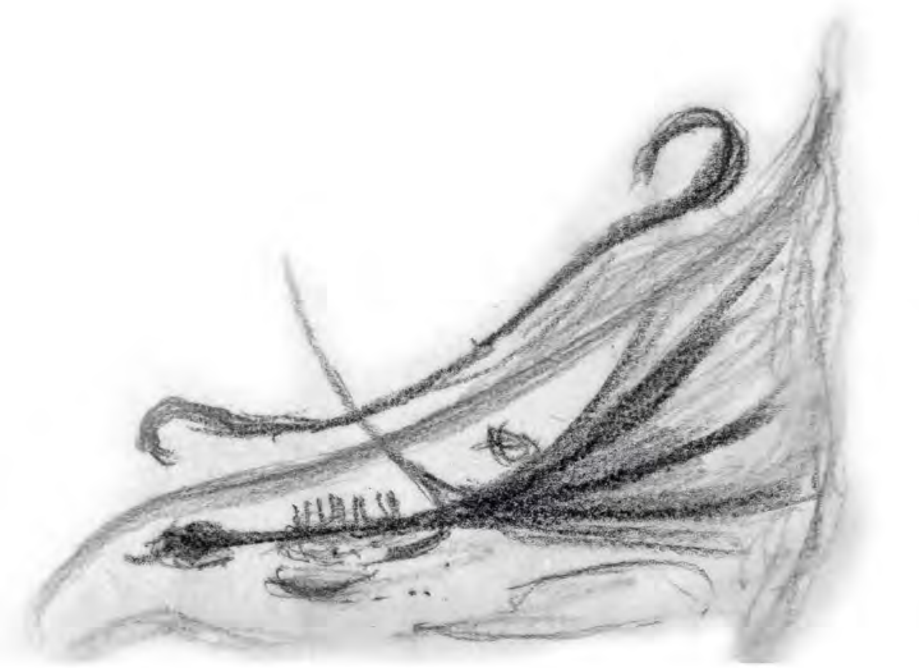


Figure 43: Unearthing process on site. This activity was conducted after understanding the processes that would be required, while still taking into account the physical and ephemeral cues presented by the site itself. (Author, 2013)

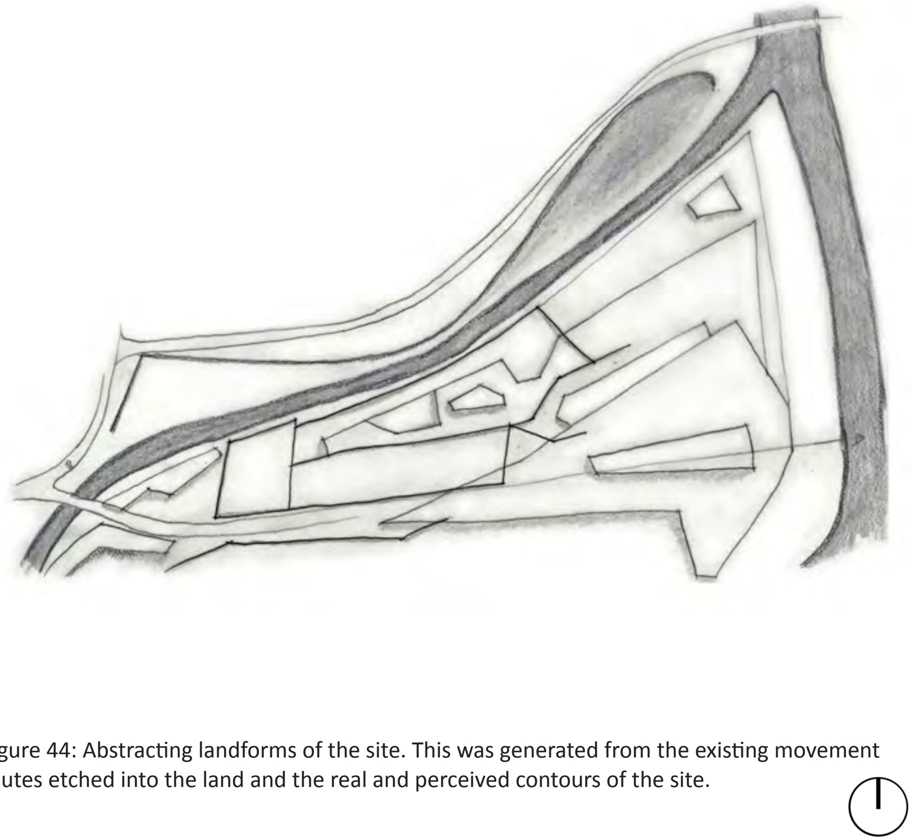


Figure 44: Abstracting landforms of the site. This was generated from the existing movement routes etched into the land and the real and perceived contours of the site.

The first design exploration was an intuitive but analytical response as to how the filtration process could work on site. (Figure 45) It would involve pumping water onto site using sluice gates to control storm surges in the river. Wetland and agriculture cells were integrated across the site, with natural wetlands on the edges. An early decision was made not to create a transport route across the site linking with Black River Parkway, as this would cause stress to the existing bird habitats and create heavy traffic, contradicting the site characteristics of peaceful and reflective connections within the urban fabric.

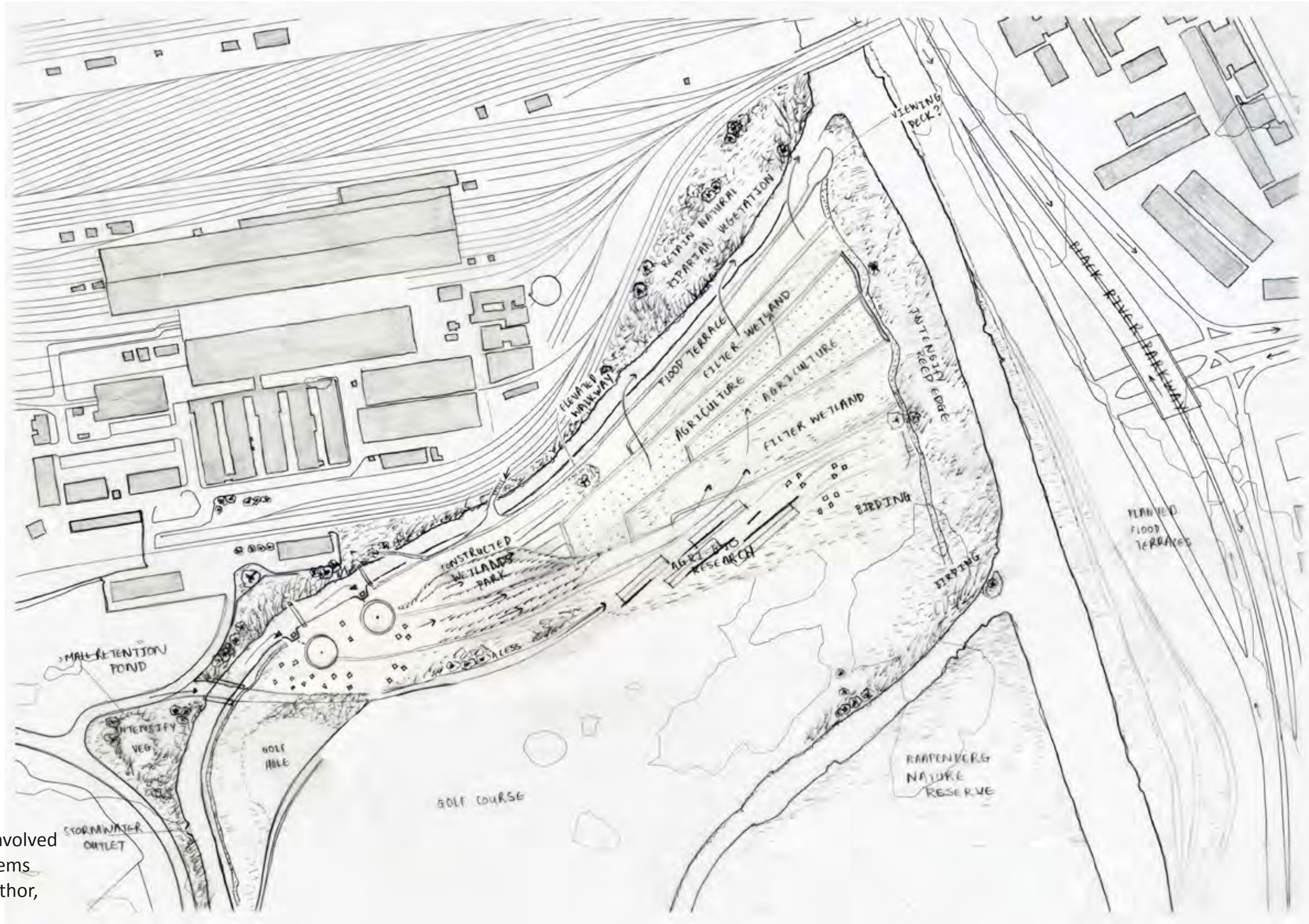


Figure 45: The initial response to the site involved purely functional systems spanning the site. (Author, 2013)

Sketch Design

The sketch design proposed an urban park along the future mixed - use development at the Transnet Rail Park, which is linked to the site with a pedestrian bridge. A greater emphasis was placed on the hydroponic growing beds, which are located in an existing clearing, while meandering paths facilitate movement across the natural wetland. Important aspects of the design included acknowledging the river's farming heritage, interpreted through the soft machine. Movement through the site allows for the connection to the earth at the most basic level, yet provides space for inflection and collective participation at points on site. The soft machine was designed as layers of programme, overlaid within the landscape to create nested systems. (Figures 47, 48) Throughout the design process, the proposal was tested using both drawings and models.

As the initial design was quite static, further explorations dealt with changing the geometries of the beds and locating the research station on the site (Figure 49). A continual struggle at this stage was dealing with a large site, while still trying to achieve a complex programme.

Weiss/Manfredi's Olympic Sculpture Park (2001-2007) makes use of layered systems in order to achieve a complex programme spanning a large site (Figure 46). The simple concept, that of a single line folded on itself, guided process thinking within the soft machine. The built works acts as both the plan and diagram of function on site.

Although the support facilities are important components of the productive landscape, the focus of the dissertation is on the development of an architecture of large-scale site works. The buildings on site therefore form part of the background of the soft machine (Figure 50).

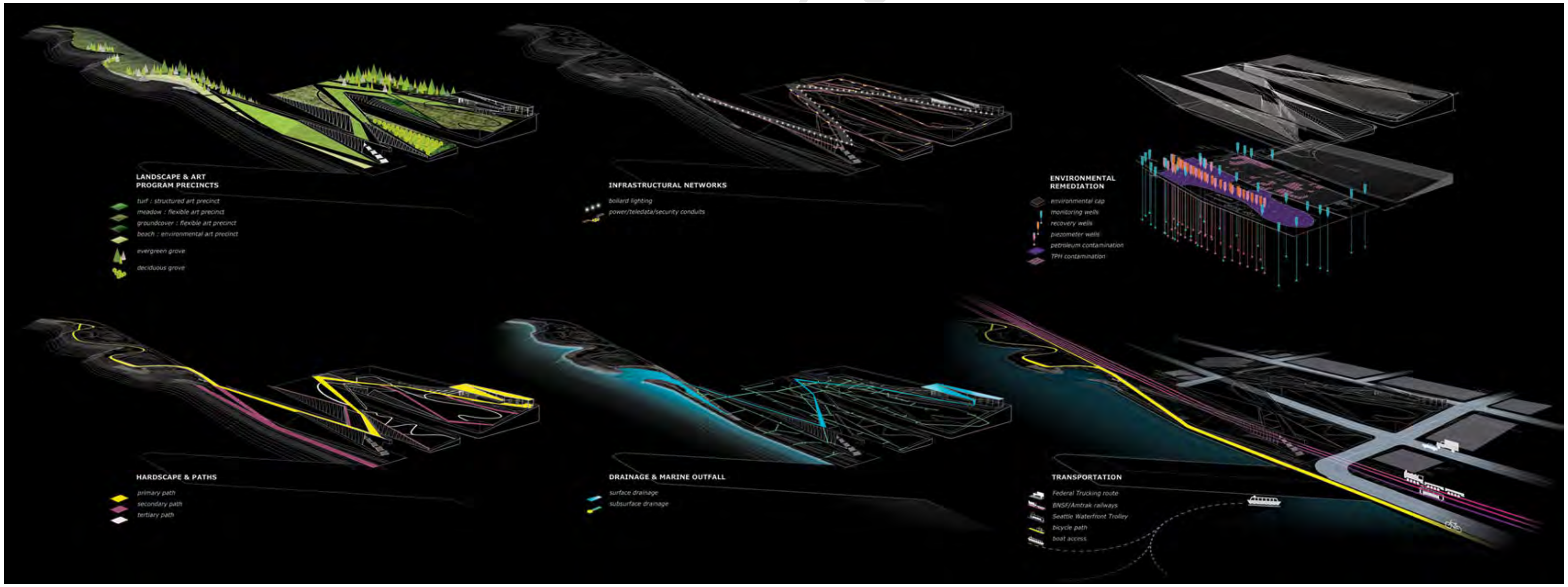


Figure 46: Layered systems form the Olympic Sculpture Park in Seattle, by Weiss/Manfredi. (Manfredi et al, 2008)

