Architecture as a driver for the athletic performance enhancement of professional swimmers at the University of Pretoria, TuksSport

by Ruan Ras - 04462794

Figure 1: Spectator's view at the TuksAquatics Centre (Author, 2021)

Declaration

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

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

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

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Ruan Ras

Figure 2: Swimming at the TuksAquatics Centre (Author, 2021)

Project Summary

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Research field: Memory, legacy and identity

Programmes:
Olympic standard aquatics sports training and competition venue with supporting facilities
Pubic recreational swimming pool and food court

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Key words:
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Figure 3: Swimming at the TuksAquatics Centre (Author, 2021)

Abstract

Sports architecture, through the standardisation and the intense control held by sports authorities over the past century, has experienced a change in identity: from a tool for social movements to a shell for commercial institutions (Payandi, 2013: 5-6). The commercialisation of sport has resulted in sport as an industry - and as a result, its architecture - having the main objective of economic gain, as opposed to the initial goal of sport to “better the individual” (Tao, 2017: 314). Architects should, therefore, revert back to this original objective, if they aim to design sports architecture that facilitates the enhancement of athletic performance for professional athletes as the main user-group of this project.

Contemporary sports architecture has evolved into a unified “international-style” of sports venue design (Payandi, 2013: 6-7), dislocated from its context and favouring *functionality* as the main design driver. The *experience* of the user or athlete is often ignored during the design process resulting in the architect only responding to some aspects of the professional athlete as their main user group. If the architecture carries any potential of “bettering the individual” (Tao, 2017: 314), through athletic performance enhancement specifically, the designer must spatially respond to the athlete as a whole - physically, emotionally, mentally and spiritually (Reynaldi et. al, 2019: 70). By responding to an athlete’s psyche (*experiential*) and their physical condition (*functional*), the architecture will be able to maximise its performance enhancement potential. In this mini-dissertation, the TuksAquatics Centre is used as a prototype site to investigate the impact that architecture can have on sport and its athletes.

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Part 1:

In this chapter, the research questions and objectives explored in this mini-dissertation are explained. A literature review aids in gaining a better understanding of the topic at hand, that is: sports architecture and its impact on the user and athlete. Through the literature review, a general, urban and architectural issue is identified and viewed in terms of the identified site: The TuksAquatics Centre at the University of Pretoria's Hillcrest Sports Campus. The state of current sports architecture is further analysed to determine the site's positioning in the continuum of local sports architecture. Lastly, a methodology of evidence-based design strategies paves the way for the following chapters.

Introduction

The need for sport largely roots from its ability to fulfill athletes' needs physically, emotionally, mentally and spiritually. In order for an athlete's needs to be fulfilled through sport, certain infrastructure is required to provide a 'place' for this activity to occur (Reynaldi et. al, 2019: 70). This infrastructure needs to be designed to accommodate the unique needs of athletes. David Winner implies an inherent relationship between the nature of *sport* and that of *architecture*. In his book, *Brilliant Orange: The Neurotic Genius of Dutch Soccer,* he describes sport as a "kind of architecture on the field" (Winner, 2008: 46-47). He expands on this by connecting athletes' movements to a form of spatial organisation (Cleary, 2017) (Figure 4). Space and movement are interlinked. These movements, whether they occur in informal play areas or in a large stadium, are all, in one way or another, a form of spatial expression (Cleary, 2017). Each movement takes place within a physical frame; be it markings in the sand or painted score-lines on a well-maintained pitch. The frame transforms general '*space'* into *'place'* (Cleary, 2017).

Sports architecture as 'places of activity' involve two factors: the frame (figure 5) and the performance (figure 6). The *frame* describes the physical layout and structure of the playing field, while the *performance* speaks of the actual movements and actions of users in the space (Cleary, 2017). Sports design therefore has an effect not only on the physical structure of a facility, but also on the performance of the athletes using it - the *frame* impacts the *performance*. Consequently, architecture plays a vital role in how a sport is played. However, functionality has become favoured in sports design (Payandi, 2013: 27-28) and the experience of the athlete is often omitted during the design process. This has resulted in architects not maximising the athletic performance enhancing potential of sports design.

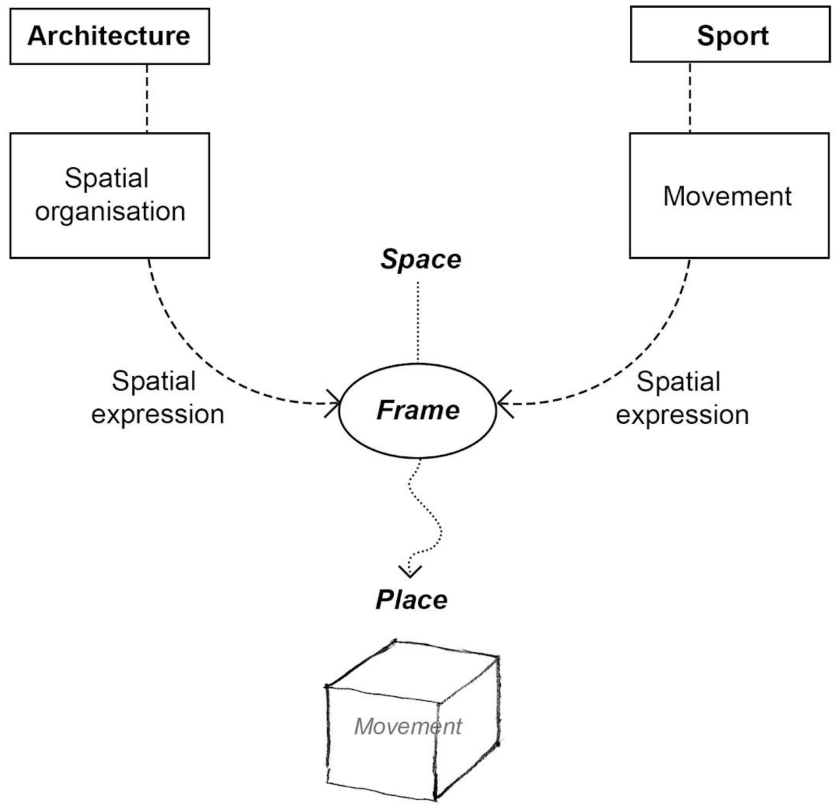

Figure 4: Relationship between sport and architecture (Author, 2021).

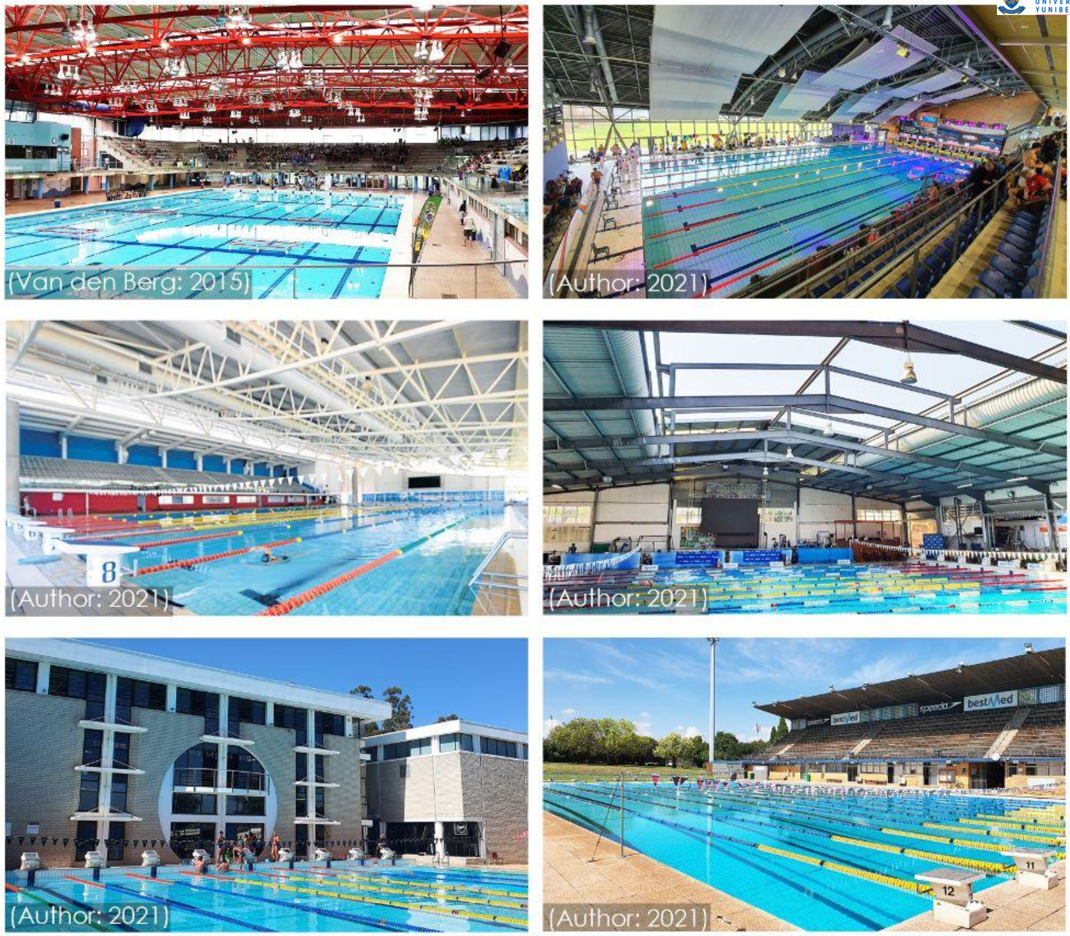

Figure 5: Examples of frames in the sport of swimming.

Figure 6: Examples of performances in the sport of swimming.

Research Questions and Objectives

In this dissertation I aim to identify spatial and functional drivers that aid in physically and psychologically enhancing athletic performance by determining a prototype for professional-athlete-centred sports architecture in the local context, specifically related to professional swimmers at TuksSport at the University of Pretoria.

The following questions arise:

1. How is current sports architecture, for professional athletes specifically, failing the athletes who use it?

2. How can the design of sports architecture be improved to benefit and enhance the athletic performance of the professional athletes it serves?

Figure 7: Currently failing sports facilities (O'Bryan, 2021).

Figure 8: The current condition of the TuksAquatics Centre (Schlechter, *2021*).

Literature Review

The *frame* discussed earlier presently takes the form of a variety of architectural typologies for sports facilities - each type serving a particular *function* and *user group*. The functions are divided into various scales of intervention ranging from national-scale to school-scale facilities (Reynaldi et. al, 2019: 71). The users correlate to the levels of sports participation, ranging from *professional-level* participation to *recreational* participation to *non-participation* (Deleen et. al, 2018).

Under closer investigation, these sports architecture typologies are formed around well-defined 'boundaries'. These boundaries regulate how the sport is played (Cleary, 2017). Regulation authorities and sporting associations typically set standards and requirements for the design of facilities in each specific sporting code. This gives architects a relatively good reference when designing sports facilities. However, there are few building typologies or standards that regulate the optimum training or competition environments outside of the physical dimensions of the field of play; for example, the intermediate spaces that athletes interact with on the lead-up to their race or match, like the marshalling room where athletes report before their race (Figure 9).

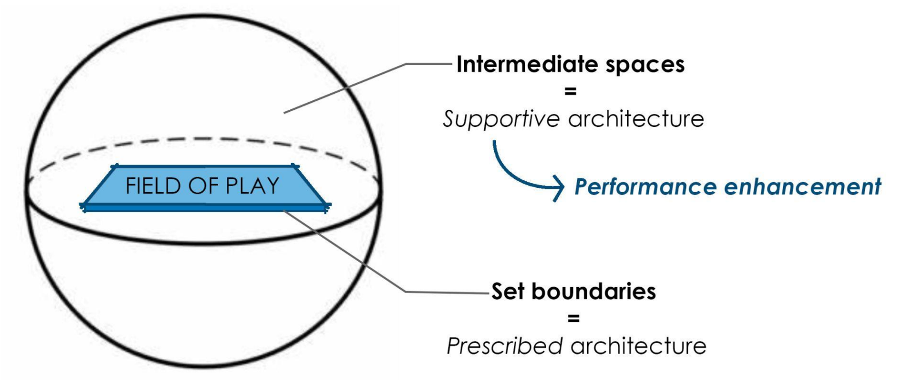

Figure 9: Intermediate spaces in sports architecture (Author, 2021).

Most sporting histories follow the general trend of the transformation of *informality* and *improvisation* into *standardisation* and *specificity* (Cleary, 2017). As the competitive nature of sport, in contrast to basic 'play', or other practices increased, the need to standardise playing fields grew to ensure fairness in competition. Earlier playing fields, which lacked specificity, allowed early sports architecture to be adapted and altered as needed by designers. Similarly, early games could be adapted to suit a variety of spaces, depending on the type of space available to athletes (Cleary, 2017). However, modern sport requires much more standardised settings (Figure 10). Most physical court or field dimensions became fully standardised in the 1920s (Cleary, 2017). Various sporting authorities emerged as a result of the need to govern this standardisation and fair practice in sport.

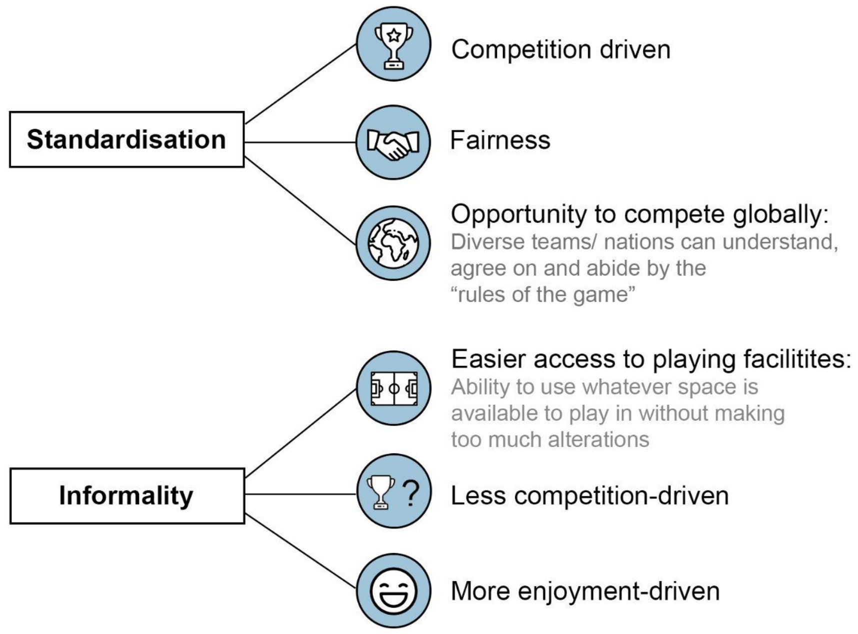

Figure 10: Standardised sport vs. Informal sport (Author, 2021).

As a **general issue**, sports architecture, through this standardisation and the intense control held by sports authorities over the past century, has experienced a change in identity: from a tool for social movements to a shell for commercial institutions (Payandi, 2013: 5-6) (figure 11). The commercialisation of sport has resulted in sport as an industry - and as a result, its architecture - having the main objective of economic gain, as opposed to the initial goal of sport to “better the individual” (Tao, 2017: 314). Architects should, therefore, revert back to this original objective (figure 12), if they aim to design sports architecture that facilitates the enhancement of athletic performance for professional athletes as the main user-group of this project.

In terms of the **urban issue**, contemporary sports architecture, also through the process of standardisation, has evolved into a unified “international-style” of sports venue design (Payandi, 2013: 6-7). This disconnect from context and global approach to design, has resulted in sports architecture becoming dislocated from its urban environment and from the people who live, work, train and play there. Also, over the past century, notions of nationalism, militarism and totalitarianism have skewed the role of sports architecture in the city (Payandi, 2013: 28): resulting in ‘sports architecture as monument’.

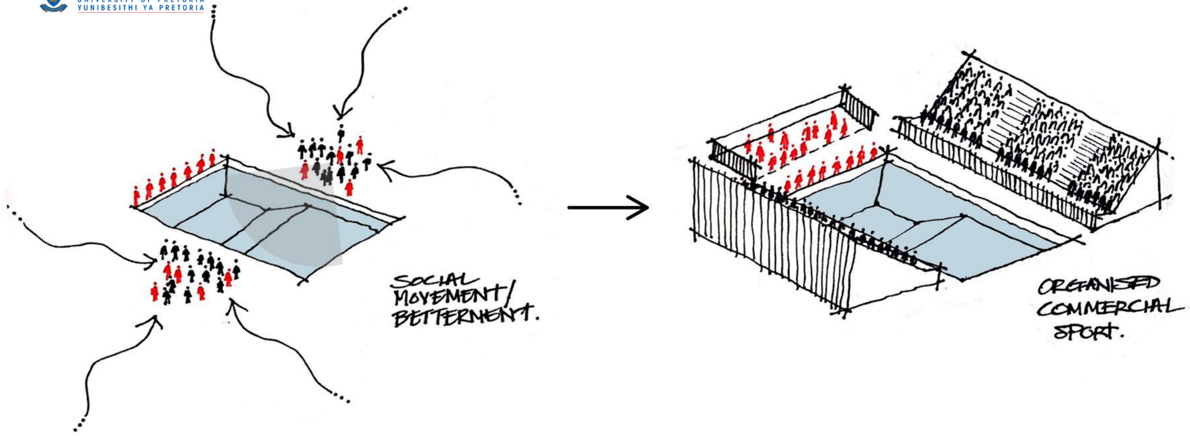

Figure 11: From a social tool to a commercial entity (Author, 2021).

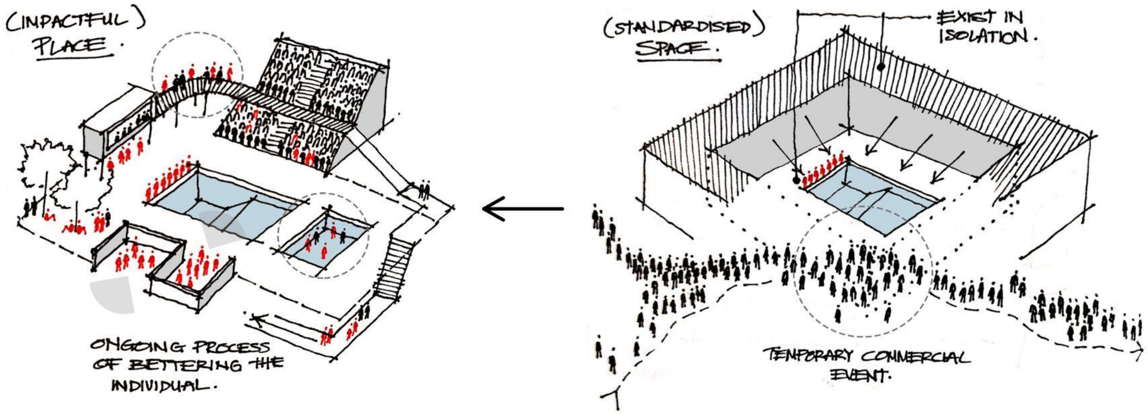

Figure 12: Return to an architecture to improve the individual (Author, 2021).

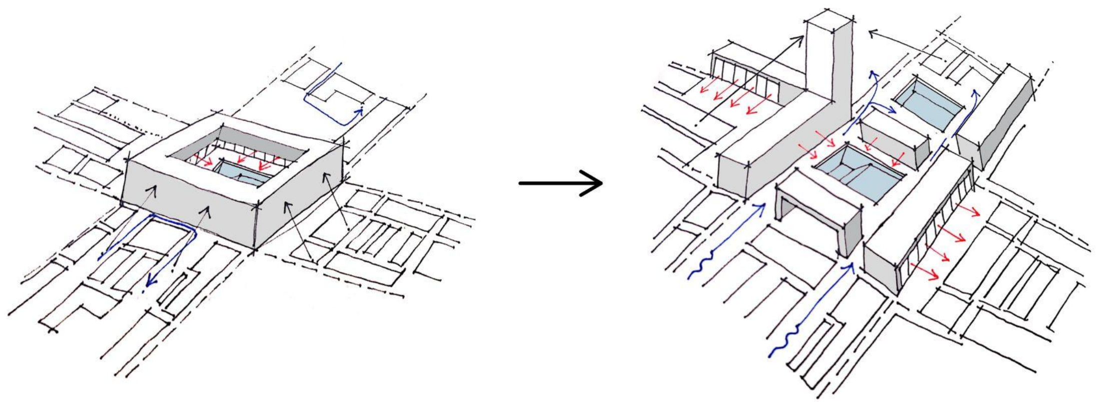

Figure 13: Reconnecting sports architecture to the surrounding fabric (Author, 2021).

Fortunately, current sports architects have started to move away from this idea of monumentalisation and have started to look to sports architecture as "modern cathedrals" in the city: places for "mass-pilgrimage" and "representative of hope" (Payandi, 2013: 27-28). For example, the 2012 London Olympics employed the slogan of "architecture for humanity" in an attempt to use the international sporting event and the *frames* which housed this event to make a positive contribution to the local people, economy and environment. Locally, these issues of monumental sports architecture that are disconnected from their urban environments can be generally seen in the stadiums constructed for the 2010 World Cup. The world-class stadiums remain heavily underused due to their *design's* lack of effective urban integration (Imray, 2012). Stadiums as landmark urban features may have many benefits, but if not correctly integrated into the urban fabric, they can often dominate and negatively impact the direct surroundings (Twardowski, 2018: 54). The design needs to respond to the periodicity of sports events (Figure 14).

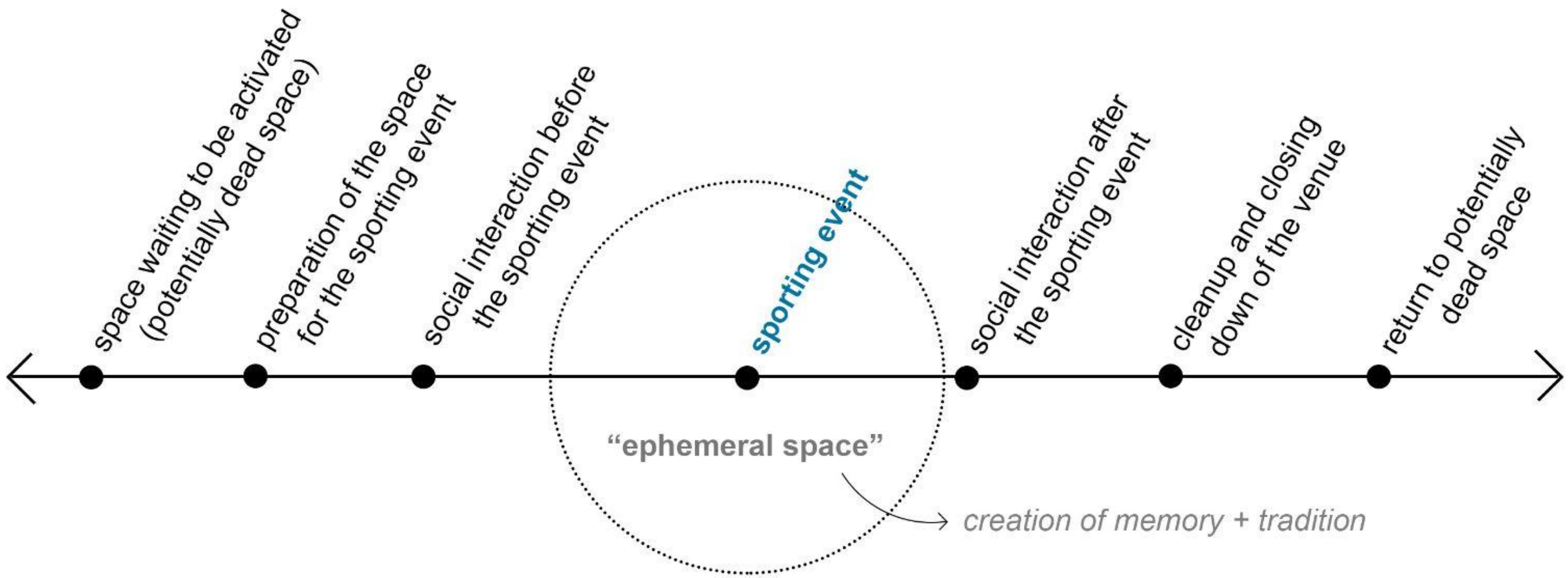

Figure 14: Periodicity in sports architecture (Author, 2021).

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Figure 15: Aerial view of the TuksAquatics Centre (Schlechter, 2021).

Figure 16: Aerial view of TUKS swimmers training (Schlechter, 2021).

Locally, rapidly decaying local swimming training and competitions facilities has become widely evident in South Africa (Crossley, 2021; Scheepers, 2021; O'Bryan, 2021) (figure 17). With no users and activity, even the 'memory of place' is eventually lost (figure 18). Disconnected and unsustainable design solutions mean that the sports venues will be unable to assist our professional athletes - detracting from the athletic performance enhancement potential of sports architecture.

Figure 17: Rapidly decaying local sports architecture.

(Citizens of Mzanzi: 2021)

(Forgotten in Africa: 2021)

Figure 18: Abandonment and loss of memory.

The selected site is at the TuksAquatics Centre of the University of Pretoria, Hillcrest Sports Campus, built during the 1970s (figure 19). The campus and Aquatics Centre specifically, currently accommodate the training and competition of various national and international-level athletes and swimmers, making it the ideal environment to design architecture that enhances athletic performance. Architecture on the sports campus can be located as part of the continuum of sports architecture by comparing it to the evolution of the stadium (Payandi, 2013: 37-44) as the most iconic form of sports design. The general architectural trend seen on campus exists between the basic and the multifunctional stadium (Figure 20).

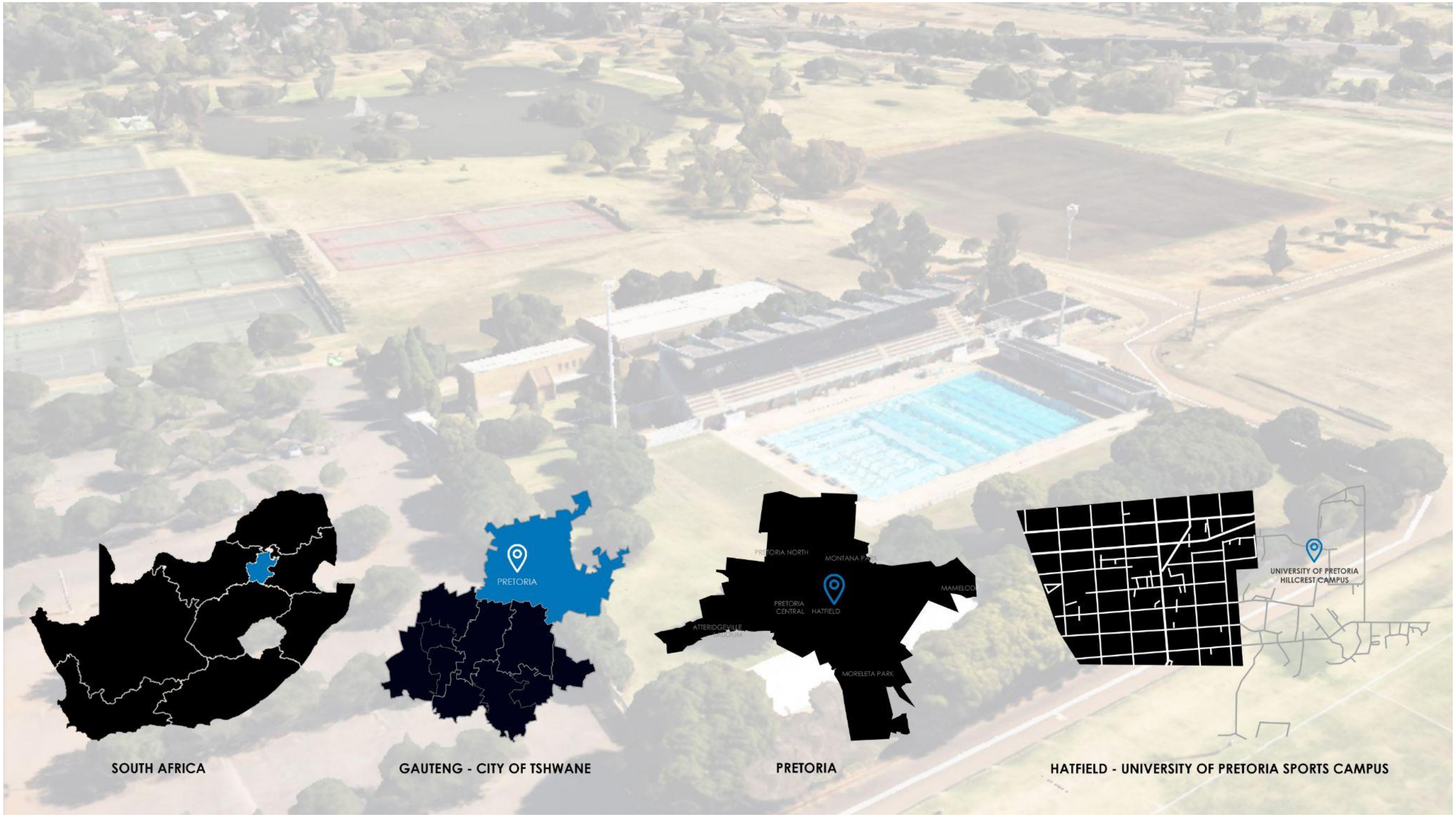


Figure 19: Site location (Based on GoogleEarth, 2021).