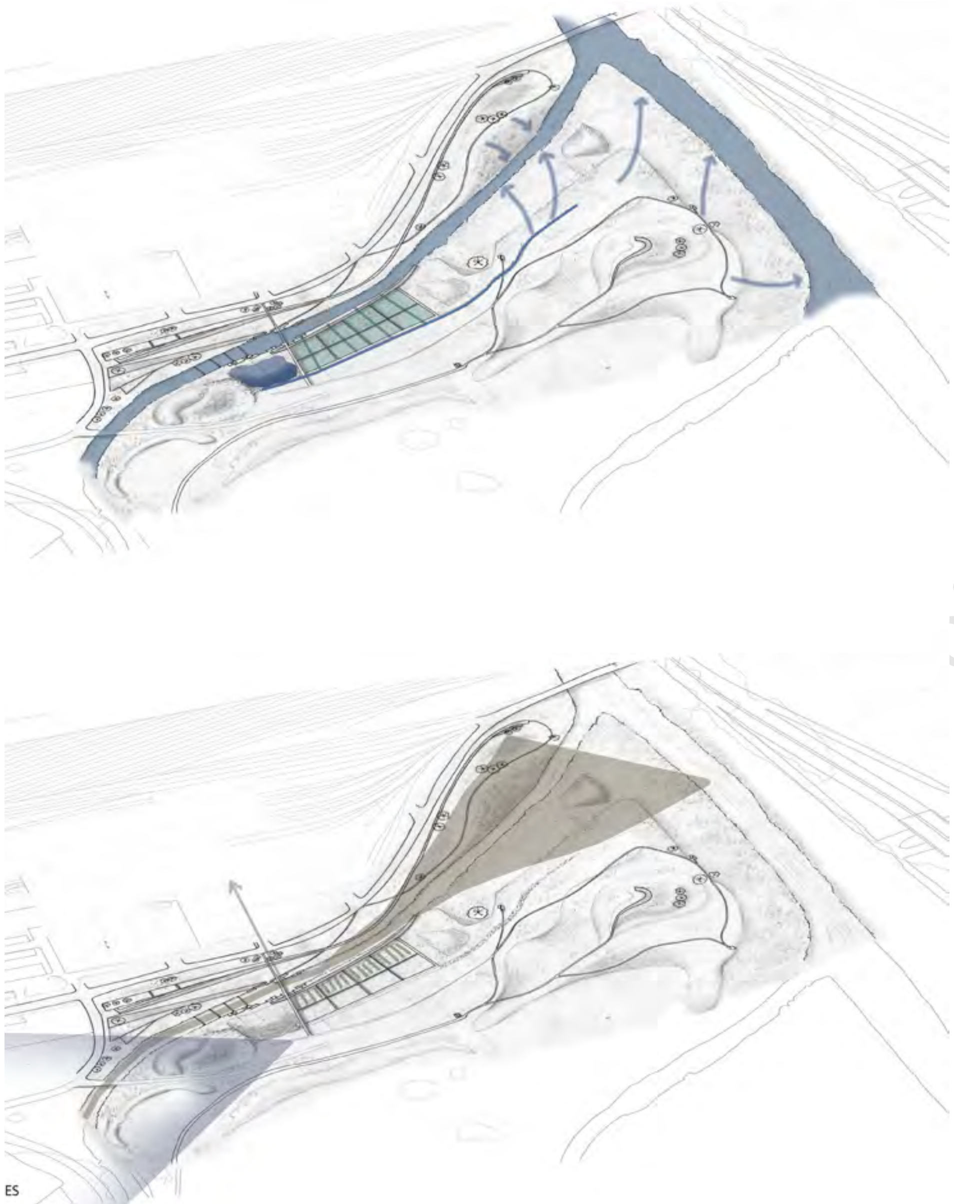


Figure 47: Site layers of water (top) and the boundary zone (bottom) (Author, 2013)

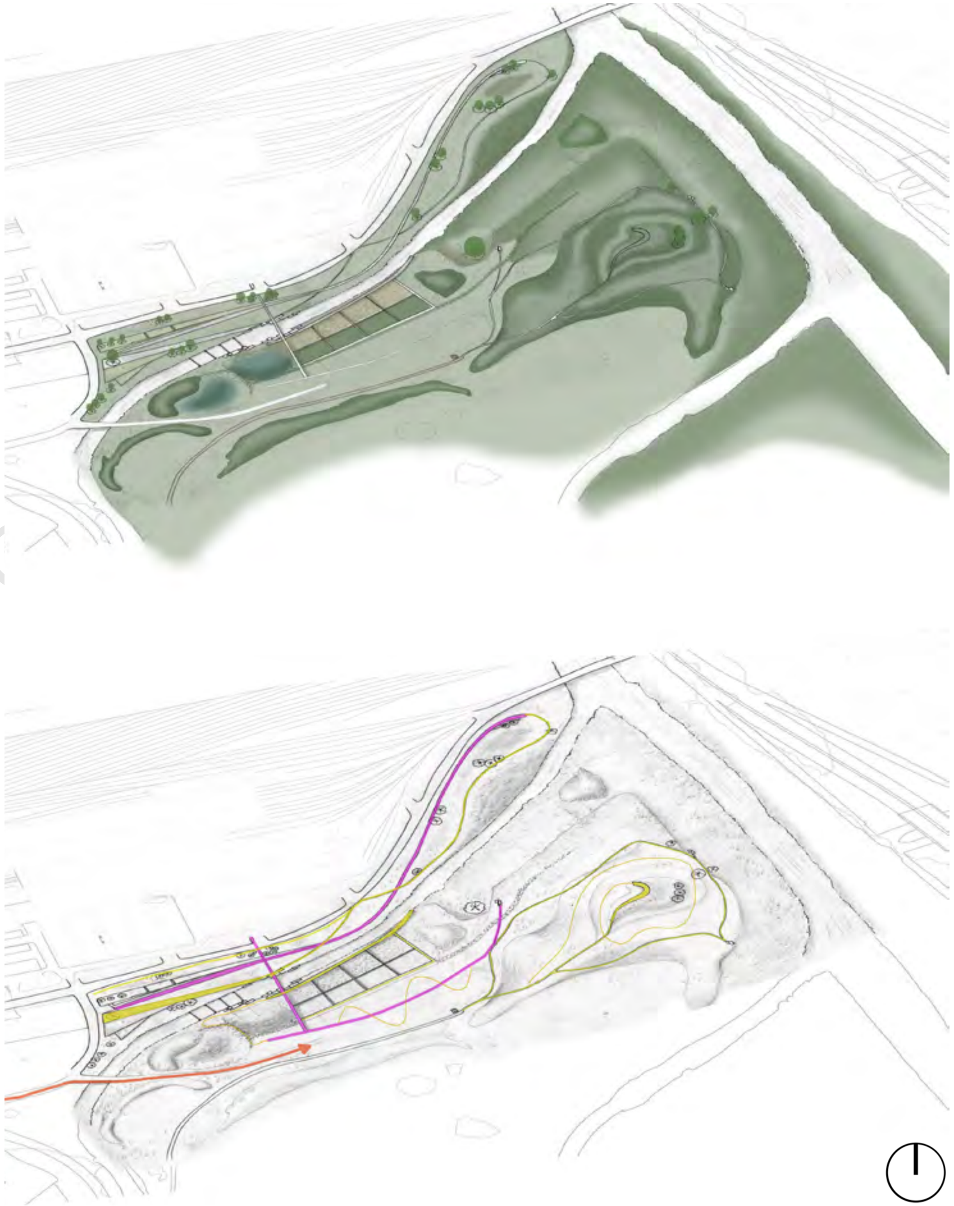


Figure 48: Site layers of landscape (top) and movement (bottom) (Author, 2013)

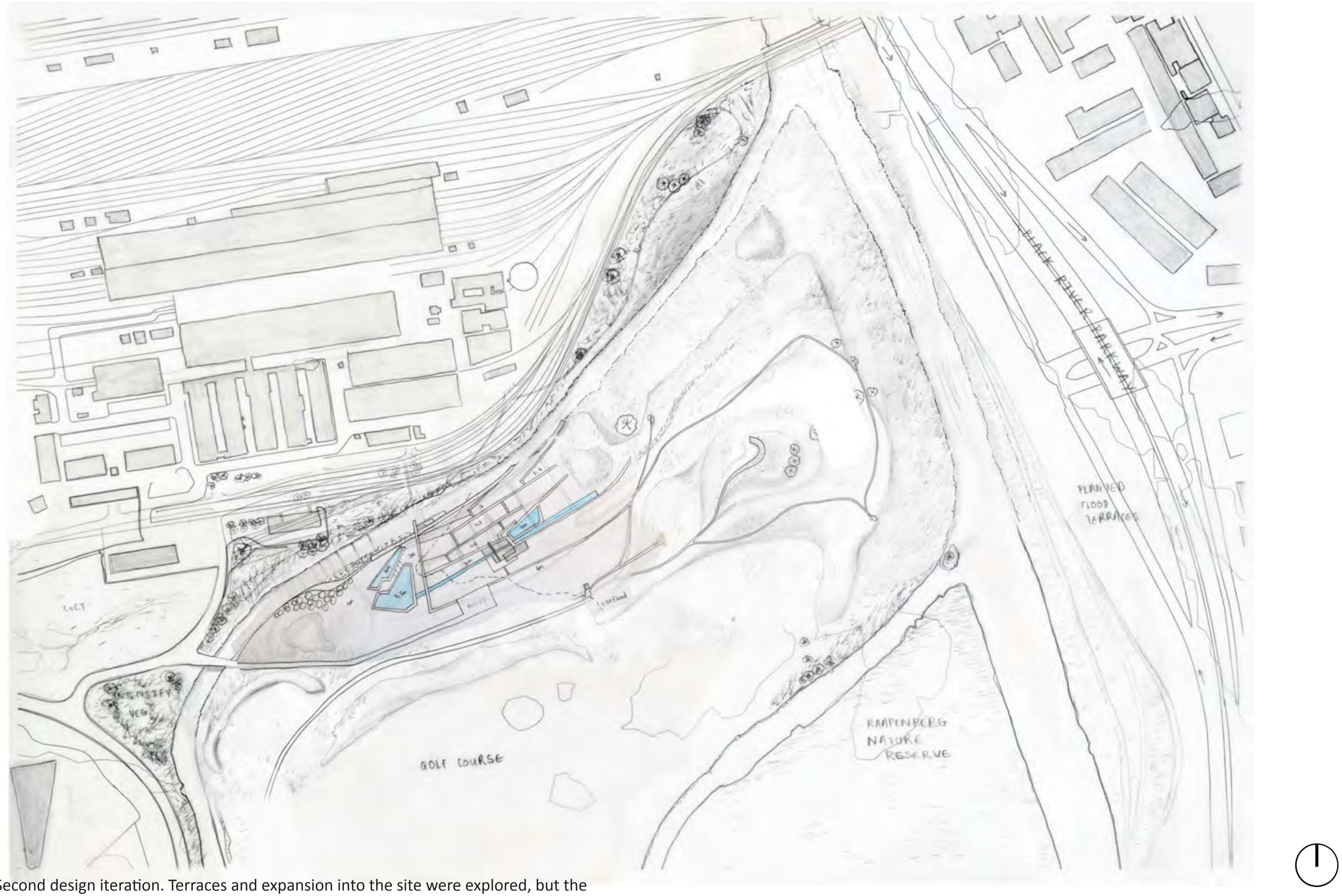


Figure 49: Second design iteration. Terraces and expansion into the site were explored, but the geometries created were generated randomly. (Author, 2013)

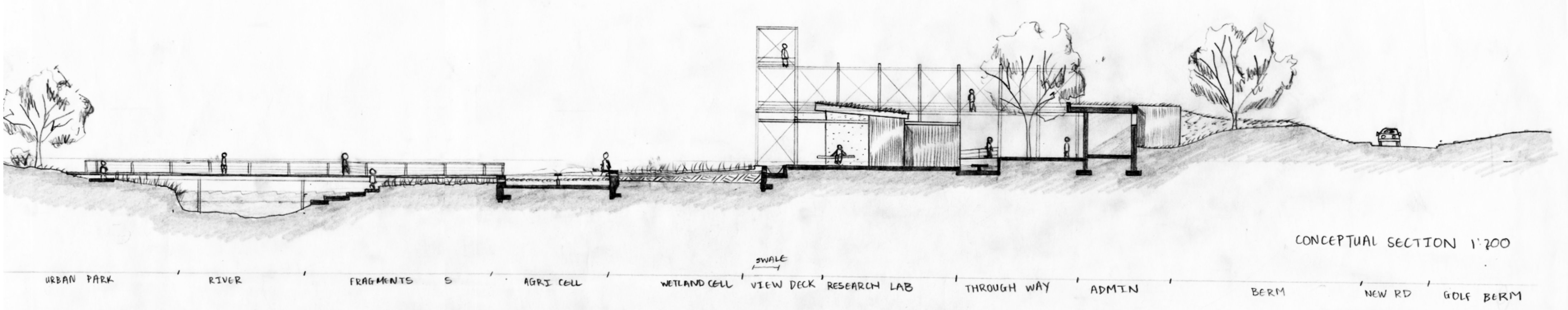


Figure 50: Conceptual work building site sections.
NTS (Author, 2013)