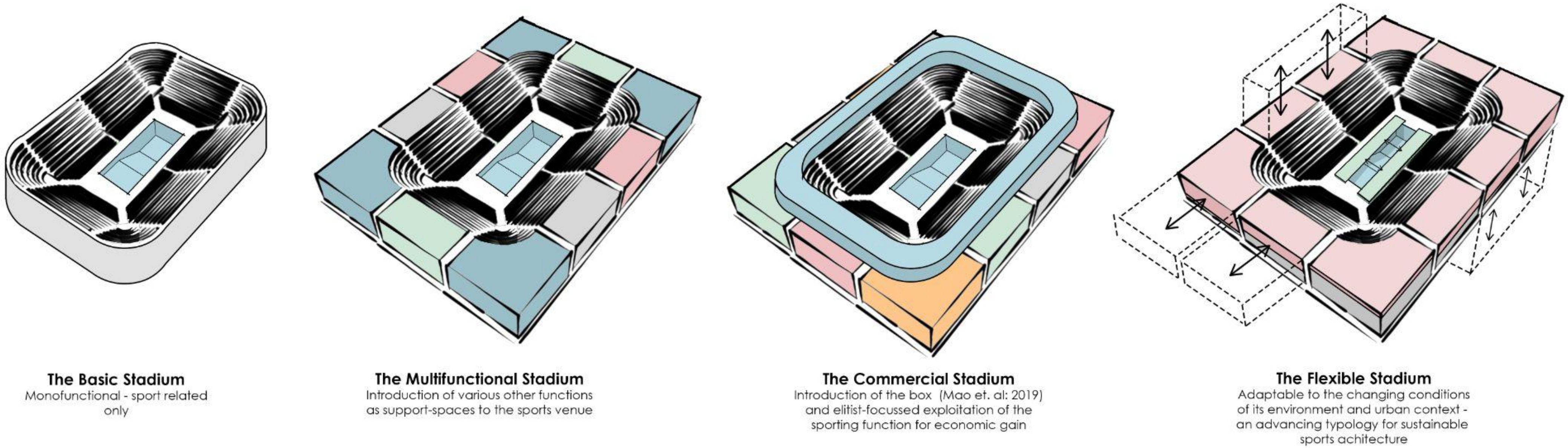


Figure 20: Evolution of the stadium (Author, 2021).

Bernard Tschumi conceptualises architecture as “the activation of a space through the movement of bodies” (Tschumi, 1995). However, sports spaces on the campus depend on their function to keep them alive. As soon as function, in the form of sporting events, ceases, so too does the activity on the campus. The temporality of sports architecture must, therefore, be addressed. The architecture on the Hillcrest campus must borrow from newer notions of stadium design: *The flexible stadium* (Payandi, 2013: 44). Existing principles of responsible urban design, public integration, sustainable design and adaptable architecture can be used to provide lasting training and competition venues that support our local athletes (Twardowski, 2018: 54).

Past stadium-designs have proven unsuccessful in this regard, with Sheard comparing them to “inhospitable concrete bowls of the twentieth century” (Sheard, 2001: p.1-18). However, recent designs of Olympic stadiums have begun to employ *adaptable* and *multifunctional* design principles to enhance their sustainability (Hudec et. al, 2016: 1393-1397). For example, the IOC insists that its sporting venues are designed with strict environmental sensitivity in mind (Sheard, 2001: 60-67). Issues that are promoted by the IOC include: environmentally friendly construction materials, efficient energy usage and waste management, minimising building maintenance and designing contextually sensitive buildings that are responsibly inserted into existing urban structures with the aim of improving and uplifting these structures (Twardowski, 2018: 54).

Furthermore, in terms of the architectural issue, due to the commercialisation of sport and through the process of standardisation in sports environments, functionality has become favoured in sports design. The experience of the user or athlete is often ignored during the design process resulting in the architect only responding to some aspects of the professional athlete as their main user group. If the architecture carries any potential of “bettering the individual” (Tao, 2017: 314), through athletic performance enhancement specifically, the designer must spatially respond to the athlete as a whole - physically, emotionally, mentally and spiritually (Reynaldi et. al, 2019: 70) (figure 21). By responding to an athlete’s psyche (*experiential*) and their physical condition (*functional*), the architecture will be able to maximise its performance enhancement potential.

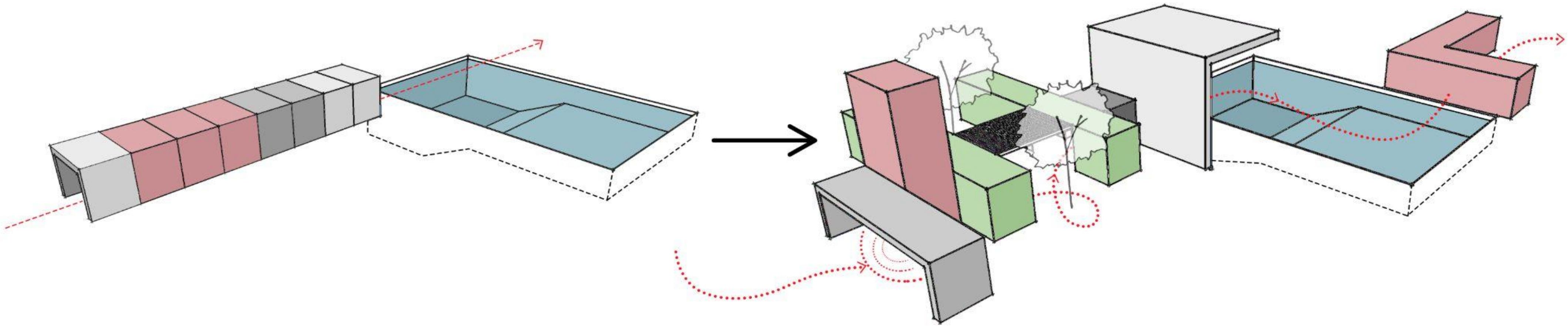


Figure 21: Injecting ‘experiences’ into functional architecture (Author, 2021).

Current condition of sports architecture

The physical space of the typical sporting venue can be organized into *levels of interes*t (Figure 22). Woodbine describes these levels as a series of layers or circles expanding outwards from the playing field (Cleary, 2017). Each level of interest induces a different design approach to suit the varying users and their unique functional and experiential needs. These levels of interest can be further subdivided into sub-levels like *class*. The separation of class in spectator spaces dates back to as far as the ancient Colosseum in Rome, where seats were divided into five zones based on class and prestige (Mao et. al, 2019).

Many present-day sporting arenas also separate spectator spaces based on levels of class: from the basic spectator seat (open, shared and grouped according to its distance from the playing field) to the *boxes* for the more privileged sports enthusiasts (exclusive viewing rooms with added features like bar areas, better views and private ablutions). Since the 1990s there has been an increasing number of spectator boxes in NBA arenas (Mao et. al, 2019). These commercialised sports centres target elite groups to increase the profitability of the venue.

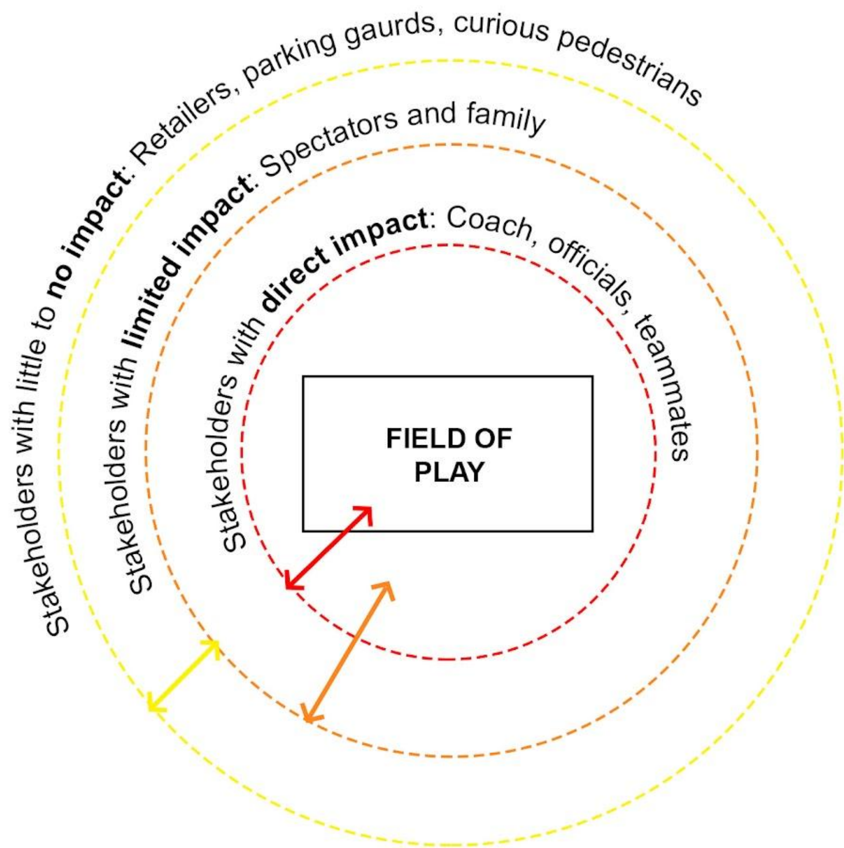


Figure 22: Injecting 'experiences' into functional architecture (Author, 2021).

However, one can design for more inclusive ways of ensuring the economic feasibility of sports facilities (Figure 23). For example, in 2010 at the Guangzhou Asian Games, nearly 20 years after the introduction of the box in NBA stadiums, China fully adopted the United State's commercialised model of the box. Boxes became not only a platform for sports entertainment, but also for a variety of performing arts. Its multifunctionality improved its utilisation rates, in turn, increasing its profitability (Mao et. al, 2019). In this way, designing adaptable and multifunctional spaces can enhance the usability and sustainability of the architecture, making it more economically viable.

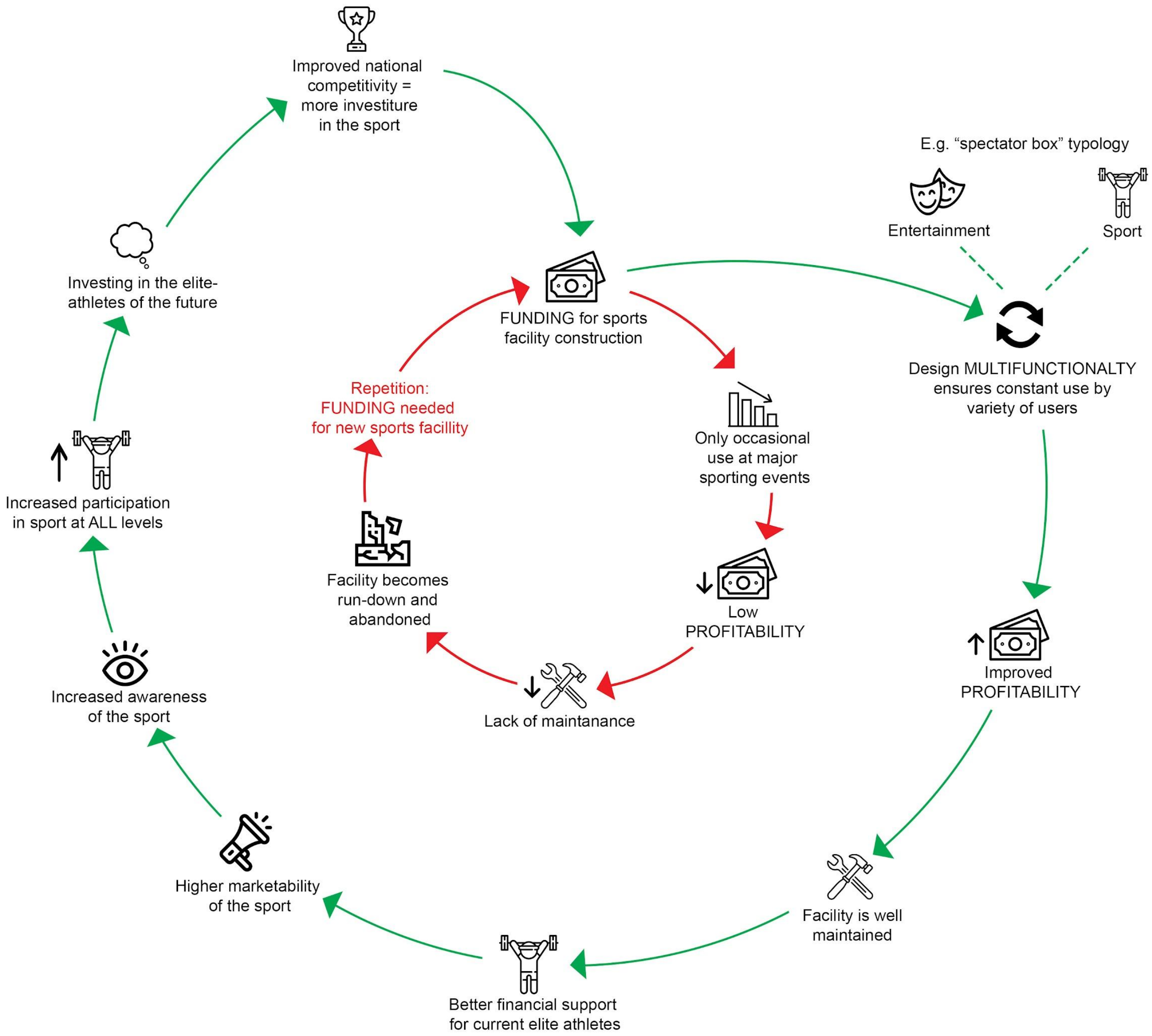


Figure 23: Economic feasibility in sports architecture (Author, 2021).