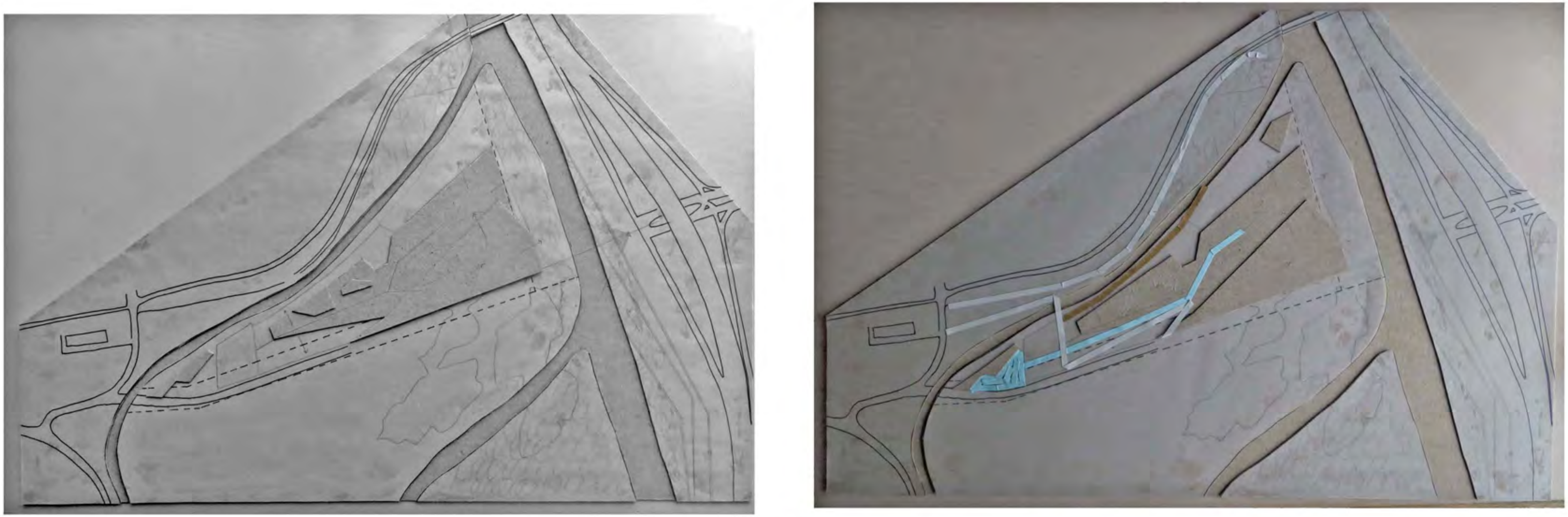
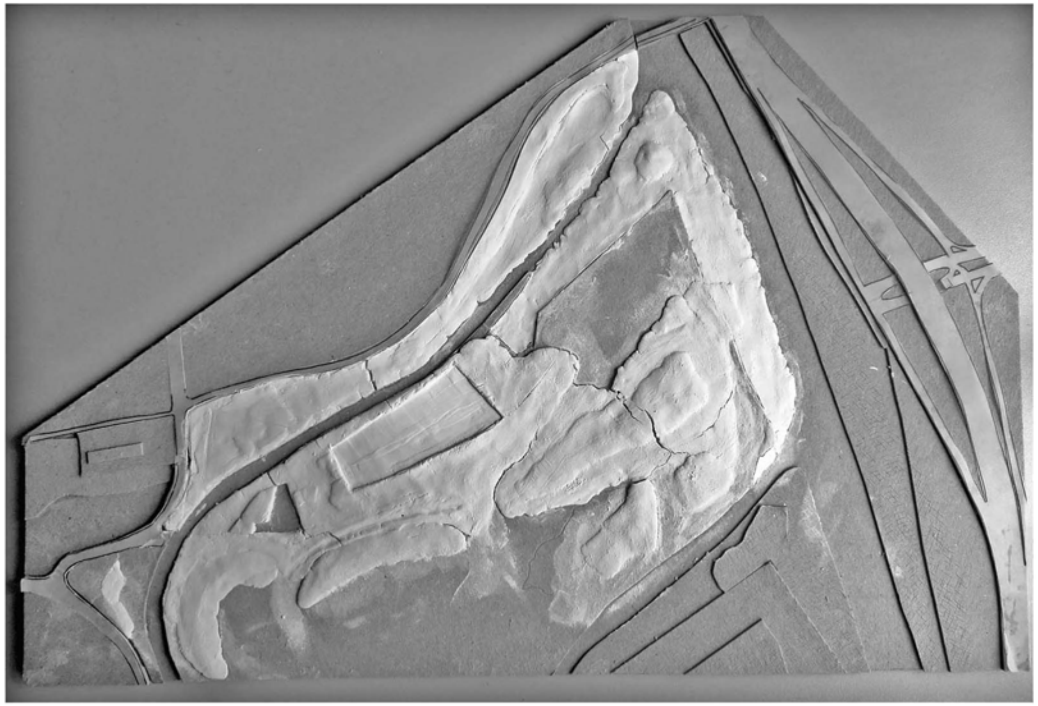
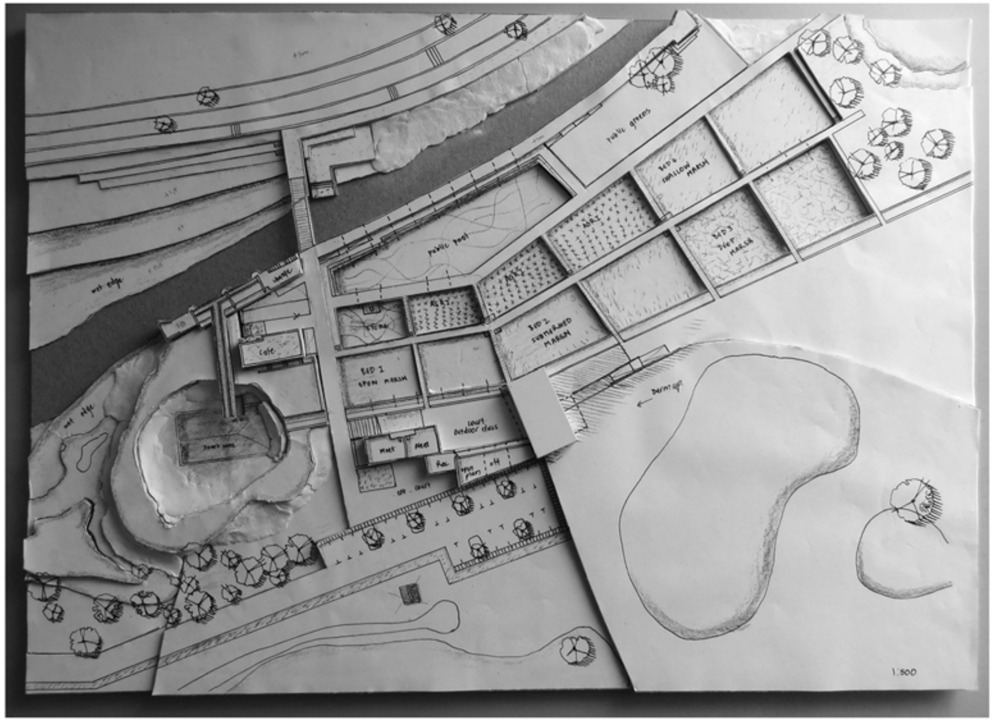


Figure 51: Tracking design development through model - making. (a) Contour mapping. (b) Movement and flow patterns (c) Sketch design (d) Design development. (Author, 2013)




public greens
BED 4 SHALLOW MARSH
public pool
BED 3 DEEP MARSH
BED 2 SUBMERGED MARSH
cafe
BED 1 OPEN MARSH
court outdoor class
1:500

Developing the Design

The design was constantly developed through the lens of Girot's theories relating to layering sites. In *finding*, the careful analysis of the macro and micro site qualities allows for the design to highlight the different characteristics of the site. In *landing*, the legacy of production has allowed for the restoration of the land through wetland rehabilitation and agricultural produce. By creating a productive landscape that facilitates public interaction, the identity of the site becomes apparent, thereby *grounding* both the permanent and fleeting qualities of the site. The new intervention allows for a more resilient site that accommodates for a constantly changing environment through *founding*.

The development of the design saw a greater emphasis on the public aspect of the programme. A public pool, café and ablutions were introduced to the site. The geometries of the surroundings were incorporated into the design, resulting in a system that fans out across the site from a grid form. The intention of the design was to create a form that spreads out into the landscape, but contains a process that folds in on itself. This allows for containment of the scientific systems, but encourages visitors to explore the natural wetlands.

The project seeks to explore the relationship between built form and pure landscape, and therefore the realm of architecture versus landscape architecture. It was decided early on that ambiguity, as a theme, would be incorporated in the project as a means of dealing with this issue.

4 distinct design areas within the soft machine were revealed:

1) The natural wetland, consisting of meandering pathways, bird hides and a flexible edge.

The locality plan shows meandering pathways leading to bird hides and a collective seating/viewing area on the east side of the site. The building is accessed off the road leading to the Transnet Railway Workshops, which is closed after hours, allowing access to the site to be monitored (Figure 53). Once the Raapenberg wetland has been rehabilitated, the growing beds can be used for a city-wide wetland nursery, for cultivation of endangered plants or for growing flowers for sale.

Figure 52: Shanghai Huton Park, by Turenscape Architects (2007-2009). This living landscape is located in a former industrial site along the Huangpu River. The design includes a constructed wetland, ecological flood control, reclaimed industrial structures and materials, and urban agriculture. Particularly important is the language of meandering walkways along the river and through riparian vegetation, as well as the design for a flexible edge that can accommodate flooding. (Singhal, 2008)

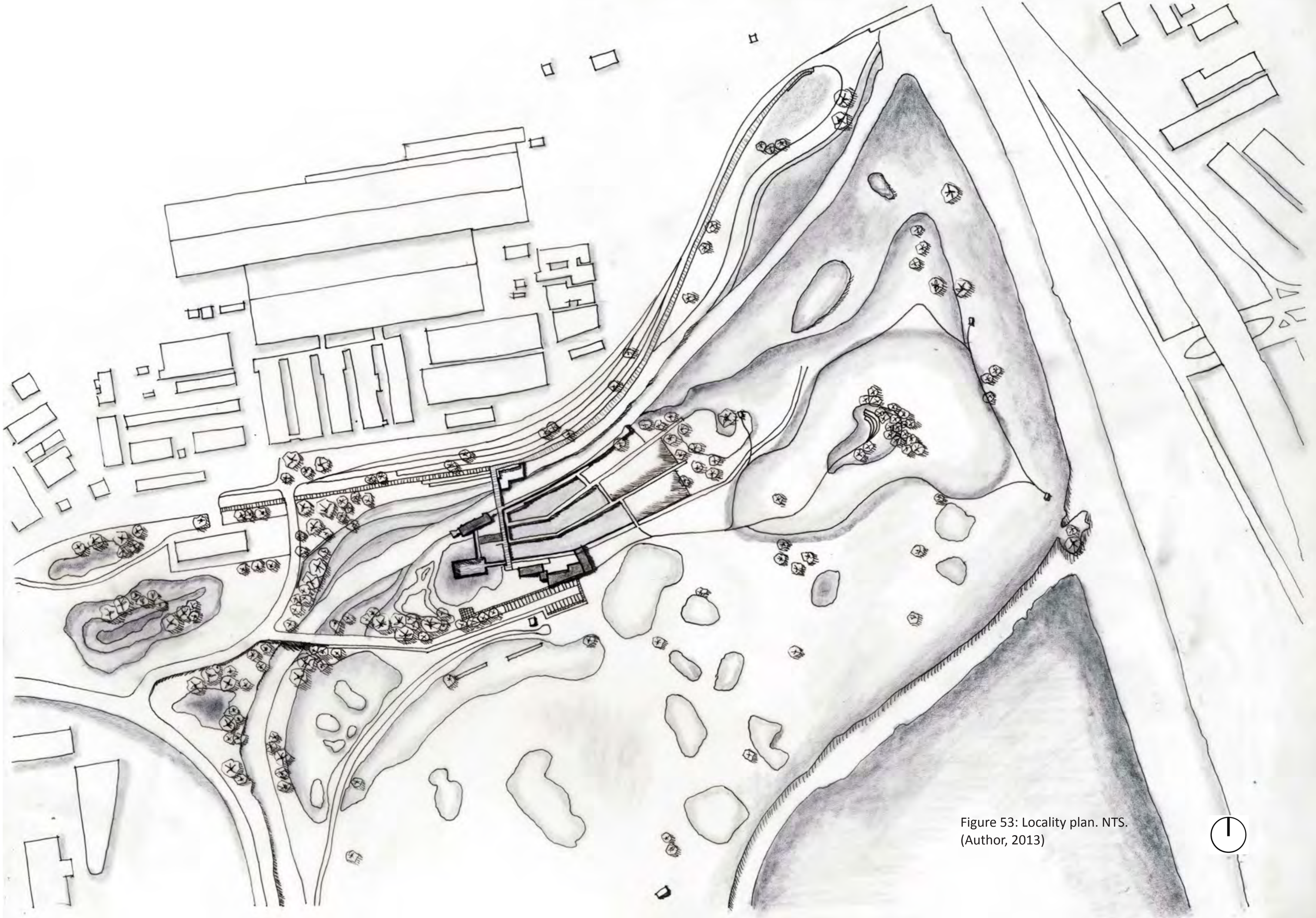


Figure 53: Locality plan. NTS.
(Author, 2013)

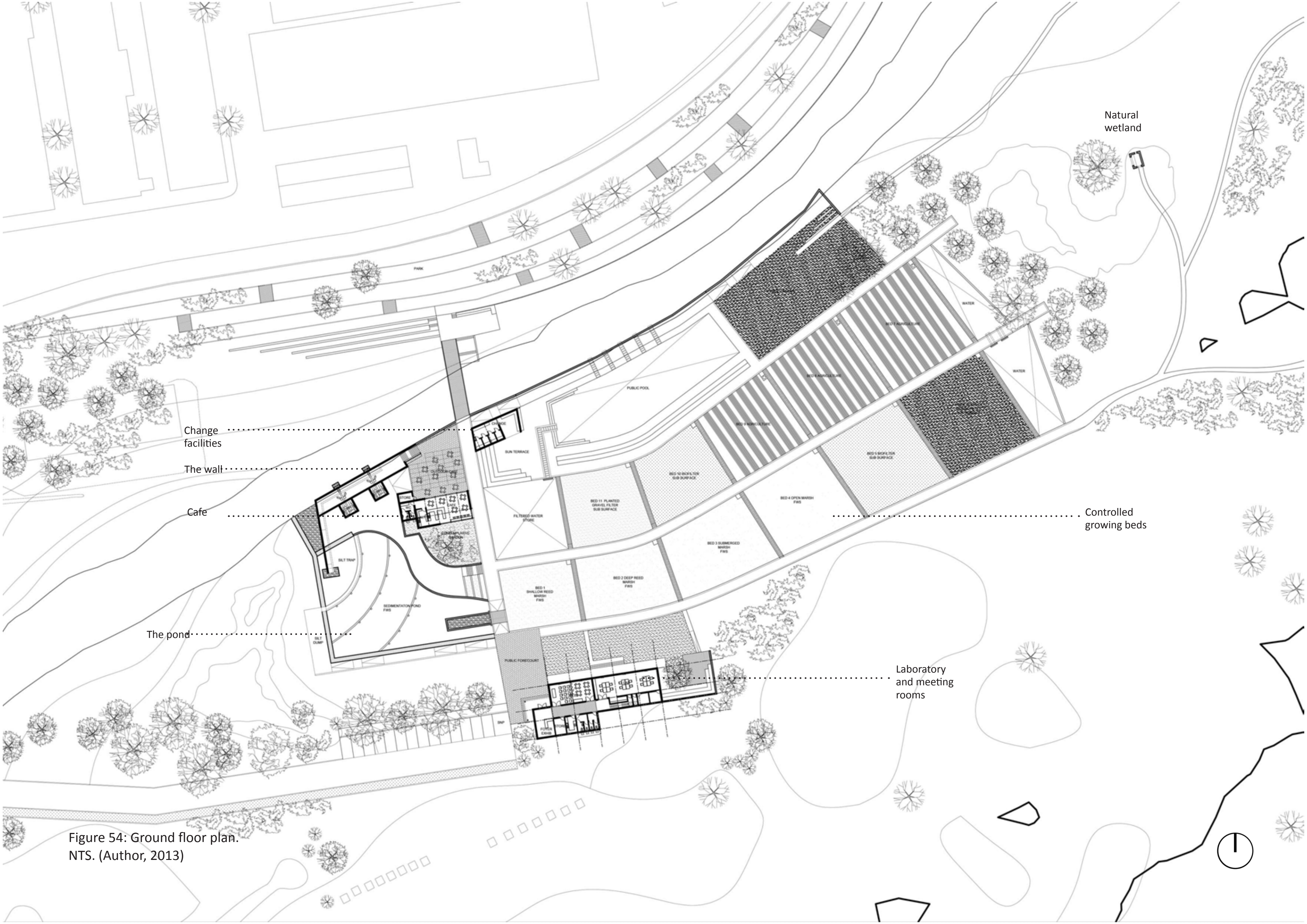


Figure 54: Ground floor plan.
NTS. (Author, 2013)

2) The wall, consisting of pump jacks, a water conduit, changing area, promenade and bridge.

3) The pond as a fixed and changing area for the sedimentation process, fronted by a public café. Water enters the pond from a cascaded channel. The pond is designed to reveal itself as visitors move through the site, but is fully visible when driving past the area.

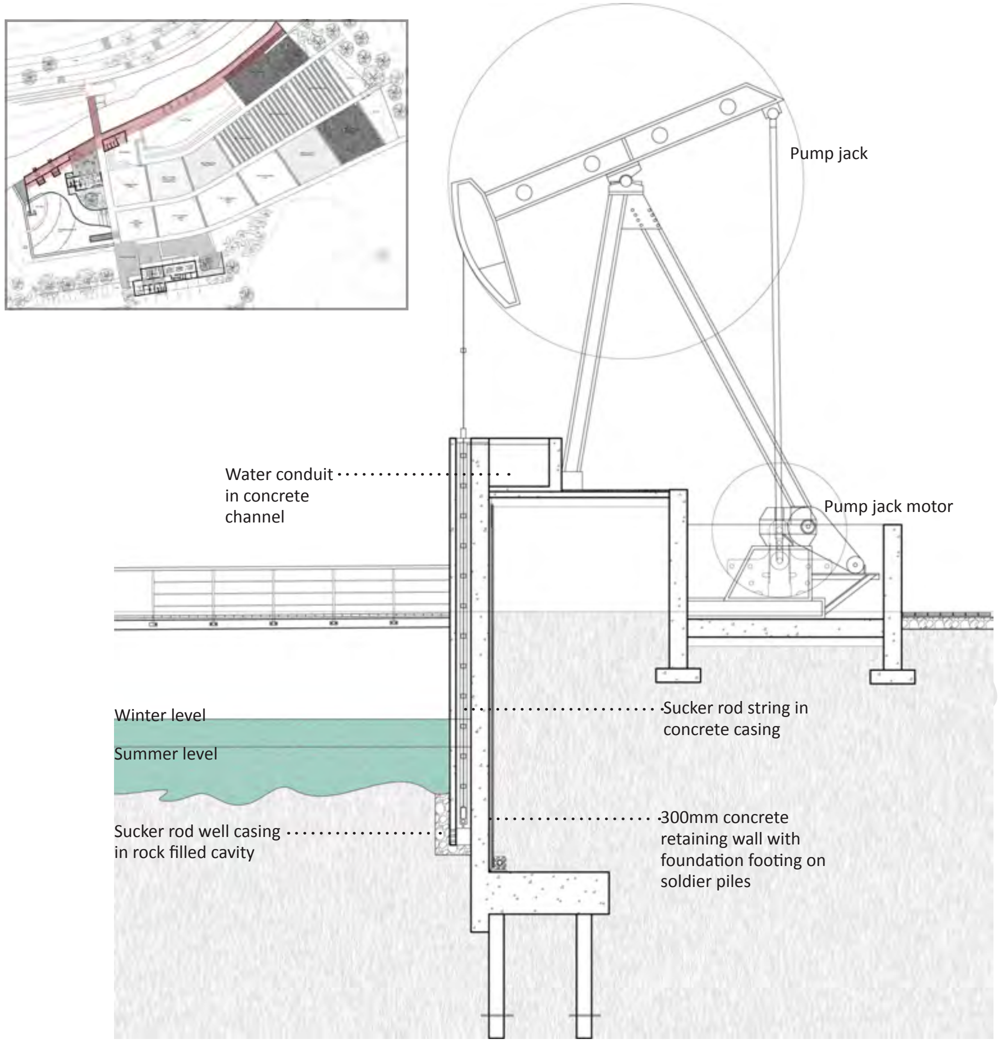


Figure 55: Retaining walls are an important part of the design. The above detail explores the river- facing retaining wall. It was decided to have a bold edge at the start of the process, resulting in the shear concrete face. The pump jack size was later decreased. NTS. (Author, 2013)

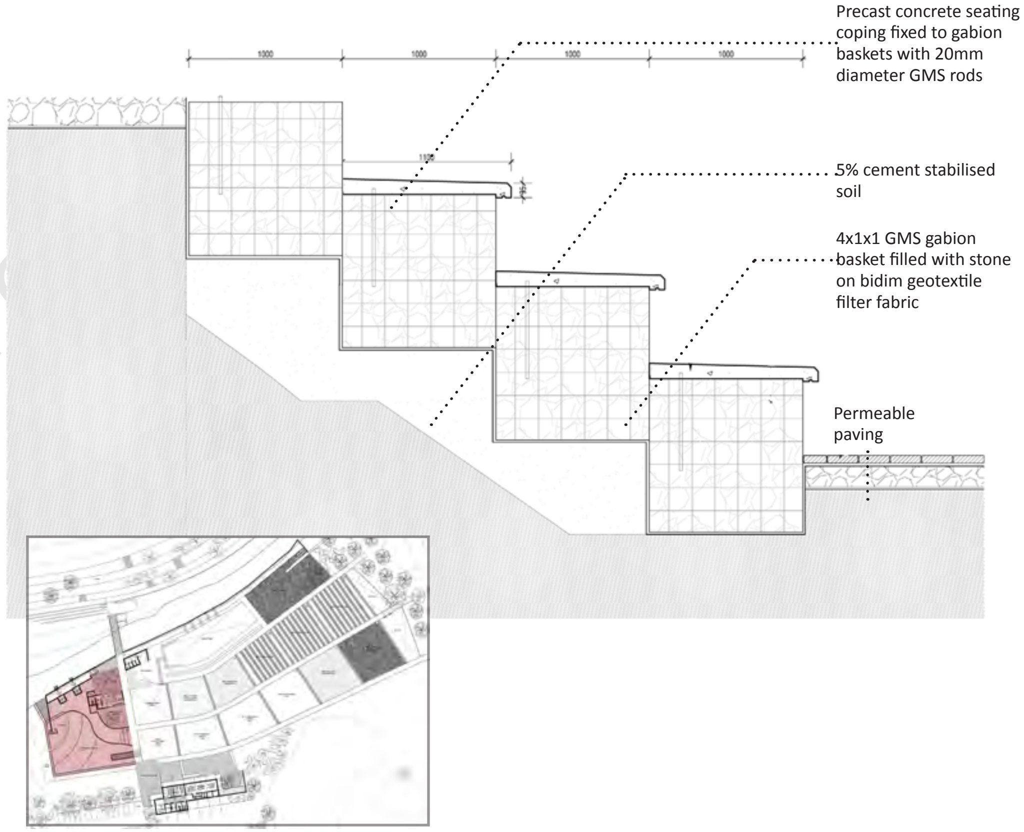


Figure 56: Gabion retaining walls will be used as a green alternative to the concrete wall system. The above detail explores a terraced wall that includes seating, located next to the sedimentation pond. NTS. (Author, 2013)

4) Controlled growing beds for wetland water filtration, housing the wetland plant nursery and hydroponic agriculture farm. A public pool, research facilities and testing stations animate the scientific realm of the soft machine.