Methodology

As a competitive swimmer myself, I am also a potential user of the architectural intervention: Therefore I am borrowing from my own experiences (which are *subjective*) as well as theory (which is *objective*) to investigate the athletic performance-enhancing potential of architecture. The research methodology responds to the holistic approach needed for athlete-centred design; thus, responding to the athlete's psychological and physiological conditions to enhance the functionality and experience of sports-related spaces. This is done through interpretivist qualitative studies that are based on evidence-based design principles (figure 18). Research will be done in accordance with all required ethical considerations such as anonymity and voluntary participation in studies and interviews.

According to psychology professor Irving Weiner, environmental psychology can affect one's mood and behaviour (Moses, 2012) which, in turn, affects one's physiological condition (Deasy, 1990: 112). Environmental psychology and architecture are connected by means of 'evidence based design'. Evidence-based design can thus be used to respond to the psychological and physical stressors experienced by elite athletes. In this way, architecture is used as a holistic spatial solution. Four key aspects from Malkin's book, *A Visual Reference to Evidence-Based Design* (2008), have been identified for the effective use of evidence-based principles in architecture. These form the basis of my research methodology (figure 24):

- Contextually driven design responses related to the chosen site, the existing buildings and the proposed campus framework,
- Theory driven design through the literature review and investigation of relevant architectural theories to find confluences between sports psychology, environmental psychology and architecture,
- Critical design responses where theory is translated into spatial interventions to respond to the *experiential* quality that is needed in sports-related design, as well as
- Collaboration with the users in the form of interviews with athletes and coaches (see Appendix A).

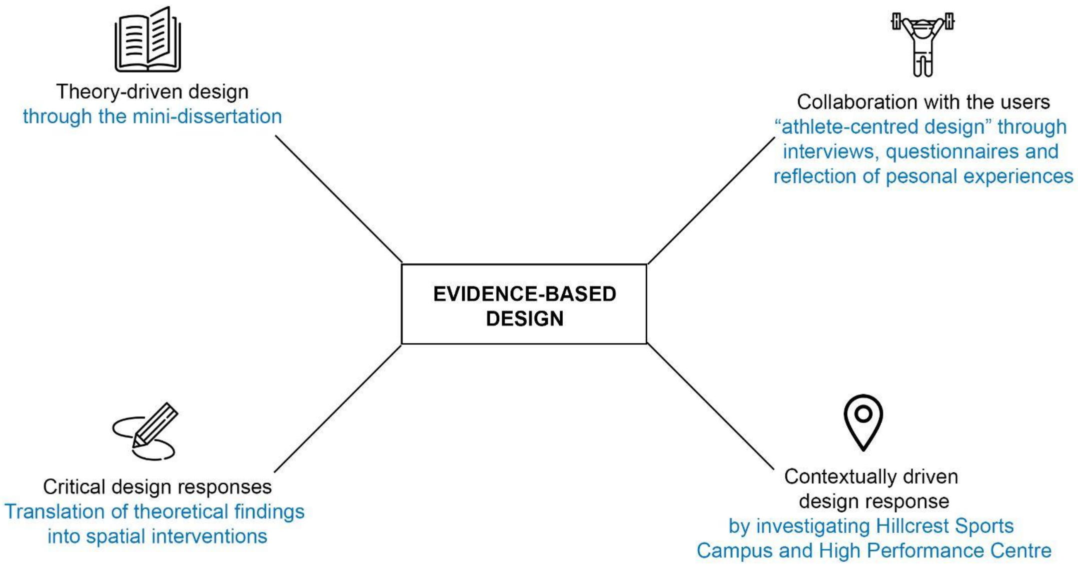


Figure 24: Key aspects for the effective use of evidence-based design principles in architecture (Adapted from Malkin, 2008).

Evidence Based Design and Sports Psychology

Evidence-based design has been widely used in research pertaining to "healing environments" in *hospitals*. The design of "healing environments" is to use neuroscience to benefit from the effect of "psychologically supportive" spaces on the immune system of patients (Malkin, 2008: 2). However, evidence-based design research goes further than merely healing environments. It is an investigation of how external stressors on users can be reduced, how the operational efficiency of a building can improve the quality of the service it accommodates as well as improving the safety of its users (Malkin, 2008: 2). Evidence-based design can thus be taken further than merely hospital design and can be incorporated into other programs as well (Figure 26).

Cohn and Gullu (2020) identify a variety of mental stressors experienced by athletes that could negatively impact their performance (figure 25). These stressors include: a lack of focus, lack of confidence, anxiety, not coping with external factors, feelings of discouragement when injuries occur as well as strained athlete-coach relationships. The architecture must employ evidence-based design principles that resolve these issues, such as:

- Noise reduction in spaces through material choices and zoning of programs to enhance focus (HMC, n.d. and Malkin, 2008: 8),
- Improved natural lighting to keep athlete's minds alert (HMC, n.d. and Malkin, 2008: 8),
- Flexible spaces to give athletes control over their environment to induce feelings of confidence (Winkel et. al, 1986 in Malkin, 2008: 8),
- Removing environmental stressors such as designing shelter from weather (Malkin, 2008: 9),
- Injecting nature into the design to induce calmness in certain spaces where athletes may feel most anxious (Ulrich, 1984 in Malkin, 2008: 8),
- Designing for social spaces that encourage healthy interaction and support between teammates (Kiecolt-Glaser, 1998 in Malkin, 2008: 8),
- Multisensory design principles that act as positive distractions to avoid pre-race anxiety (Taylor, 1997 in Malkin, 2008: 9),
- Enhancing sensory experiences in certain spaces to induce energy and excitement, for example, before a race (Malkin, 2008: 9), and
- General sustainable design principles that enhance general health such as sufficient ventilation and easy maintenance of spaces to prevent mould and other health hazards.

Figure 25: Stressors experienced by athletes pre-race (Chase, 2016).

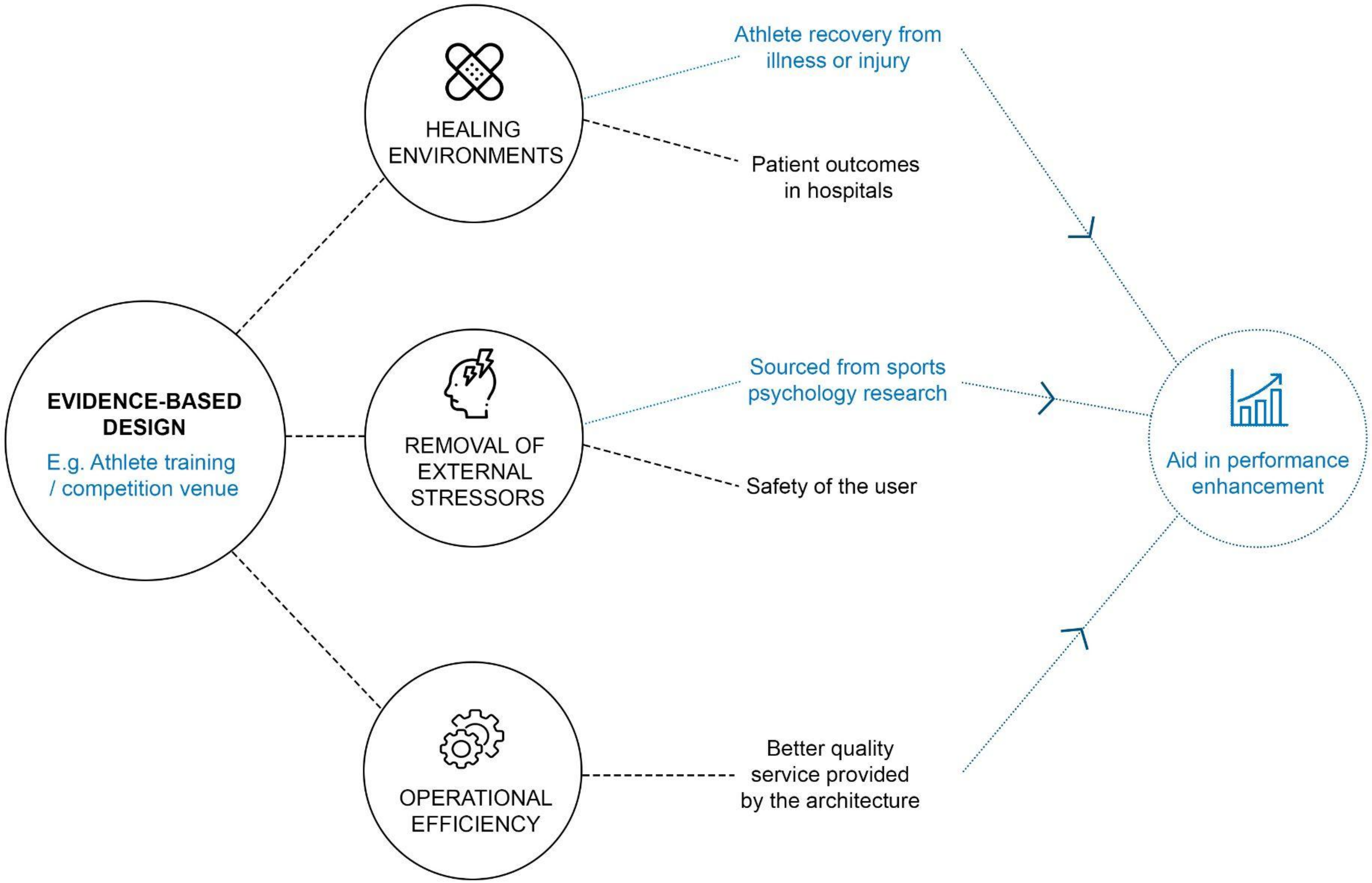


Figure 26: Relevance of evidence-based design for athletic performance enhancement (Adapted from Malkin, 2008).

Design for Athletes' Physiology

Furthermore, the physical principles of athletic performance enhancement will also be translated spatially, so functionality is not omitted as it does carry value, but no longer exists in isolation (figure 27). In terms of improving the physical condition of an athlete through design interventions, one must first look at the most common physical stressors experienced by competitive athletes. One very common example is that of injury. Firstly, the design should promote injury prevention through ergonomic design (Ju, 2016: 2). Secondly, the appropriate use of materials becomes vital, for example, the material used to construct the floor on a running track versus that of a weights room: running as a high impact exercise requires a softer floor finish, like astroturf, to reduce the impact on athletes' joints, while the floor finish in weights rooms should be considerably harder to enhance stability while lifting heavy weights.

Furthermore, the design should enhance the effectiveness of athletes' physical activities in their training environments. Reynaldi, Kridarso and Iskandar (2019) promote 'hi-tech architecture' as a major design driver for modern-day sports architecture that could aid in achieving this. They do not make reference here to the hi-tech architectural movement of the 1970s. Rather they encourage architecture that involves advanced technology to improve the building's functioning. Including technology as a key component in sports-related design can significantly impact the overall social, cultural and physical functioning of athletes' training and competition environments (Tao, 2017: 312). A variety of factors are influenced, including designing safer spaces for athletes to train and compete in (Mainetti et. al, 2016: 1).

High-Tech architecture does, however, enhance the adaptability of a building (Reynaldi et. al, 2019: 71). Adaptability in architecture defines the structure's ability to take on a new function, program or purpose (Hudec et. al, 2016: 1394). Similar to adaptable architectural structures, athletes also adapt to the actions of their opponents or teammates - changing their movements, spatial layout on the field or position on the court (Cleary, 2017). Adaptation lies at the core of both good sport and good architecture. For example, multifunctional and adaptable design can be used in sports venues to allow diverse training methods to be employed where coaches with varying training approaches would require different spatial conditions. The spaces should be flexible to be able to adapt to these changing physical needs.

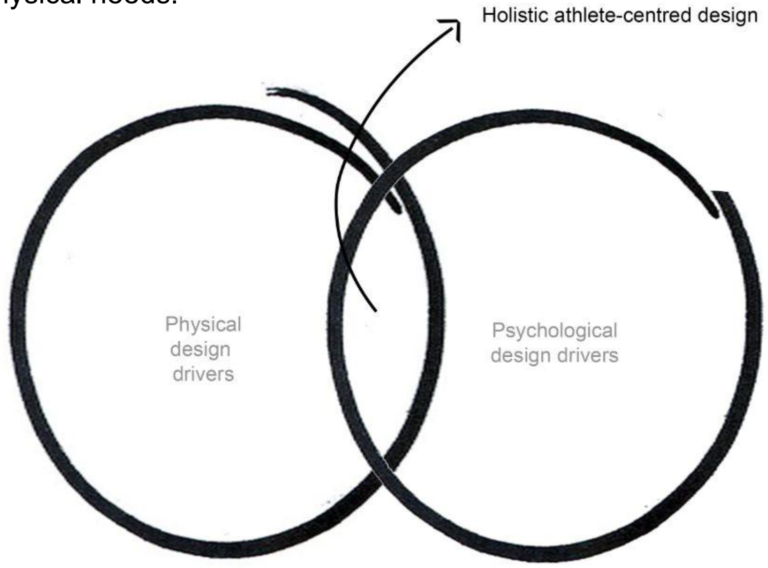


Figure 27: Holistic athlete-centred design (Adapted from Malkin, 2008).