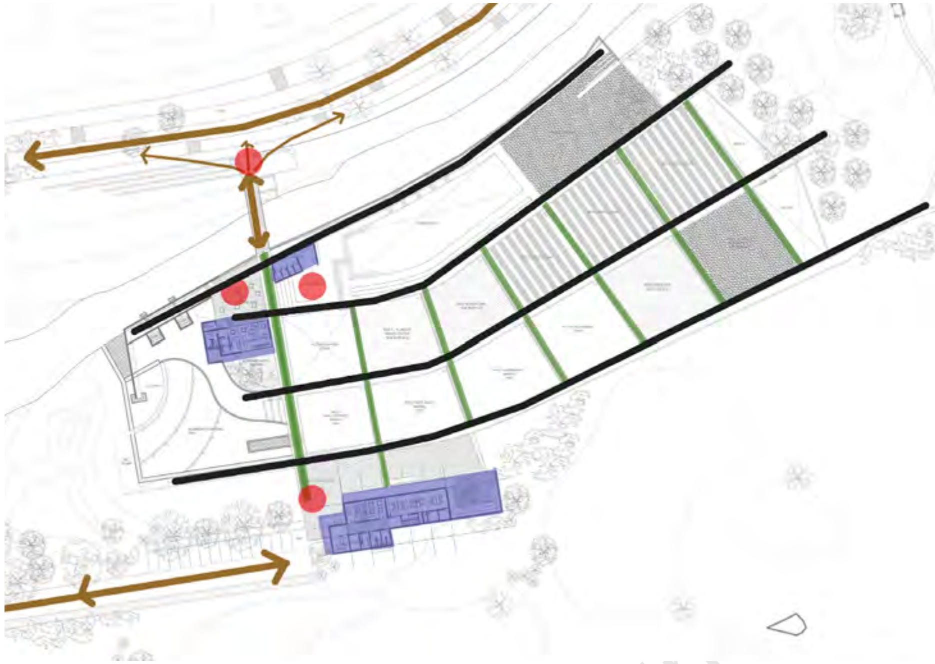


Figure 57: Movement hierarchy on site. Movement of the first order (black) is parallel to the river, which emphasises the visible connections to the mountain and city across the site. Movement of the second order (green) is perpendicular to the river, allowing visitors to experience the growing beds, but is specifically designed for servicing the cells. The support facilities (blue) act as anchors on the public route across the river and entrance to the site, shown in brown. Collective gathering spaces are shown in red. NTS. (Author, 2013)

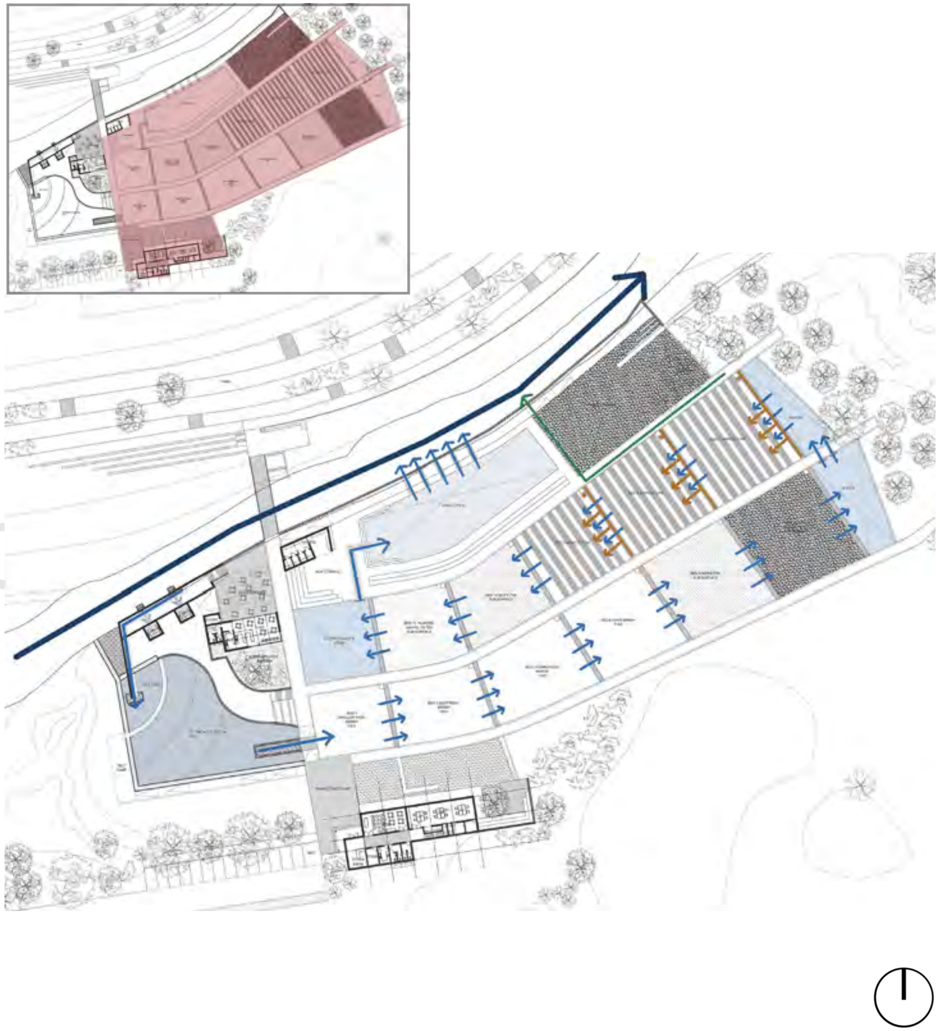


Figure 58: Movement of water on site. Perpendicular movement routes on site become water deployment mechanisms. These trenches are constructed of 2 concrete footings supporting a mentis grating walkway, allowing easy access to valve controls within the cavity. Nutrients are deployed using the drip technique from pipes running the length of the walkways in the agricultural growing beds, shown in brown. Bypass drainage of the agricultural beds is shown in green. NTS. (Author, 2013)

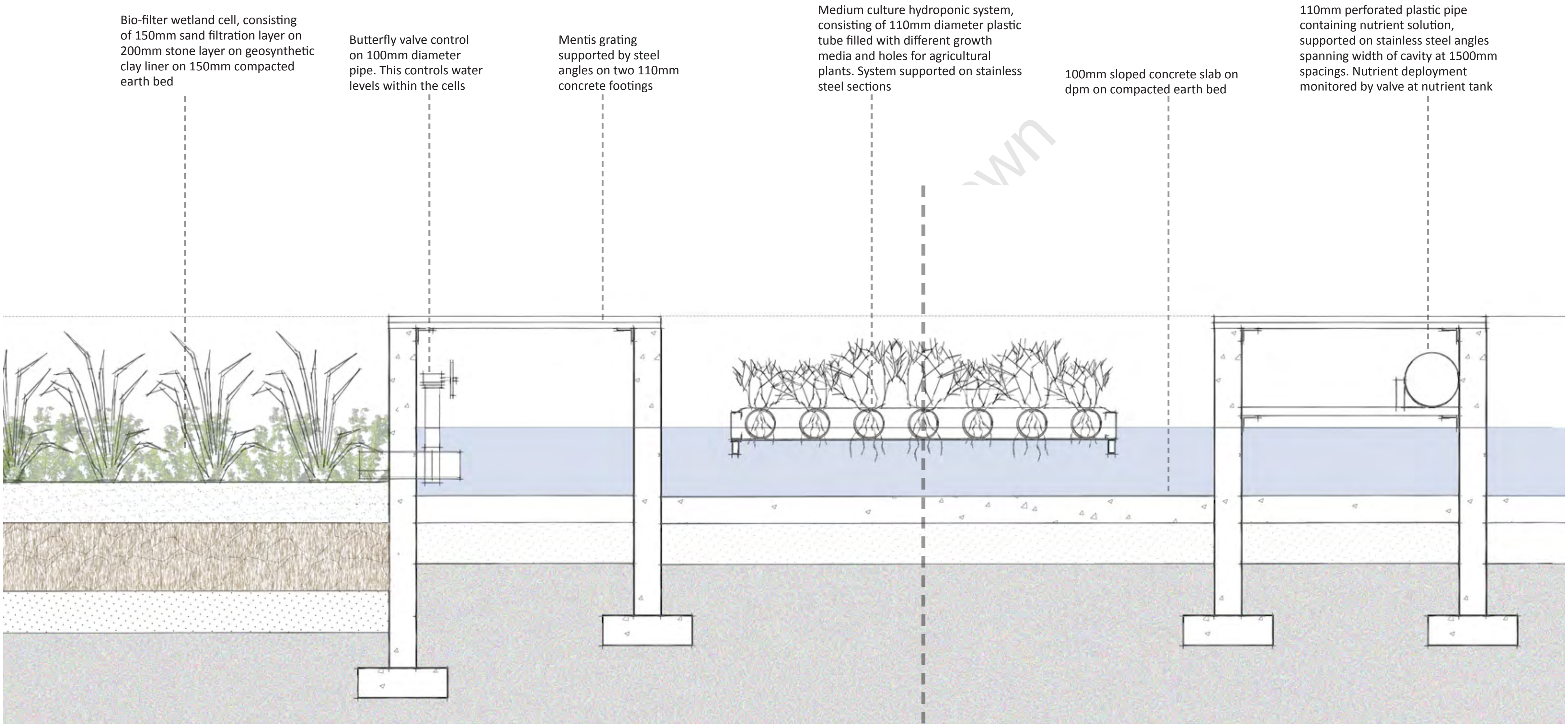


Figure 59: 1:20 detail exploration of the wetland beds. The image shows the different conditions in site, including the hydroponic system and bio-filter. Author, 2013)

7| Conclusion

This dissertation tracks a subjective design process, focussing on the potential for architecture to serve as a catalyst for the regeneration of a site that is undervalued within its context. The *boundary,* selected as the means for architectural engagement, is explored through the layers of the Raapenberg site in order to unearth the transient qualities present.

The complex programme drawn from various interests attempts to address how machine-like characteristics can be mediated through architecture to create a productive landscape. The soft machine is proposed as a design solution, comprising of an architecture of inhabited site works that embodies the process of water filtration across the site. A productive landscape is generated through the cultivation of agricultural produce and endangered wetland plants for on-site wetland rehabilitation. The building, which augments the conventional typology of landscapes of production, facilitates public interaction through the provision of public amenities. The unappreciated site is given identity and purpose through merging scientific processes with public participation.

The theoretical premise initiated a search for the blurring of boundaries to create polyvalency and to accommodate for change in a landscape of flux. However, by exploring the layers of the site in the design process, boundaries became the means of defining the different processes used on the site. The notion of boundary is stretched to become a defined zone in which both fixed and changing conditions can occur.

The complexities of the building put a spotlight on architecture's relationship with nature and the machine, while still being clear about function and purpose. The soft machine as a responsive architecture facilitates the long-term rehabilitation of the site, and allows man to experience space both as a tactile construct and as a moment to wonder at the world.

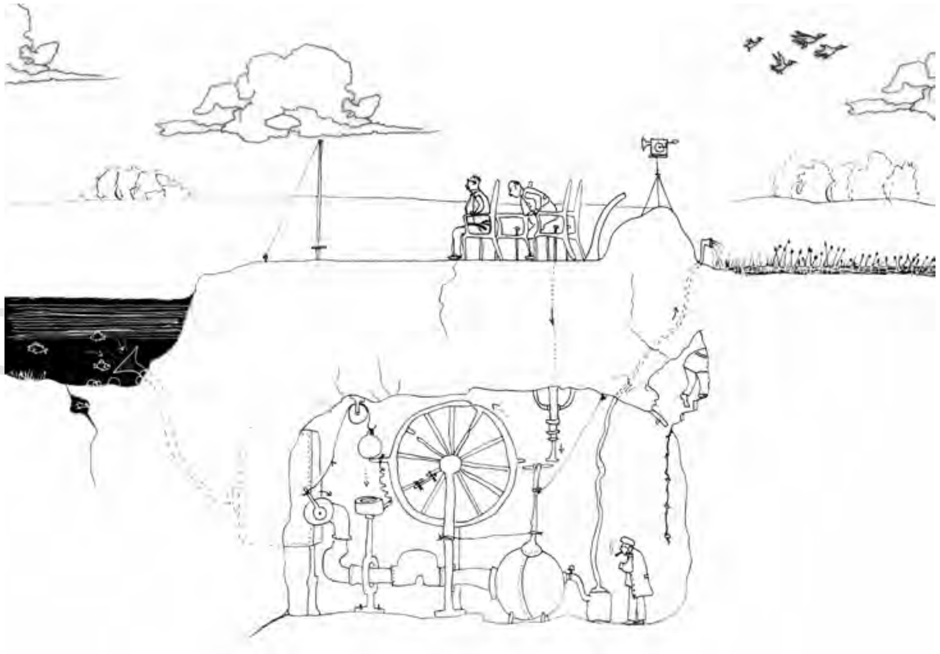


Figure 60: Early conceptual work as part of the initial project investigation. Working in the spirit of Heath Robinson, this drawing explores a playful contraption for pumping water from the river onto the site. (Author, 2013)

8 | Glossary

The definitions of the following words have been altered to apply to concepts discussed in this paper, and are intended as a quick reference to allow for a complete understanding of the terms used.

- Absorption: The chemical process in which liquids, solids or gases are taken up into another element.
- Adsorption: A chemical process in which liquids, solids or gases adhere to a solid surface to form a thin layer but do not infiltrate the surface. By passing water solutions through activated charcoal, contaminating elements adhere to the surface of the charcoal, thereby purifying the water.
- Anamnesis: Recollections of the previous histories of a site.
- Boundary: In this paper, boundary is conceived as both a fixed and permeable zone of transition and change along the Liesbeek River.
- Evapo-transpiration: The process concerning the transfer of water from plants to the atmosphere or soil through transpiration.
- Flood plain: The area susceptible to flooding within the 1:50 year demarcation.
- Heterogeneity: Having the characteristics of non-uniformity, variance and diversity.
- Homogeneity: Having the characteristics of uniformity and a deficiency in variety.
- Hydroponics: A technique using mineral nutrient water solutions to grow plants without soil
- Mnemonic: The use of landscape as a trigger for remembering past events or qualities.
- Polyvalence: The ability of a site to simultaneously have multiple interacting programmes.
- Programme: The activities and functions that are accommodated for within a built intervention.
- Riparian conditions: Naturally occurring fauna and flora along the river, including geological and topographical formations.
- Sorption: The situation when adsorption and absorption both occur in the same process. In chemistry, this refers to the integration of one substance into another of a different phase.
- TRUP: The Two Rivers Urban Park, situated at the confluence of the Liesbeek and Black Rivers in Observatory / Salt River.

9 | References

- 7 Group and Reed, B. 2009. *The Integrative Design Guide to Green Building*. New Jersey: John Wiley & Sons Inc.
- Armitage, N. 2011. T*he South African Draft Guidelines for Sustainable Urban Drainage Systems (SUDS)*. Water Research Commission of South Africa (WRC). Project K5/1826
- Atwater Hydroponics. 2013. *Aeroponic Systems* [Online] Available at: http://www.atwaterhydroponics.com/pages/Aeroponic-Systems.html (Accessed 3 March 2013)
- Brown, C; Magoba, R and the SA Water Research Commission. 2009. *Rivers and Wetlands of Cape Town: Caring for our Rich Aquatic Heritage.* Pretoria: Water Research Commission
- Carrera, J; Angles, M and Puig Torres, R. 2010. *In Favour of Public Space: Ten Years of the European Prize for Urban Public Space 2000-2010.* Barcelona: Centre de Cultura Contemporania, Actar
- City of Cape Town, Department of Water and Forestry. 2005. *State of Rivers Report.* Cape Town: Cape Town Administration
- City of Cape Town, Environmental Management Branch. 2002. *Two Rivers Urban Park Spatial Development Framework and Phase 1 Management Plan.* Cape Town: Cape Town Administration
- City of Cape Town, Environmental Management Branch. 2011. *National Environmental Management Act.* Cape Town: Cape Town Administration
- City of Cape Town. 2009. *Table Bay Spatial Development Plan & Environmental Management Framework: Technical Report.* Cape Town: Cape Town Administration
- City of Cape Town. 2009. *Cape Town Spatial Development Framework: Technical Report.* Cape Town: Cape Town Spatial Planning and Urban Design Department
- City of Cape Town: Department of Agriculture, Forestry and Fisheries. 2011. *Hydroponic Vegetable Production*. Cape Town: Cape Town Administration
- City of Cape Town. 1999. *Black River Urban Park.* Cape Town: Cape Town Administration
- City of Cape Town, Economic and Human Development. 2007. *The Economic Imperatives of Environmental Sustainability.* Cape Town: Cape Town Administration
- City of Cape Town, Environmental Management Branch. *Water Resources. In: Water Balance, Resource Planning and Management.* Cape Town: Cape Town Administration
- Corner, J.ed. 1999. *Recovering Landscape: Essays in Contemporary Landscape Architecture.* New York: Princeton Architectural Press
- Despommier, D. 2013. *The Vertical Farm Project.* [Online] Available at http://www.verticalfarm.com/. (Accessed 27 March 2013)
- Descombes, G. Shifting Sites. 1999 In: Corner, J.ed. 1999. *Recovering Landscape: Essays in Contemporary Landscape Architecture.* New York: Princeton Architectural Press
- Evans, A. 2007. *Rivers of the World.* London: Thames Festival Trust
- Geyer, H; Schloms, B; du Plessis, D and van Eeden, A. 2011. *Land Quality, Urban Development and Urban Agriculture within Cape Town's Urban Edge.* SSB/TRP/MDM 2011 p41-52

- Grant, G. 2011. *Water Sensitive Urban Design and Sustainable Drainage Systems.* [PDF] Available at: http://www.scotland.gov.uk/Resource/Doc/1221/0120064.PDF (Accessed 27 March 2013)
- Girot, C. Four Traces Concepts in Landscape Architecture. 1999. In: Corner, J.ed. 1999. *Recovering Landscape: Essays in Contemporary Landscape Architecture.* New York: Princeton Architectural Press
- Heidegger, M. 1971. *Building Dwelling Thinking*. New York: Harper Collins Books
- Ingersoll, R, 2012. The Ecology Question and Architecture. In: Crysler, C; Cairns, S and Heynen, H.ed . 2012. T*he Sage Handbook of Architectural Theory.* Los Angeles: Sage
- Jensen, MH. 1997. Hydroponics. In *HortScience* Vol 32 (6) October 1997, p 1018-11023
- Kronenburg, R. 2001. *Spirit of the Machine*. London: Wiley-Academy
- Leatherbarrow, D. 2000. *Uncommon Ground: Architecture, Technology, Topography*. Cambridge: MIT Press
- Manfredi, M; Weiss, M and Mertins,D. 2008. *Weiss/Manfredi: Surface/Subsurface.* New York : Princeton Architectural Press
- Marot, S. The Reclaiming of Sites. 1999. In: Corner, J.ed. 1999. *Recovering Landscape: Essays in Contemporary Landscape Architecture.* New York: Princeton Architectural Press
- Mathur, A and da Cunha, D. 2009. *Soak: Mumbai in an Estuary.* National Gallery of Modern Art (New Delhi, India) New Delhi : Rupa & Co.
- Mostafavi, M and Najle, C. ed. 2003. *Landscape Urbanism: A Manual for the Machinic Landscape*. London: AA Publications
- Onderstall, N. 2013. *Liesbeek River Habitat* [Posters] Personal collection
- Pieterse, EA. ed. 2010. *Counter- Currents: Experiments in Sustainability in the Cape Town Region.* Auckland Park, South Africa : Jacana Media
- PUB. 2009. *ABC Waters Design Guidelines.* Singapore: Ministry of Environment and Water Resources
- Reed, P. 2005. *Groundswell: Constructing the Contemporary Landscape.* New York: The Museum of Modern Art
- Regionalverband Ruhr, 2010. F*ield Studies: The New Aesthetics of Urban Agriculture.* Basel: Birkhauser.
- Roberto, K. 1994. *How- to Hydroponics.* New York: The Futuregarden Press
- Shannon, K, 2012. Landscapes. In: Crysler, C; Cairns, S and Heynen, H.ed . 2012. *The Sage Handbook of Architectural Theory.* Los Angeles: Sage
- Singhal, S. May 2008. *Shanghai Hutan Park.* [Online] Available at: http://www10.aeccafe.com/blogs/arch-showcase/2011/05/15/shanghai-houtan-park-in-shanghai-china-by-turenscape-architect/ (Accessed 27 March 2013)
- Turner, B. 20 October 2008. *How Hydroponics Works.* [Online] Available at: http://howstuffworks.com/home/hydroponics.html. (Accessed 27 March 2013)
- United Nations. 2012. *World Water Development Report 4.* United Nations
- United Nations Department of Economic and Social Affairs. 2013. *Water Scarcity.* [Online] Available at http://www.un.org/waterforlifedecade/scarcity.shtml (Accessed 27 March 2013)
- United Nations Works. 2008. *The Global Water Crisis: Water for Life.* [Online] Available at: http://www.un.org/works/sub2.asp?lang=eng&s=19. (Accessed

3 March 2013)

- US Environmental Protection Agency. 1988. *Constructed Wetlands and Aquatic Plant Systems for Municipal Waste Water Treatment.* Ohio: Office of Research and Development, National Risk Management Research Laboratory.
- US Environmental Protection Agency. 2004. *Constructed Treatment Wetlands*. Ohio: Environmental Protection Agency
- Wall, A. Programming the Urban Surface. 1999. In: Corner, J.ed. 1999. *Recovering Landscape: Essays in Contemporary Landscape Architecture*. New York: Princeton Architectural Press
- Willis, C. 2013. *Hydroponics*. [Online] Available at: http://www.androidworld.com/prod26.htm (Accessed 27 March 2013)
- Wyatt, J. 1997. Wetland Fix Part 6. In: *Alien Plant Control Guide*. Cape Town: Mondi Wetlands Programme

10 | Appendix

Upper Reaches

LOCATION | Table Mountain, Kirstenbosch, Bishopscourt

AVERAGE DEPTH: 100mm

AVERAGE WIDTH : 2,2m

SPECIFICS | Hard weathered sandstone, natural character retained

AQUATIC VEGETATION | Indigenous plants: Palmiet, Sedges, Mosses

MARGINAL VEGETATION |Indigenous plants: Fluitjiesriet

RIPARIAN VEGETATION

Indigenous trees: Wild Almond, Wild Holly, Cape Beach

Indigenous plants: Wild Grape, Arum Lily, Mountain Fynbos

FISH | Small Galazias, Carp, Catfish, Trout, Guppies

ANIMALS | Water Scavenger / Predatory Diving / Whirligig Beetles, Stone Flies, Snails, Hydra, Planarians, Parasitic Leeches, Amphipods, Crabs, Water Mites, Oligochaetes, May / Dragon / Damsel Flies

AMPHIBIANS | Tadpoles / Frogs

BIRDS | White throated Swallow, Cape Francolin, Black headed Heron, Spur winged / Egyptian Goose, Blacksmith Plover, Black Swift, Grey Heron, African Black Duck, Cape Shoveller

ISSUES

- Water extraction by older households and damming reduces natural habitats, results in poorer water quality downstream

- Afforestation: Alien plants require more water than indigenous species, thus increasing water extraction

- Loss of indigenous vegetation results in erosion

POTENTIALS

- By preserving character in the upper reaches, no intervention will be necessary

(Author 2013, adapted from Onderstall, 2013)

Foothill Zone

LOCATION | Claremont, Newlands, Rondebosch

AVERAGE DEPTH: 100mm

AVERAGE WIDTH : 4m

SPECIFICS | Stones with sand, canalised in parts

AQUATIC VEGETATION

Indigenous plants: Palmiet, Sedges, Mosses

Alien plants: Water Hyacinth

MARGINAL VEGETATION

Indigenous plants: Fluitjiesriet

Alien plants: Spanish / Giant Reed

RIPARIAN VEGETATION

Indigenous trees: Wild Almond, Wild Holly, Cape Beach

Indigenous plants: Wild Grape, Arum Lily,

Alien trees: English Oak, Norfolk Pine

Alien plants: Wild ginger, brambles

FISH | Small Galazias, Carp, Catfish, Trout, Guppies

ANIMALS | Water Scavenger / Predatory Diving / Whirligig Beetles, Stone Flies, Snails, Hydra, Planarians, Parasitic Leeches, Amphipods, Crabs, Water Mites, Oligochaetes, May / Dragon / Damsel Flies

AMPHIBIANS | Tadpoles / Frogs

BIRDS | White throated Swallow, Cape Francolin, Black headed Heron, Spur winged / Egyptian Goose, Blacksmith Plover, Black Swift, Grey Heron, African Black / Fulvous / White faced Duck, Cape Shoveller, Cape Teal, Rock Pigeon

ISSUES

- Shallow water table = drainage important

- Canals remove natural habitats and prevent ground water infiltration

POTENTIALS

- Natural springs converge on Liesbeek River

(Author 2013, adapted from Onderstall, 2013)

Middle Reaches

LOCATION | Rosebank, Mowbray, Observatory

AVERAGE DEPTH: 100mm

AVERAGE WIDTH : 4m

SPECIFICS | Stones with sand, canalised in parts, revitalisation programmes

AQUATIC VEGETATION

Alien plants: Water Hyacinth, Red Water Fern [Waterblommetjies, Blue Water Lily]

MARGINAL VEGETATION | Alien plants: Spanish / Giant Reed [Fluitjiesriet]

RIPARIAN VEGETATION

Alien trees: English Oak, Norfolk Pine [Wild Peach / Almond, Red Alder, Cape Beech]

Alien plants: Wild ginger, brambles, Morning Glory, Cannas [Arum Lily, Tabakbos, Wild Grape]

FISH | Small Galazias, Carp, Catfish, Trout, Guppies

ANIMALS | Water Scavenger / Predatory Diving / Whirligig Beetles, Stone Flies, Snails, Hydra, Planarians, Parasitic Leeches, Amphipods, Crabs, Water Mites, Oligochaetes, May / Dragon / Damsel Flies

AMPHIBIANS | Tadpoles / Frogs

BIRDS | White throated Swallow, Cape Francolin, Black headed Heron, Spur winged / Egyptian Goose, Blacksmith Plover, Black Swift, Grey Heron, African Black / Fulvous / Mallard / Yellow billed / White faced Duck, Cape Shoveller, Cape Teal, Rock Pigeon, Black winged Stilt, Southern Masked Weaver, Purple Heron / Gallinule, Red Bishop, African Jacana, Red knobbed Coot, Glossy Ibis

ISSUES

- Canals remove natural habitats and prevent ground water movement

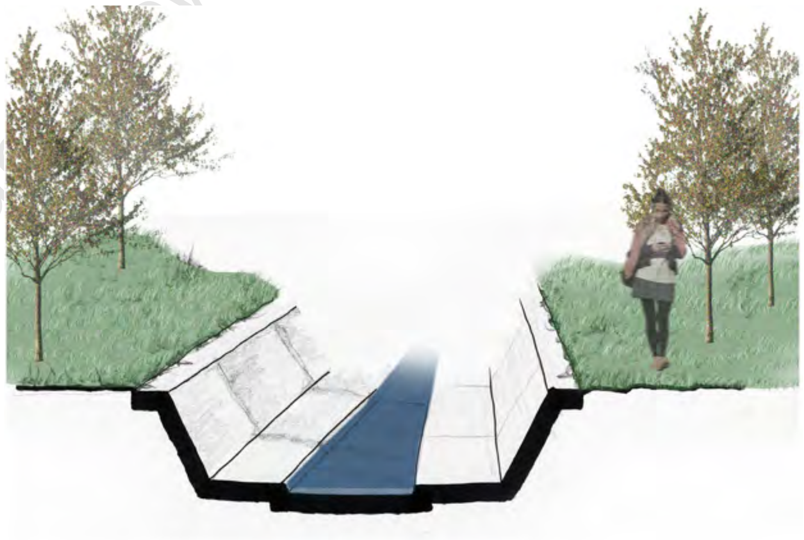
- Surface hardening of river banks = greater runoff