Conclusion

The setting for the majority of modern sports has well-defined ‘boundaries’ that regulate how the sport is played (Cleary, 2017). However, few building typologies or standards regulate optimum training or competition environments of intermediate spaces outside of the physical dimensions of the field of play. These intermediate spaces have major physical and psychological effects on the eventual performance of an athlete. An internationalised standard sports design prototype will not suffice. Rather, a holistic approach to athlete-centred design is needed that spatially responds to the athlete’s psyche, emotions and physical condition in sustainable ways to promote the further development of the sporting industry and its athletes. In line with my normative position, a contextually responsive, sustainable and user-centred design that employs both functional and experiential design principles could potentially aid in spatially enhancing the athletic performance of local athletes in their training and competition environments.

Figure 28: Swimmers training at the TuksAquatics complex (Caldecott, 2019)

Part 2: Design research

In this chapter, an analysis of the existing spatial, functional and experiential condition is conducted. The existing issues on site, in terms of performance enhancement, are addressed through the new intervention's response to the old. The new intervention is unpacked below, describing how evidence based design theory is translated spatially to create a more appropriate and beneficial architecture for the athlete.

Introduction

Architecture, shaped by its boundaries, impacts the user far beyond the mere physical presence of the building as an object in space (Sfinteş, 2012: 1). Instead, its scope goes further to satisfying various human desires and needs. Architecture carries potential to enhance athletic performance through the psychological and physiological impact that designed spaces have on athletes (Moses, 2012 and Deasy: 1990, 112). Through the lens of *evidence-based design* as a means of bridging the gap between architecture, environmental psychology and sports psychology (Malkin, 2008), the *context* and *user* play a vital role in the success of the design's intention to aid in athletic performance enhancement. The context is investigated through an analysis of the existing spatial characteristics, materiality, functionality and architecture that is found on the University of Pretoria Hillcrest Sports Campus; while the user is placed central to the design scheme through critical design responses based on theory and confluences found between sports psychology and environmental psychology as well as collaboration with the end user and other important stakeholders. This critical approach to design is where theoretical findings are translated into spatial and functional interventions that form the architecture - as opposed to a predetermined form into which functions are placed (as is the case in many sports architecture and stadium designs). The formalist approach seems to negate the *experience* of the user - the very experience that evidence-based design theory has proven can have positive psychological and physiological effects on the athlete and, in this project specifically, contribute to their athletic performance enhancement. Rather, form is derived through spatial translations of evidence-based design theory. The role of architecture shifts from a *passive* one to an *active* one; a permanent functional shell to a dynamic space that evokes unique experiences that allow for the creation of a *place* (Sfinteş, 2012: 2).

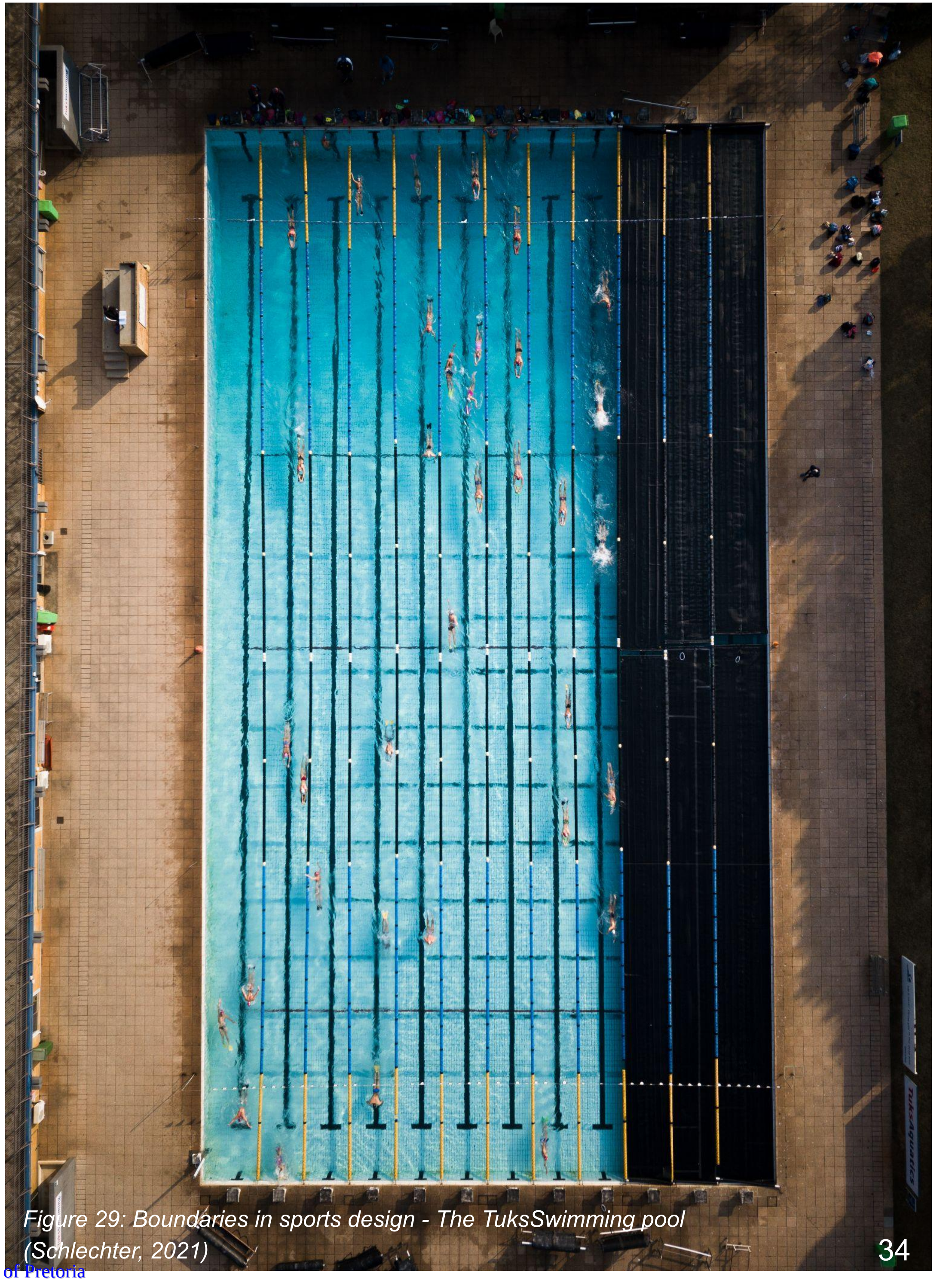


Figure 29: Boundaries in sports design - The TuksSwimming pool (Schlechter, 2021)

Unpacking the existing

The existing TuksAquatics and squash complex houses a variety of spatial problems that could possibly detract from athletic performance. In order to find solutions to ineffective sports architectural typologies, the faults and problem spaces on the site need to be identified. The complex exists as an isolated element in the larger landscape of the Hillcrest campus, almost entirely blocked off from surrounding facilities and urban spaces. The existing site is yet another example of sports architecture that is disintegrated from its urban (or campus) environment.

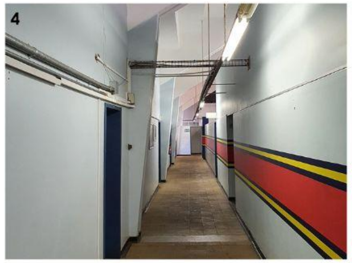
The complex is perceived to be highly inaccessible with only one small entry and exit point to the entire complex. The site is further rendered inaccessible due to the impenetrable edge conditions of the existing buildings. At the west, the existing squash courts create a solid mass, restricting both physical and visual access into the site. At the north, pump rooms and store rooms create a wall of monofunctional spaces that do not interact with the street edge. Furthermore, the impermeable boundary condition creates pockets of dead space throughout the perimeter of the site (figure 30 and 31).

Upon entry into the site, a narrow walkway leads users towards a dead-end with sharp turns to the pool complex at the east or the squash courts at the west. The supporting spaces to the field of play are organised along narrow hallways with no visual access to the internal spaces. Many of the existing internal spaces and rooms have been left unused and either lie empty or as unplanned, unorganized store rooms. Furthermore, the spectator spaces are accommodated only by small staircases at each end. Function and minimum spatial requirements seem to be catered for, but the experiential factor of space appears to be fully negated. Missed spatial opportunities on site include closed-off rooms at the perimeter of the central courtyard as well as disconnected green spaces stretching from west to east across the site. In summary, the major issues lie in the disconnected spaces within the site and, ultimately, the site's disconnection with surrounding facilities on campus (figure 30 and 31).

Western facade of the squash courts: Solid, inaccessible wall.

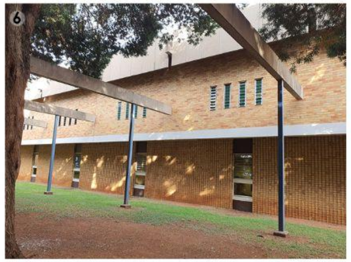
Northern facade of the pool complex: Monofunctional dead spaces (pool pumps and storage rooms).

Resultant dead spaces on the perimeter of the site.



Long, narrow hallways in the swimming pool complex with no visual access to internal spaces.

Long narrow hallways in the squash complex with limited views to the central courtyard.



No provision made for live-out spaces to the central courtyard (eastern facade of the squash court complex)

No provision made for live-out spaces to the central courtyard (western facade of the swimming pool complex). No views through to the field of play.

Figure 30: The existing condition of the TuksAquatics Centre (Author, 2021).

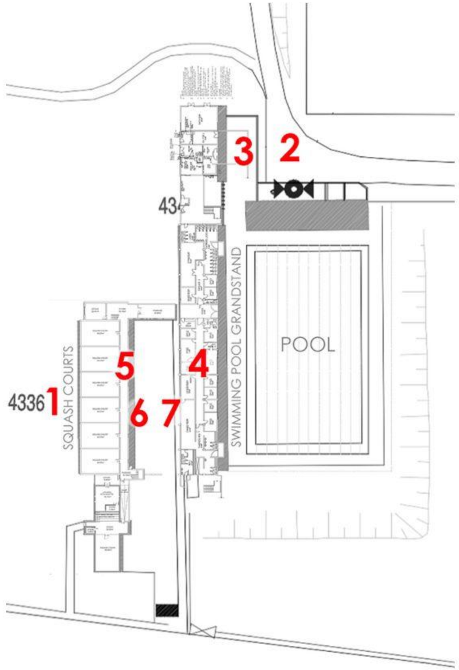


Figure 31: Plan of existing building as key for photographs (Adapted from Verbeek, 2020).

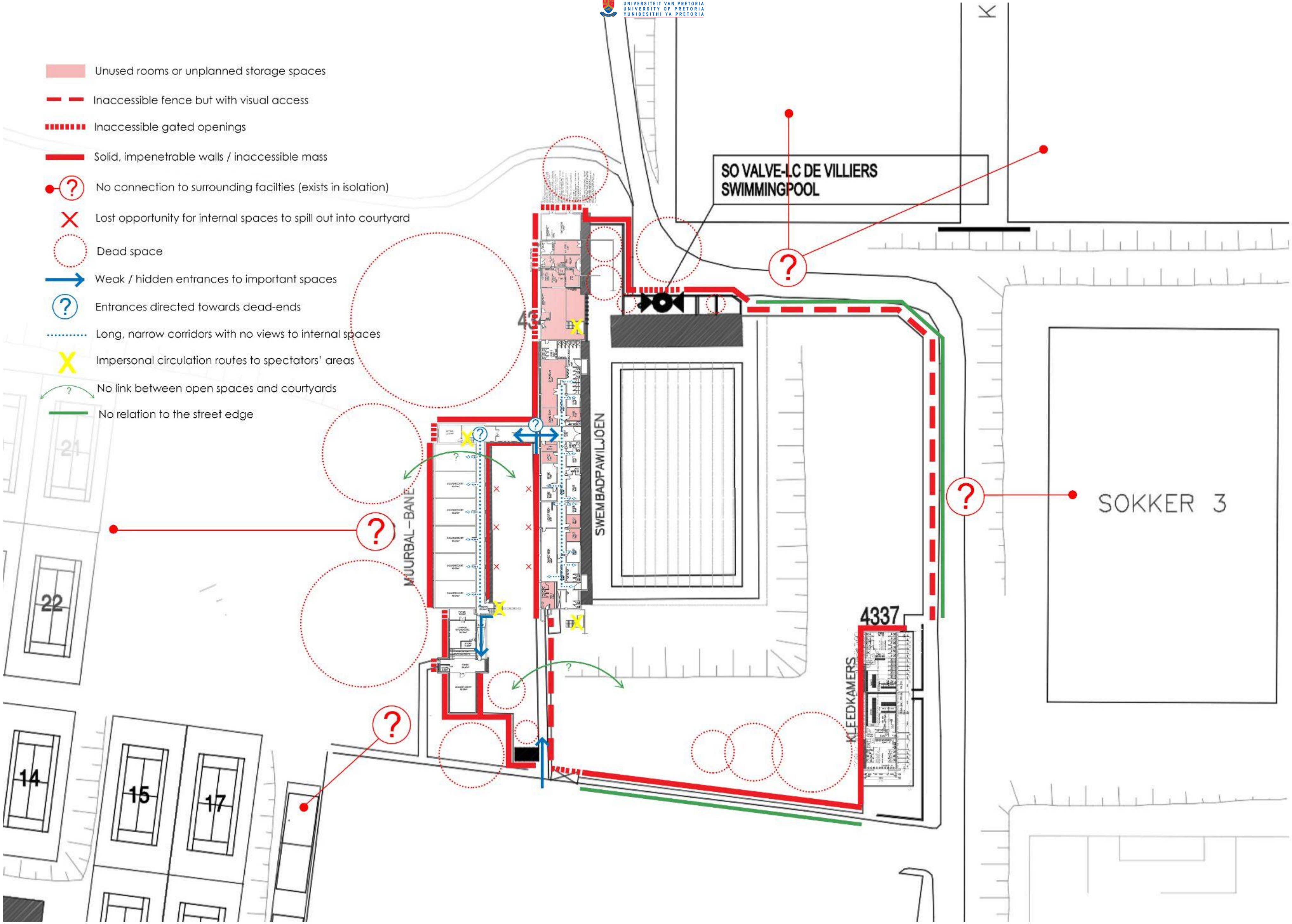


Figure 32: Critique of the existing condition of the TuksAquatics complex (Based on Verbeek, 2017; Dinolofatsi, 2009; Dinolofatsi, 2020, Dinolofatsi, n.d.).

Unpacking the existing:
Photos of existing spaces on site

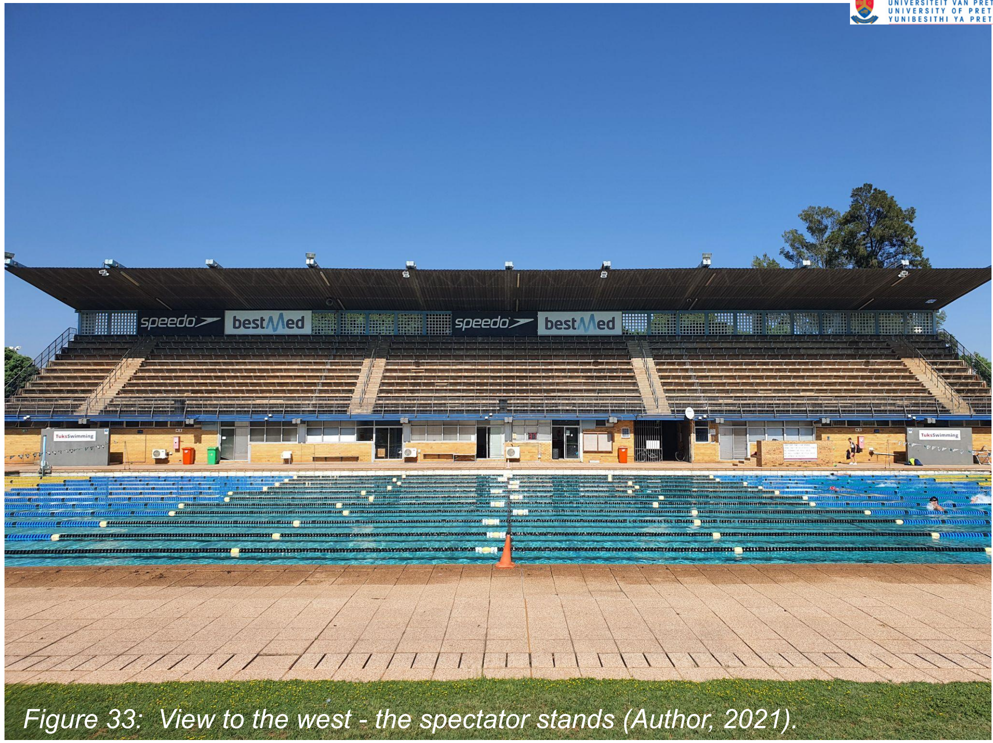


Figure 33: View to the west - the spectator stands (Author, 2021).

Figure 34: View to the north (Author, 2021).

Figure 35: Green open space at the south (Author, 2021).


Figure 36: Unused gym at the north (Author, 2021).

Unpacking the existing:
Photos of existing spaces on site

Figure 37: Pool-deck access to shared ablutions (Author, 2021).

Figure 38: Forgotten victories hidden in the coach's office (Author, 2021).

Figure 39: Unwelcoming coach's office (Author, 2021).

Figure 40: Unused braai area due to bad locality (Author, 2021).

Unpacking the existing:
Photos of existing spaces on site


Figure 41: Old equipment stored and left unprotected (Author, 2021).


Figure 42: Informal kit-bag storage on pool-deck (Author, 2021).

Figure 43: Failed tuks-shop and cafe' due to bad locality (Author, 2021).


Figure 44: Waterpolo equipment left without dedicated storage (Author, 2021).

Unpacking the existing:
Photos of existing spaces on site

Figure 45: Staircase to the spectator stands (Author, 2021).

Figure 46: The spectator stands (Author, 2021).

Unpacking the existing:
Photos of existing spaces on site


Figure 47: View to the north-east from the spectator stands (Author, 2021).


Figure 48: View to the west from above the spectator stands (Author, 2021).


Figure 49: View to the south-east from the spectator stands (Author, 2021).


Figure 50: View to the west from above the spectator stands (Author, 2021).

Unpacking the existing:

Photos of existing spaces on site

Figure 51: Vehicle entrance to the pool (Author, 2021).

Figure 52: Concrete fences surrounding the entire facility (Author, 2021).

Figure 53: Main pedestrian entrance to the pool (Author, 2021).


Figure 54: Views to the pool from far-off through the fences (Author, 2021).

Unpacking the existing:
Photos of existing spaces on site

Figure 55: Competition squash court (Author, 2021).

Figure 56: Unused open land and impermeable walls at the west of the squash courts (Author, 2021).

Figure 57: Fences and gates within the facility (Author, 2021).

Figure 58: Closed-off edges of the squash complex (Author, 2021).


Figure 59: Endless fences at the north (Author, 2021).


Figure 60: Inaccessible spectator spaces (Author, 2021).

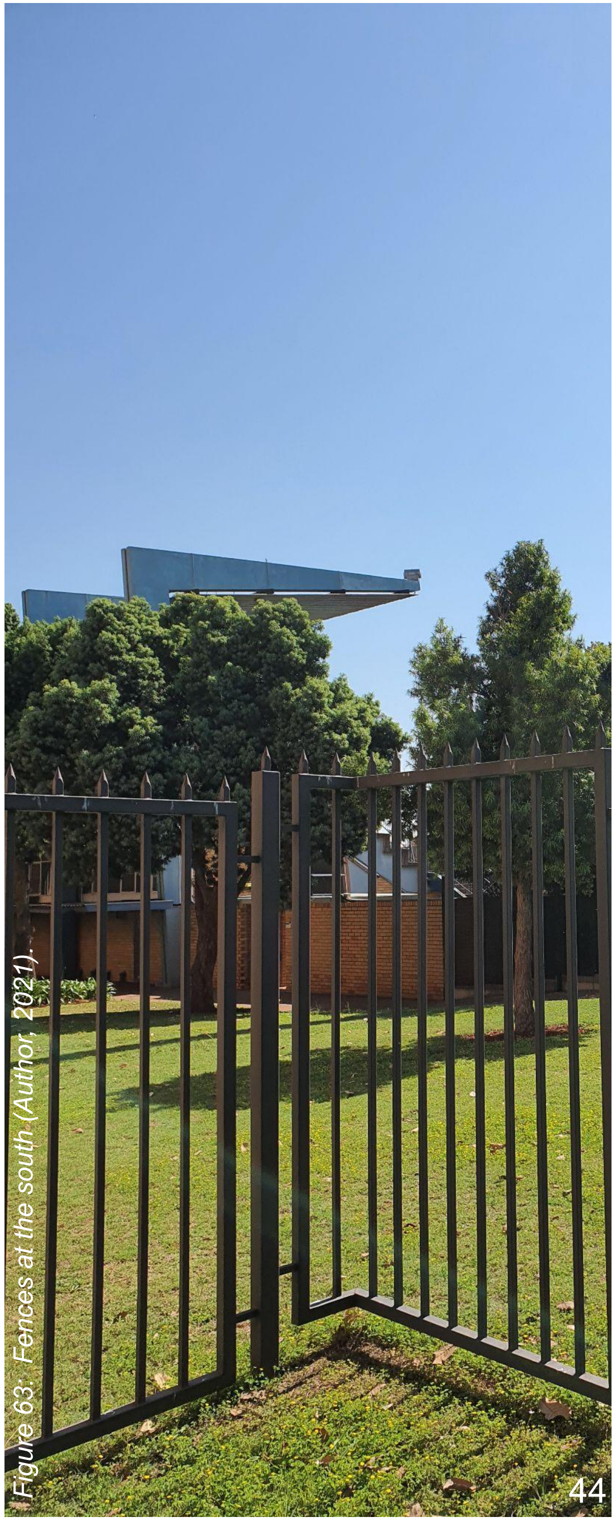


Figure 63: Fences at the south (Author, 2021).


Figure 61: Endless fences at the east (Author, 2021).


Figure 62: Endless fences at the south (Author, 2021).

Figure 64: Main pedestrian route to the pool-deck (Author, 2021).

Figure 65: Closed-off views to the field of play (Author, 2021).

Figure 66: Central courtyard between the squash courts (left) and the pool complex (right) (Author, 2021).

Figure 67: Restricted visibility to the field of play from within the facility (Author, 2021).

Figure 68: Dead spaces surrounding the northern site boundary (Author, 2021).

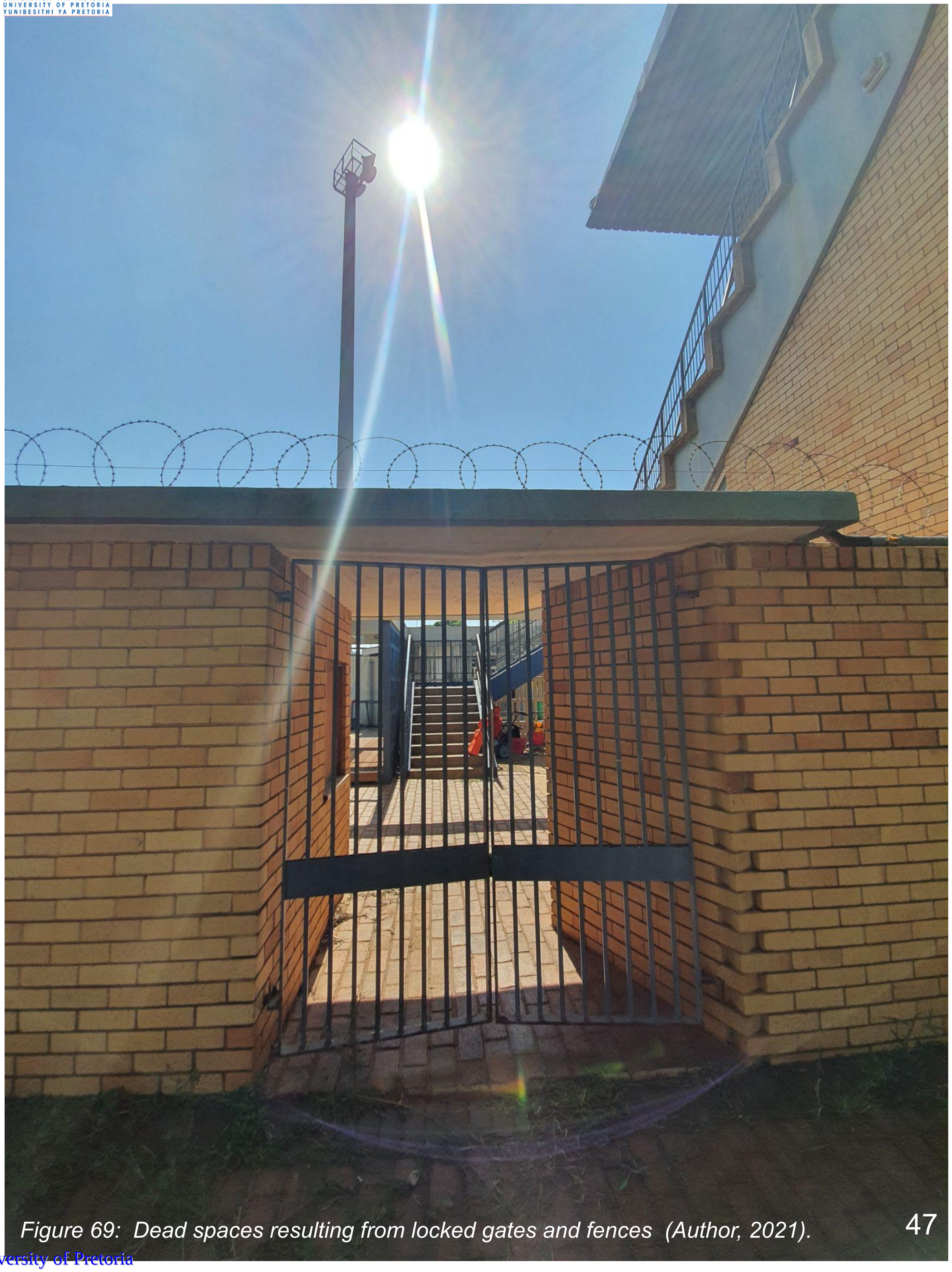


Figure 69: Dead spaces resulting from locked gates and fences (Author, 2021).

Initial design responses

In terms of the larger site, I considered the proposed campus vision of connecting the TuksAquatics Complex to Arcadia Street and intersecting it with the Uitspan public node. This is done as a means to enhance the site's interaction with its campus and urban surroundings.

Figure 70: Proposed connection between Arcadia Street, the campus and the site (Google, 2021 and Author, 2021)

Design themes are derived through the existing topography that stretches from the proposed pedestrian entrance at Arcadia Street to the site itself: The fall of the landscape exposes certain functions at the west and encloses other functions at the east. Hence, the public functions of the new proposal are situated at the west - exposed, open and accessible - while the more private functions are located at the east - enclosed, controlled and protected (figure 71).

The treatment of proposed water bodies across the site occurs in a similar manner (figure 72): The existing Uitspan dam with its social swimming facilities is fully accessible, natural and public in comparison to the 50m training and competition pool for the professional athletes, which exists in a more private and controlled setting. The connection between the two nodes is achieved through a public running route and a 250m long open water channel.

This channel acts as a hybrid space, merging the organic public function at the west with the rigid private function at the east. It serves both private functions (as a training ground for professional open water swimmers) as well as public functions surrounding the open water channel.