- Larger storm water deposits as erfs decrease in size

- Fertilizers allow for rapid alien plant growth

POTENTIALS

- Large parcels of undeveloped land - ecological conservation opportunity



(Author 2013, adapted from Onderstall, 2013)

Lower Reaches

LOCATION | Observatory, Salt River, Paarden Eiland

AVERAGE DEPTH: 100mm

AVERAGE WIDTH : 4m

SPECIFICS | Canalised in parts, wetlands, mixed soil types

AQUATIC VEGETATION

Alien plants: Water Hyacinth, Parrot's Feather, Fresh water Algae [Alkali Bulrush, Mat Sedge]

Indigenous plants: Palmiet, Stergras, Mosses [Waterblommetjies, Floating Hearts]

MARGINAL VEGETATION | Indigenous plants: Fluitjiesriet

RIPARIAN VEGETATION

Alien trees: Weeping Willow, Port Jackson, Silver Beech [Wild Peach, True Yellowwood, Water Heath]

Alien plants: Balloon Vine, BlackJack, Kikuyu Grass [Krulkransie, Buffalo Grass, Horsetail Restio]

FISH | Small Galazias, Carp, Catfish, Trout, Guppies

ANIMALS | Water Scavenger / Predatory Diving / Whirligig Beetles, Stone Flies, Snails, Hydra, Planarians, Parasitic Leeches, Amphipods, Crabs, Water Mites, Oligochaetes, May / Dragon / Damsel Flies

AMPHIBIANS | Chameleons, Tadpoles / Frogs: Cape River / Banded / Clicking Stream, Racous Toad

BIRDS | White throated Swallow, Cape Francolin, Black headed Heron, Spur winged / Egyptian Goose, Blacksmith Plover, Black Swift, Grey Heron, African Black / Fulvous / Mallard / Yellow billed / White faced Duck, Cape Shoveller, Cape Teal, Rock Pigeon, Black winged Stilt, Southern Masked Weaver, Purple Heron / Gallinule, Red Bishop, African Jacana, Red knobbed Coot, Glossy / Sacred Ibis, Hartlans / Kelp / Grey headed / Herring Gull, Pied / Malachite Kingfisher, Cape Commorant

ISSUES

- Canals remove natural habitats and prevent ground water movement
- Polluted Black River water, industrial effluent
- Development of wetlands

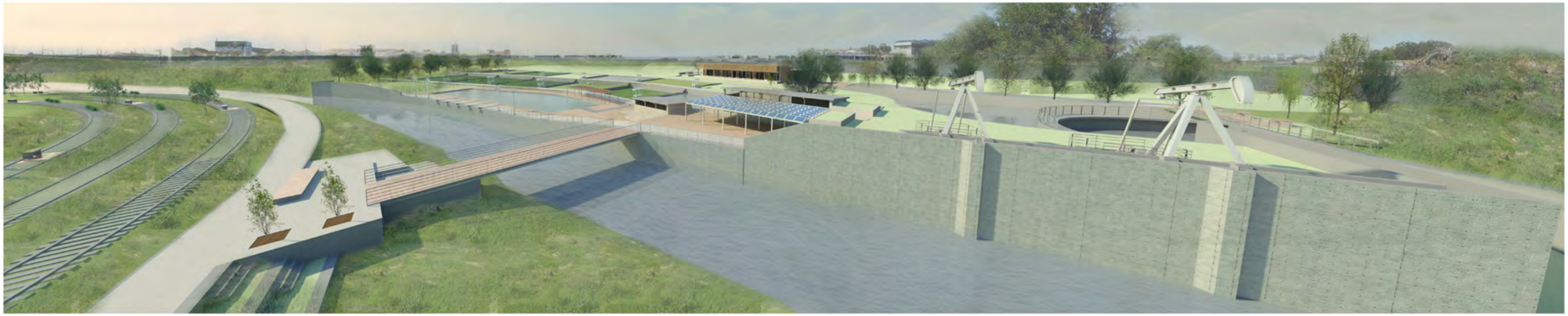
POTENTIALS

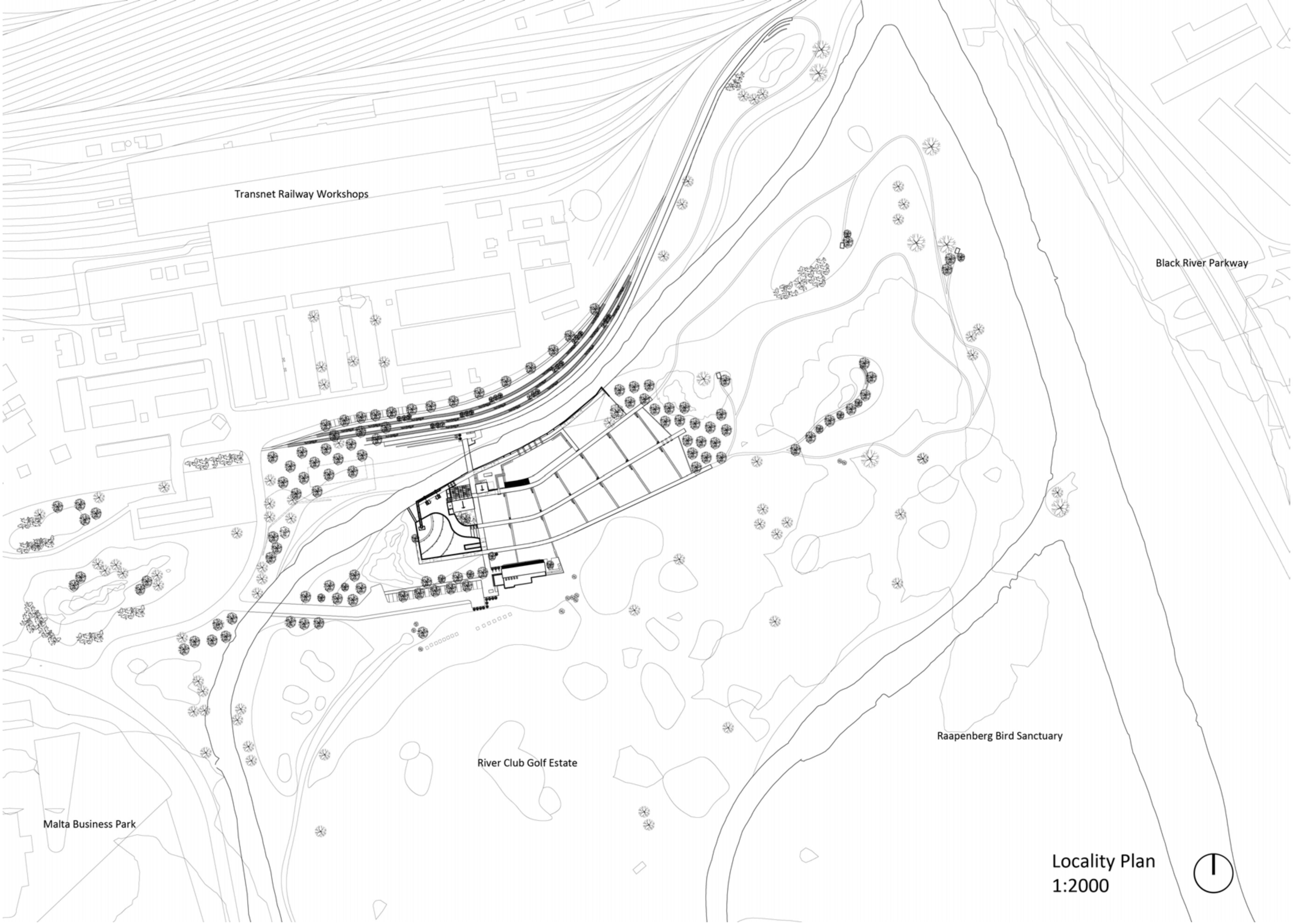
- Wetland areas and undeveloped land

(Author 2013, adapted from Onderstall, 2013)

Information gained from a variety of sources, including Brown et al, 2009; Evans, 2007; CoCT,2011; CoCT, 2012, Onderstall, 2013 and site visits by author, 2013

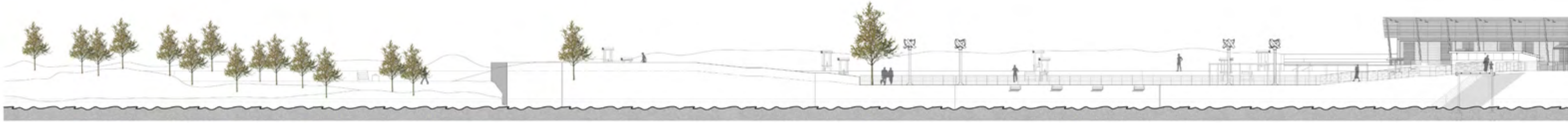
11 | Final Drawings

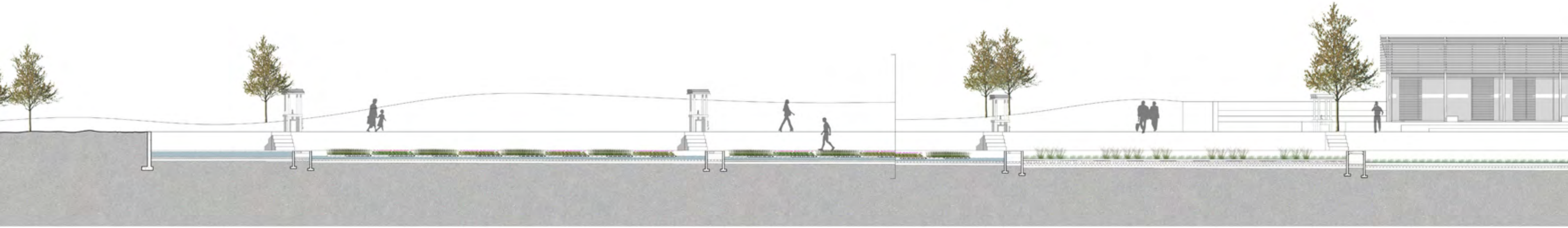


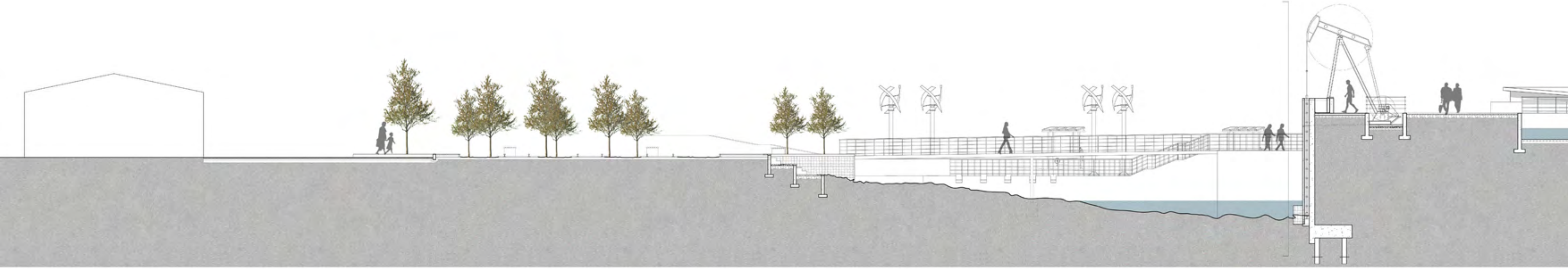


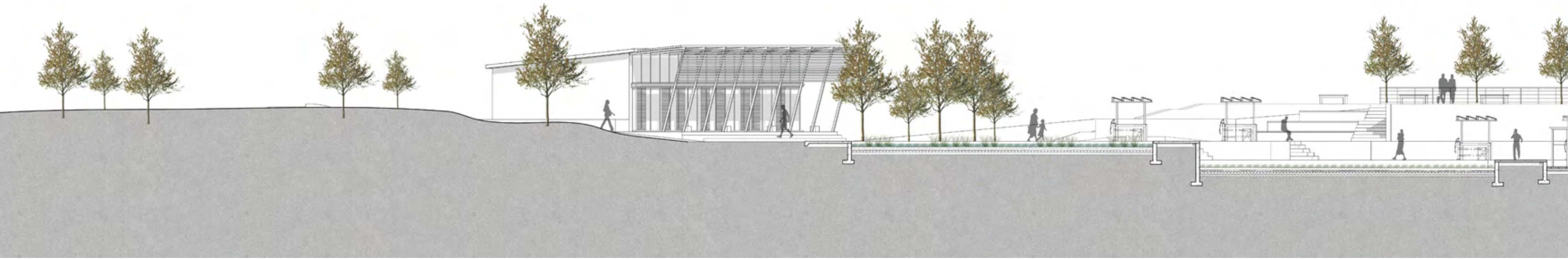
Locality Plan
1:2000

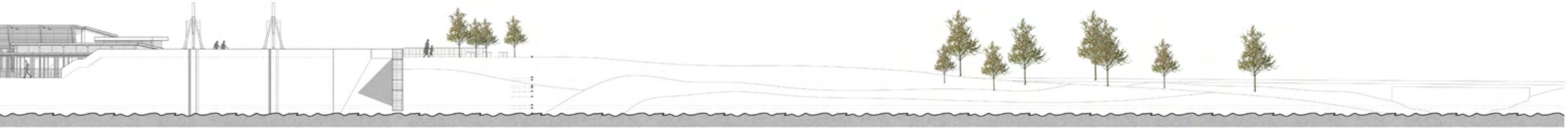
Ground Floor Plan
1:200



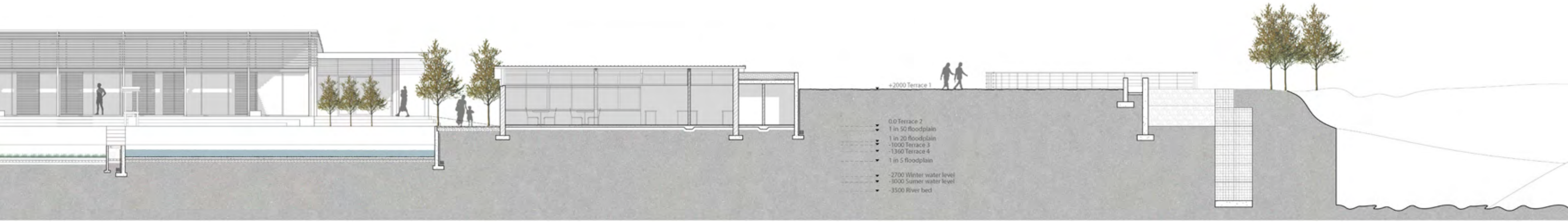




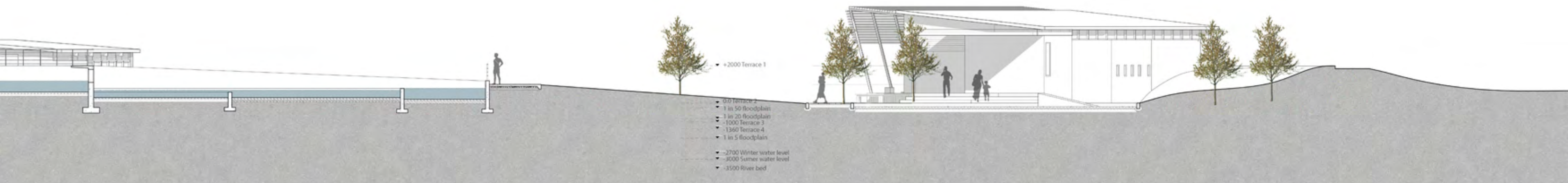




North Elevation
1:200

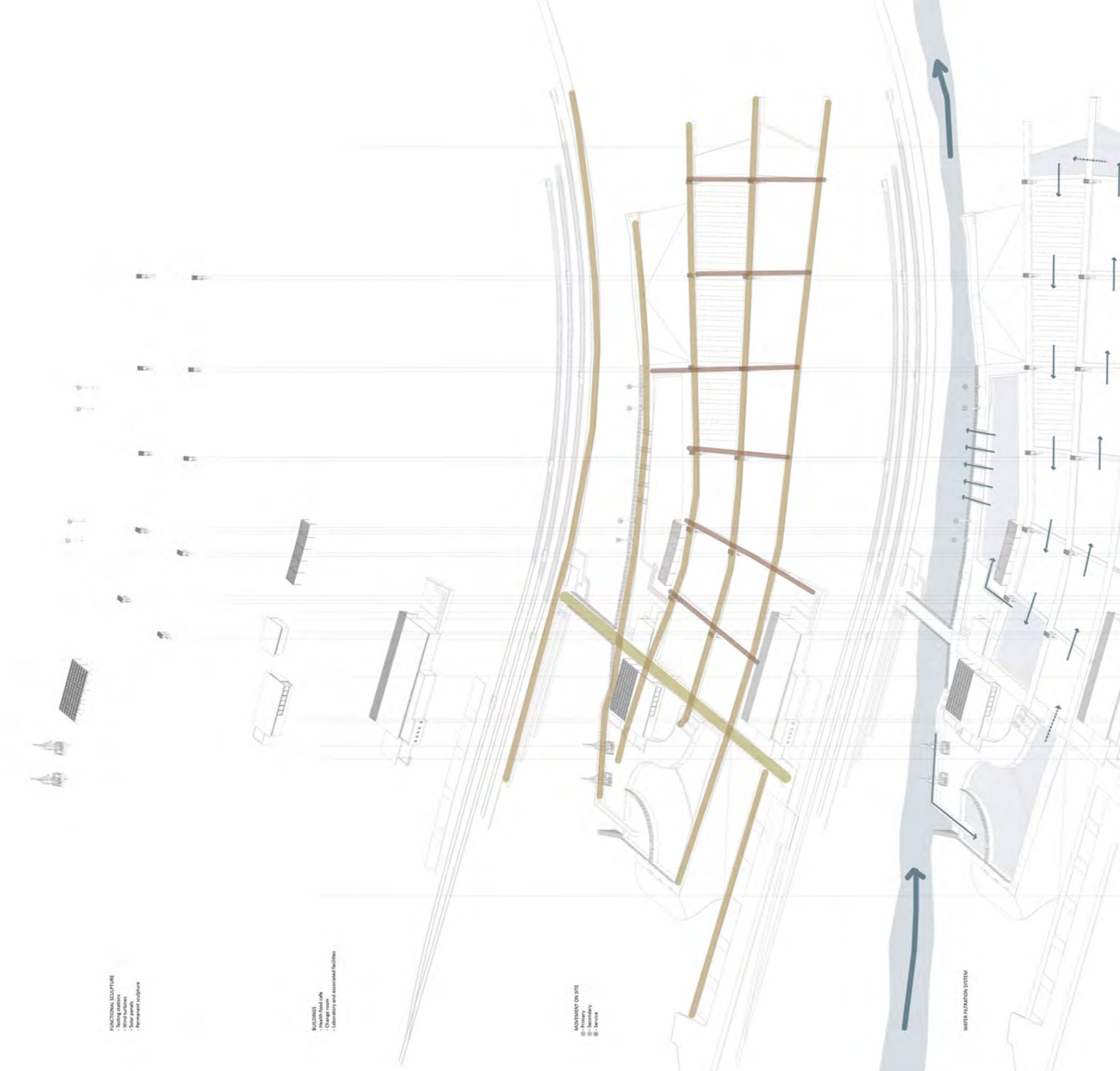


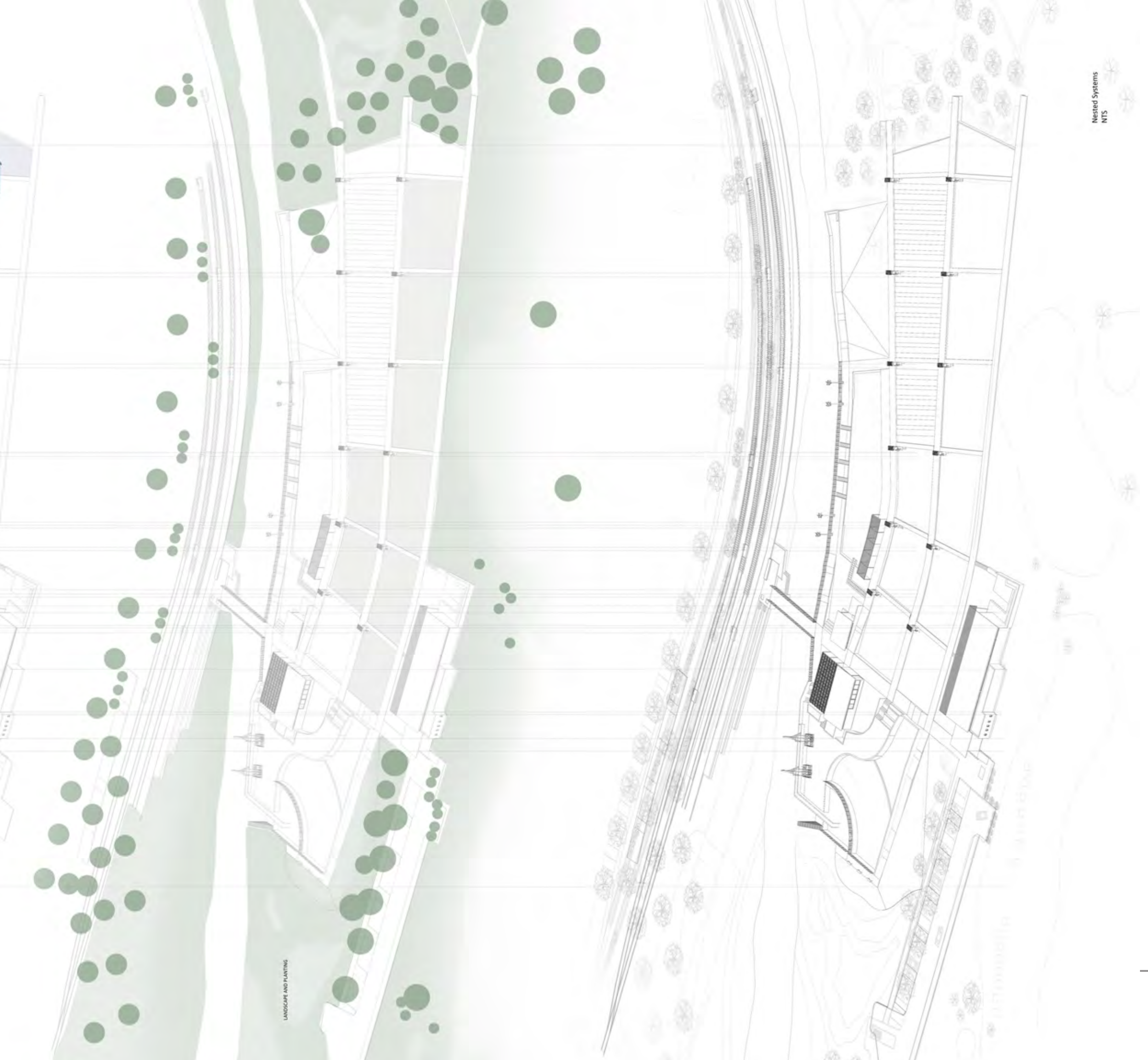
Section A-A
1:100

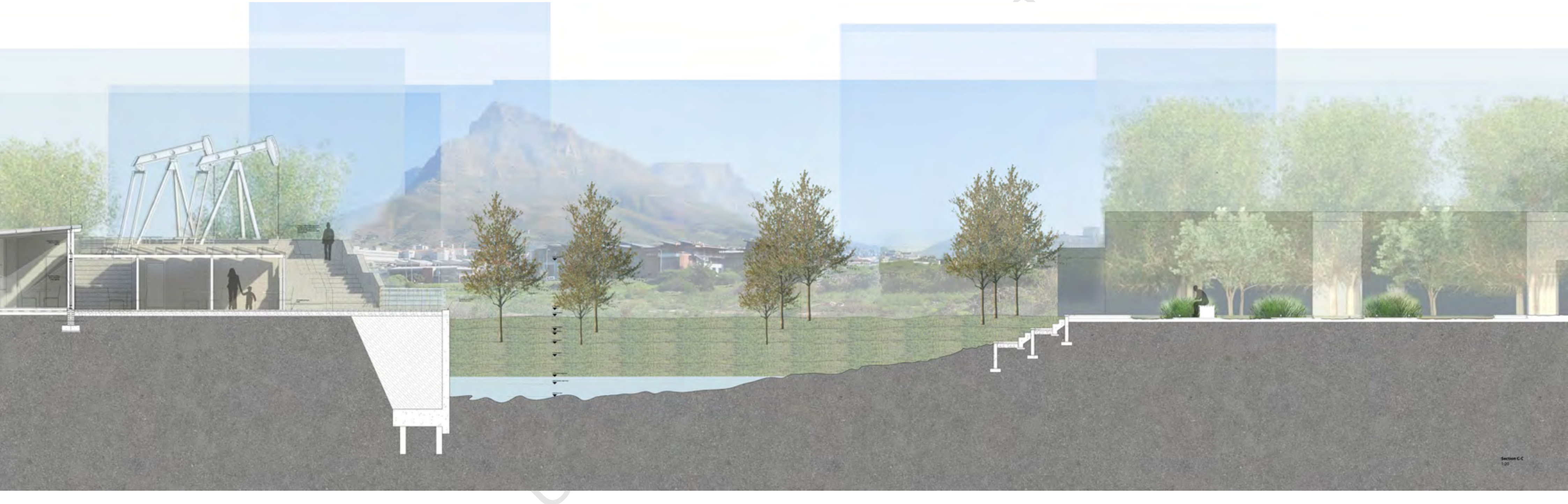


Section B-B
1:100

Section D-D
1:100


FUNCTIONAL SCULPTURE
- Testing stations
- Wind turbines
- Solar panels
- Permanent sculpture
BUILDINGS
- Health food cafe
- Change room
- Laboratory and associated facilities
MOVEMENT ON SITE
- Primary
- Secondary
- Service
WATER FILTRATION SYSTEM


LANDSCAPE AND PLANTING
Nested Systems
NTS



Long Section