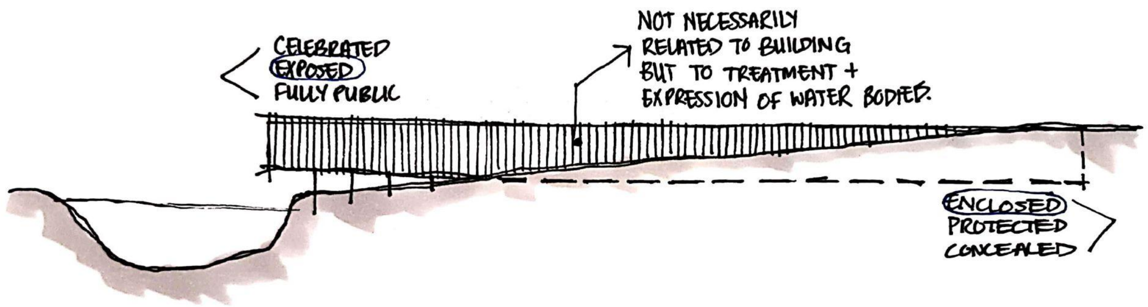


Figure 71: Expose vs enclose concept (Author, 2021)

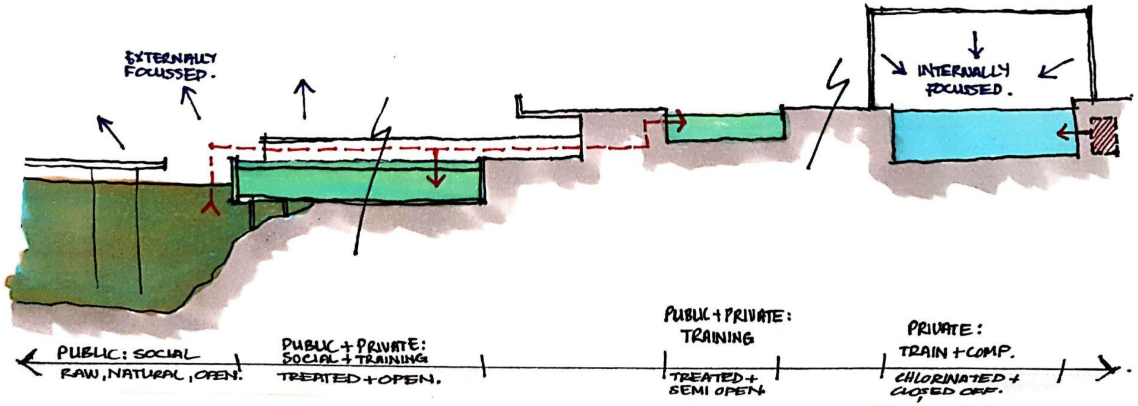


Figure 72: Treatment of water across the site (Author, 2021)

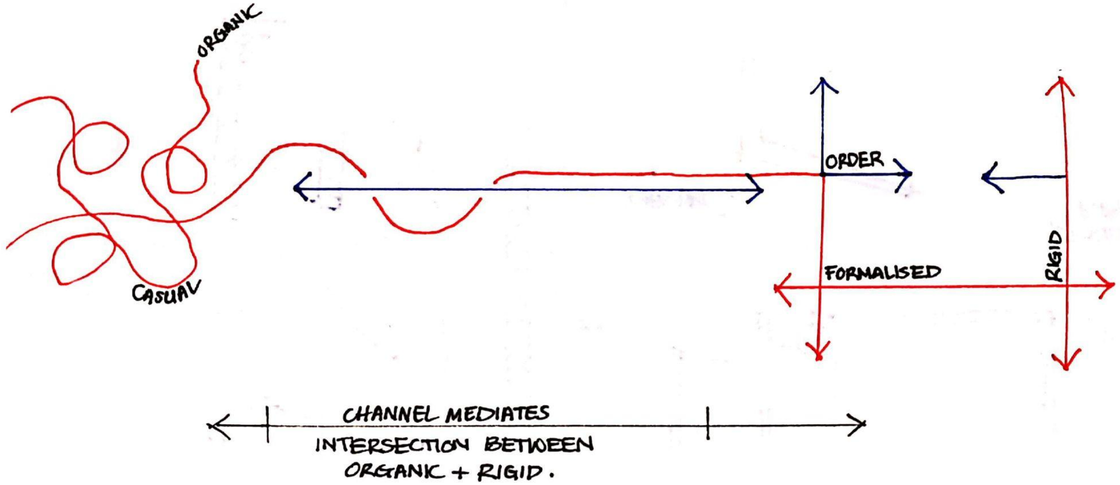


Figure 73: Conceptual progression from organic to structured spatial organisation

Figure 74: Site plan showing where sectional sketches are drawn (Author, 2021)

Furthermore, the new architectural language should respond to the low-structural intensity and high natural value evident on the Hillcrest campus through highly tectonic structures that appear minimally invasive and that sensitively engage with the existing landscape, but do not try to dominate it.

Zooming in further, in terms of the aquatics complex itself, the new architecture that is to be introduced needs to sensitively respond to the existing structures. This is necessary in order to respectfully add and make changes to the near 50 year old buildings. To place the existing sport facility within the continuum of sports architecture, the 'evolution of the stadium' can be revisited: ranging from the monofunctional, to the multifunctional, to the commercial, to the flexible stadium. Although most buildings on campus borrow from notions of the multifunctional or commercial stadium typologies, the TuksAquatics complex appears even more outdated. It exists as a merely monofunctional sports venue.

The new proposal can make this evolution and advancement of sports architecture evident through the new interventions' dialogue with the 'old'. This dialogue can be accommodated by layering facades, from new to old. The new architecture, thus, wraps around the existing structure, not hiding nor demolishing it, but rather enhancing its functionality and effectiveness for the user (figure 75). Existing functional elements of the building are altered, broken up and pierced through to induce new *experiences* in the users. This approach attempts to enhance the existing structure, site and user, both architecturally as well as in terms of athletic performance enhancement.

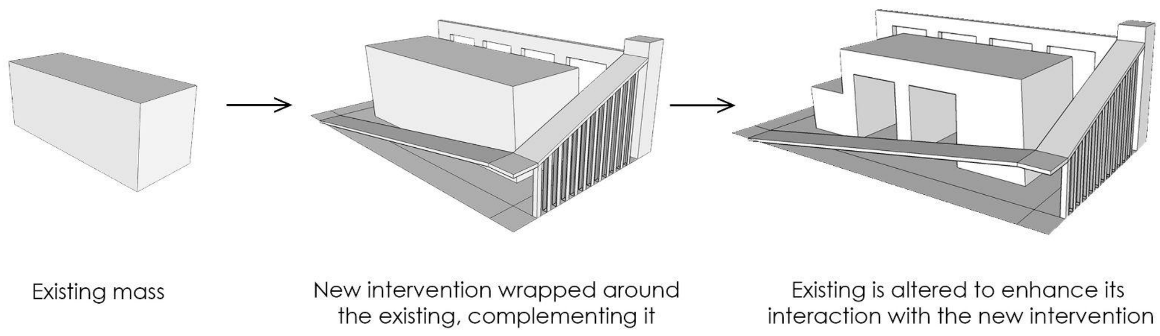


Figure 75: Approach to the existing (Author, 2021)

Critical design: Translating theory into architecture

Architecture no longer exists as a mere shell to house a variety of functions - rather evoking responses from the user through a variety of experiences (Sfinteş, 2012: 4). This evolution of architecture and, in this case specifically: sports design, transforms the architect's perception of the user from a neutral body that undergoes functional activities, to a central element of the designer's intentions (Sfinteş, 2012: 4). To allow this level of user-centrality in design, a deeper understanding of the user is required, which is why theory of sports psychology has been integrated into existing studies of environmental psychology and evidence based design in order to better understand the athlete and their needs.

The following critical design responses are based on evidence-based design theory as well as confluences found between environmental psychology and sports psychology principles. The overarching objective remains to determine the athletic performance enhancing potential of architecture. Confluences found between sports psychology (Cohn, 2008 and Gullu, 2020) and environmental psychology (Malkin: 2008) are summarised in the table alongside. Spatial aspects which can benefit from evidence-based design principles are also highlighted in the table (figure 76):

	Evidence-Based Design	Additional Spatial Responses	
Focus and Concentration	Focus To prevent "result-oriented" mindsets	Restrict visual access From external distractions	
Doubt vs. Confidence		Break-away spaces Protecion from doubt inducing external factors	
Coping skills	Positive thoughts Combat emotional toll of minor setbacks	Improved accessibility Between athlete and support figures	
Regulating adrenaline	Calmness; Energy-inducing		
Motive to perform		Athlete residence facilities	Complimentary facilities
Mental impact of injuries		Visual access to rehab spaces	Transparent design to familiarise athletes with the recovery process
Game plan		Accessible design of coach's office	Visible, centrally located game plan
Being in the zone	Improve concentration and remove distractions	Break-away spaces Avoid external distractions	
Athletes with disabilities		Universally accessibly spaces for mobility impaired athletes	Visual access for visually impaired athletes
Spirituality in sport		Social spaces for interaction between athletes	Spirituality-related design drivers for resillience
		Social spaces to encourage healthy habits	Removal of dead spaces
		Improved accessibility to training facilities	Performance spaces
Coach-athlete relationship		Locality of coach's office in relation to other stakeholders	Accessible design of coach's office and support facilities
	Promote creativity in coaching environments	Adaptable design of training venues to suit varied coaching methods	
		Transparent design of coach's office and physio rooms	
		Private space in athlete's living environments	Zoning between coach, athlete and secondary stakeholders

Figure 76: Summary table of design opportunities based on theory (Author, 2021)

Accessibility

Many athletes who experience minor setbacks during competition or training tend to over-inflate these setbacks, fixating on them and draining their own energy. This often results in underperformance (Cohn, 2008). Athletes need to stay composed by regulating their emotions. This can often be achieved through an *accessible support system*. The design must respond to this by creating spaces where athletes are able to gain access to the various components of their support system when needed, for example: their parents, coaches, teammates and sports psychologists. This may be done by, for example, not fully restricting access between the athletes' and spectators' areas, so that athletes are able to freely and easily move between the various spaces in order to reach out to their support system (figure 77). Inaccessible designs may result in the athlete feeling isolated and hopeless.

Hence, social spaces that encourage positive interaction and support between teammates (Kiecolt-Glaser: 1998 in Malkin: 2008, 8) becomes vital to the scheme. One of the ways of incorporating social spaces is through the introduction of accessible public spaces into the site (figure 77 and 78). Public use and access benefits the professional training and competition facility by adding to its sustainability. This is because youth and recreation-level swimming programs are widely used to fund and maintain professional sporting institutions. The public programs become vital to the facility's survival and maintenance - hence, public accessibility plays a major role in the success of the architecture.

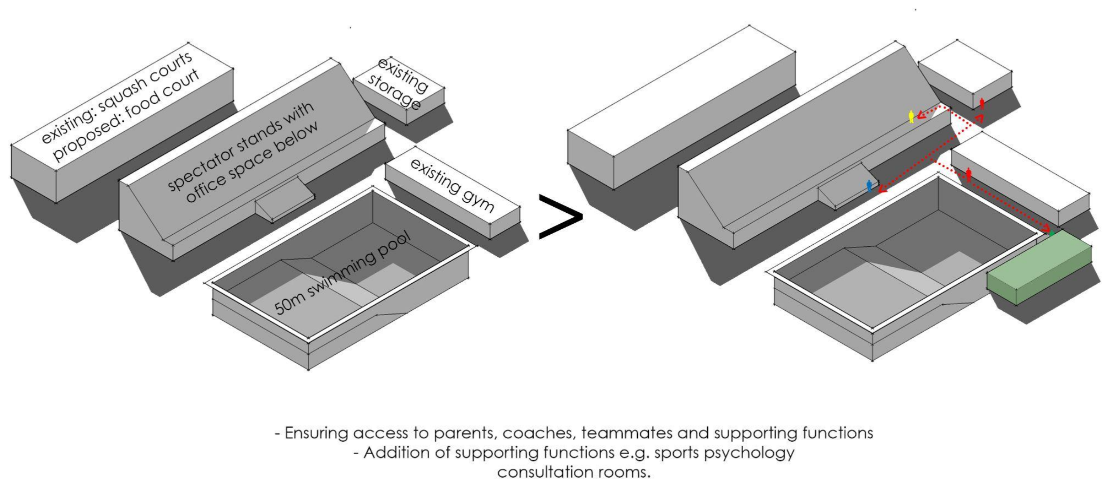


Figure 77: Free movement between athletes and supporting figures (Author, 2021)

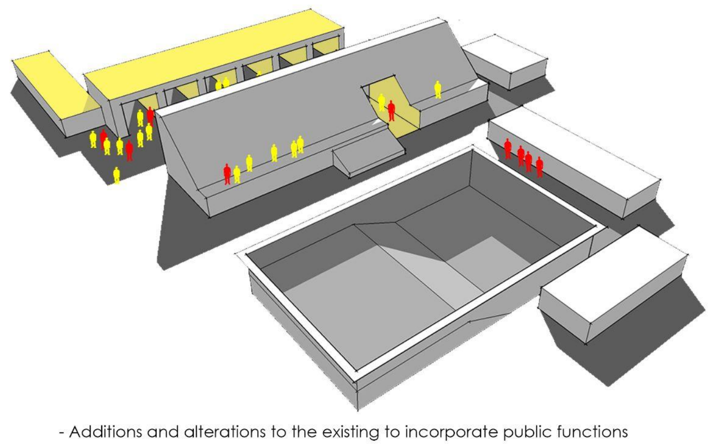
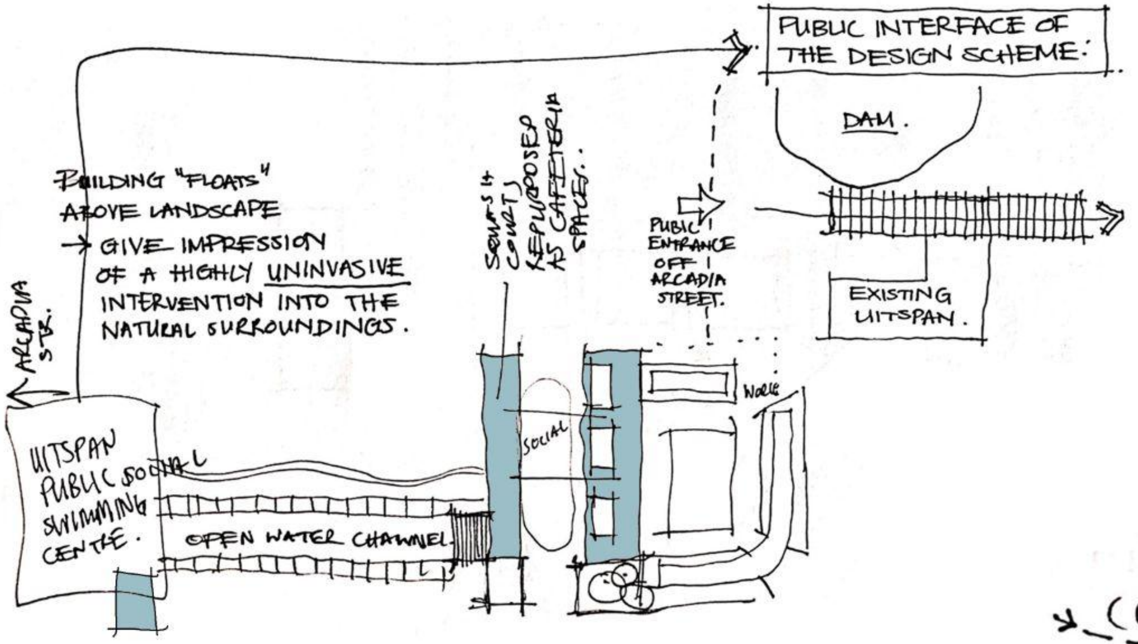
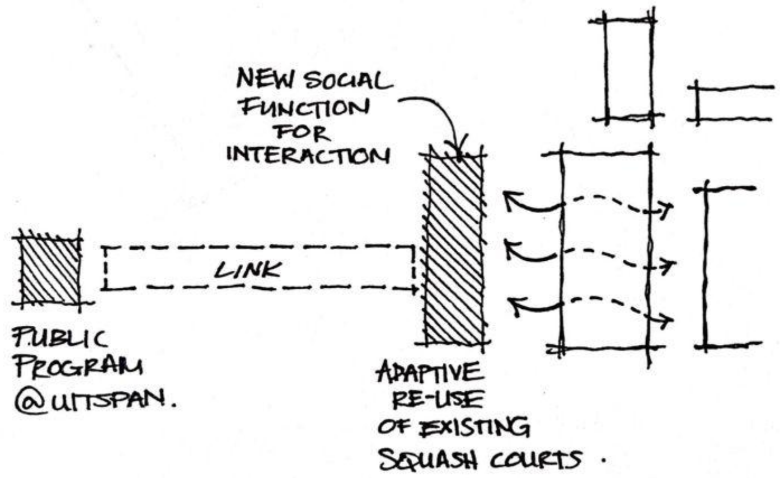


Figure 78: Positive social interaction through public integration (Author, 2021)

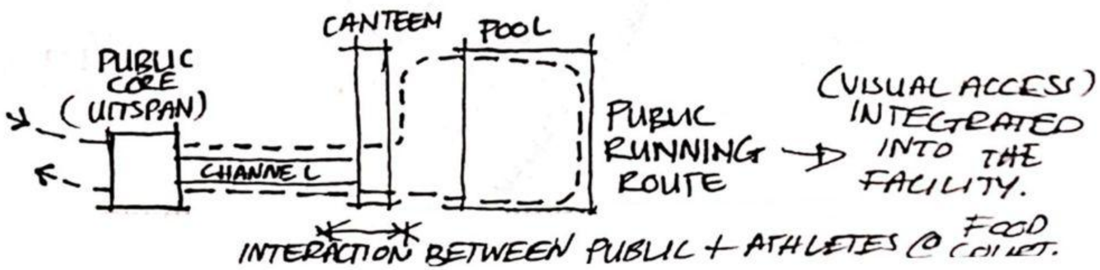
Calmness
(Ulrich: 1984 in Malkin: 2008, 8)
(Kiecolt-Glaser: 1998 in Malkin: 2008, 8)
(Malkin: 2008, 7)



Social core forms buffer between public and private space:
Interaction between athletes and the public



Linking proposed public node to the site:
Enhances social interaction



Proposed public running track merges with existing pedestrian route:
Integrates public into the facility - sometimes only through visual access

Figure 79: Positive social interaction through public integration (Author, 2021)

Accessibility to sports facilities becomes of even greater importance when one considers athletes with disabilities. Mobility impaired athletes, for example, experience major physical barriers within the built environment of sports architecture. A study indicated that the two largest barriers include the lack of or poorly designed wheelchair ramps and the lack of parking spaces for wheelchair users. Of the total interviewees, 72,1% and 69,2% respectively experienced these issues (Kljajić et. al, 2018: 16-24). Inaccessible spaces pose additional stressors on disabled athletes which could negatively impact their performance. These athletes may develop feelings of struggle and inadequacy which could limit their confidence and motivation. Sports facilities need to be designed inclusively to accommodate athletes of varying degrees of physical ability (figure 80). This includes physical access to spaces through ramps and elevators as well as visual access for visually impaired users to information through legible signage, large enough results-screens as well as the minimisation of glare over water bodies.

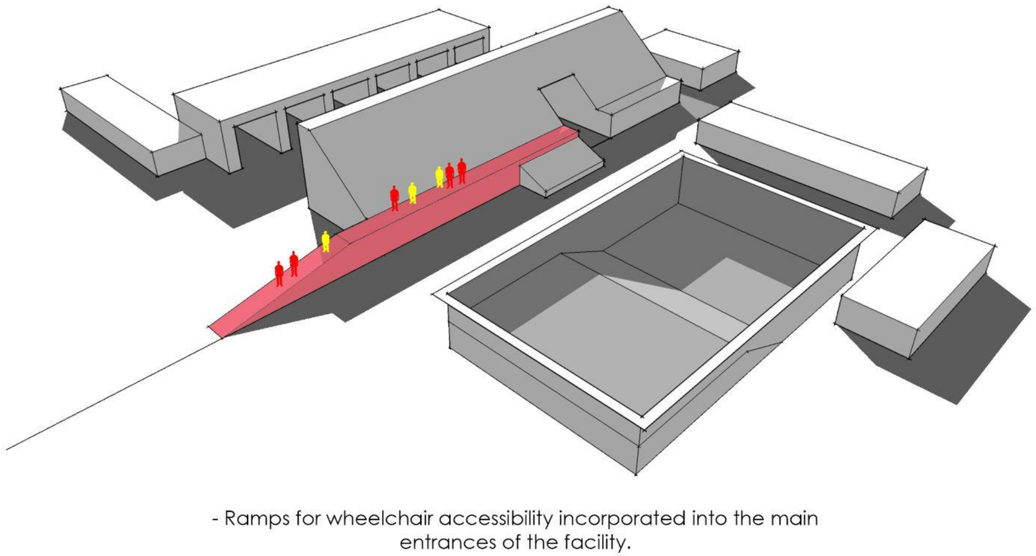
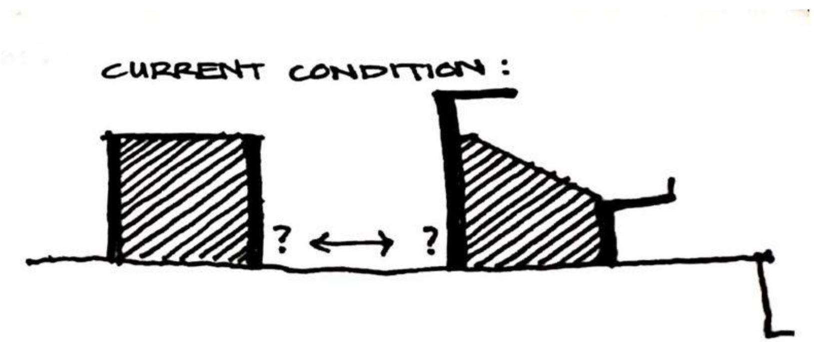


Figure 80: Inclusive design through the addition of ramps (Author, 2021)



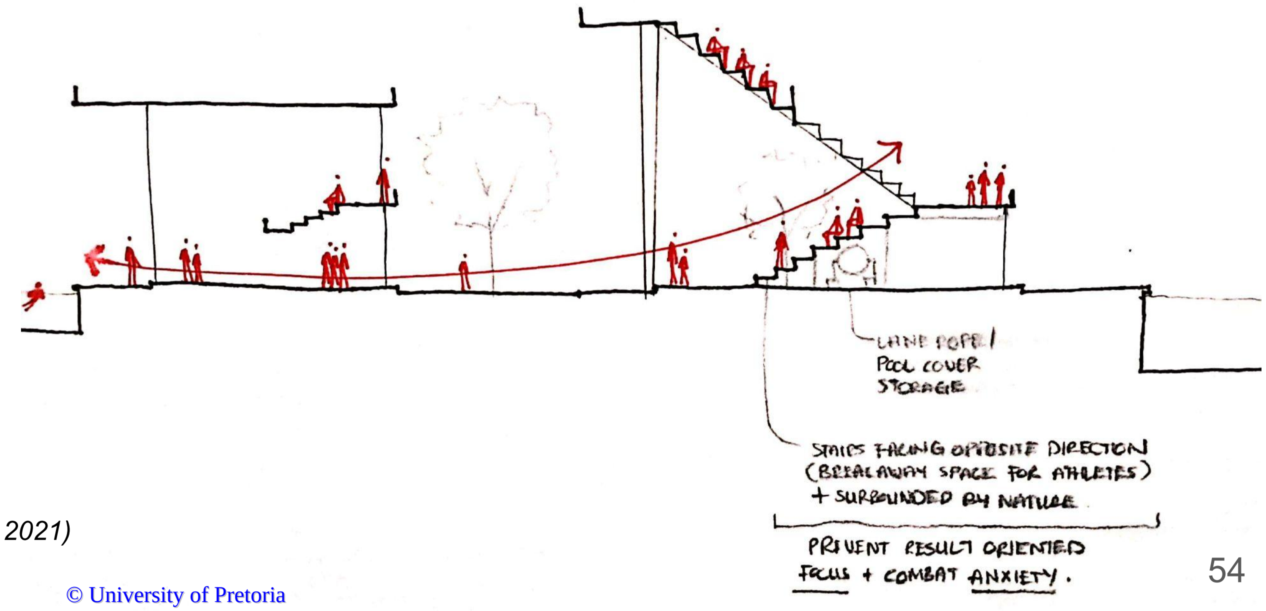


Figure 81: Altering the current condition to enhance accessibility (Author, 2021)

Pre-race spatial implications: marshalling and breakaway spaces

In order to enhance an athlete's focus pre-race, various evidence-based design techniques can be used (figure 82). However, the majority of professional-level athletes have highly-developed concentration and focus abilities. However, many athletes tend to focus on the wrong activity at the wrong time (Cohn, 2008). Cohn differentiates between "result-oriented focus" and "process-oriented focus". For example, a swimmer's mind is fixed on the time he or she wants to swim (result) while in the race, instead of focussing on the motions and intensity needed to swim that time (process). Result oriented focus distracts the athlete from what needs to be done or what process needs to be followed to achieve their goal.

Multisensory design acts as positive distractions for athletes, helping them to avoid pre-race anxiety (Taylor, 1997 in Malkin, 2008). These take the form of 'breakaway spaces' (figure 83 and 84). The spaces where athlete's experience the highest levels of doubt need to be identified and designed accordingly. For example, during warmup, some athletes may experience feelings of doubt after interaction with overly-confident competitors or teammates. Break-away spaces may be needed where athletes can temporarily prepare for their race in isolation from doubt-inducing external factors. The proposed breakaway spaces take the form of a highly social setting at the proposed social and public core of the scheme (acting as positive distractions to anxious athletes); as well as more private, quiet and natural spaces, fully removed from the venue where athletes can temporarily escape the pressures of the competition environment in the interior of the venue.

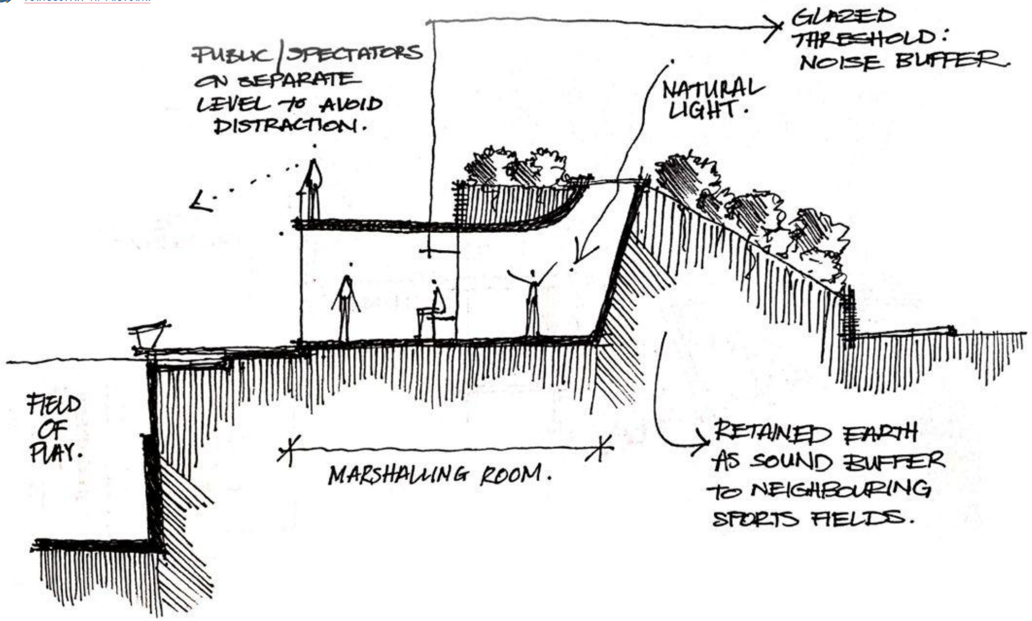


Figure 82: Design to enhance focus pre-race (Author, 2021)

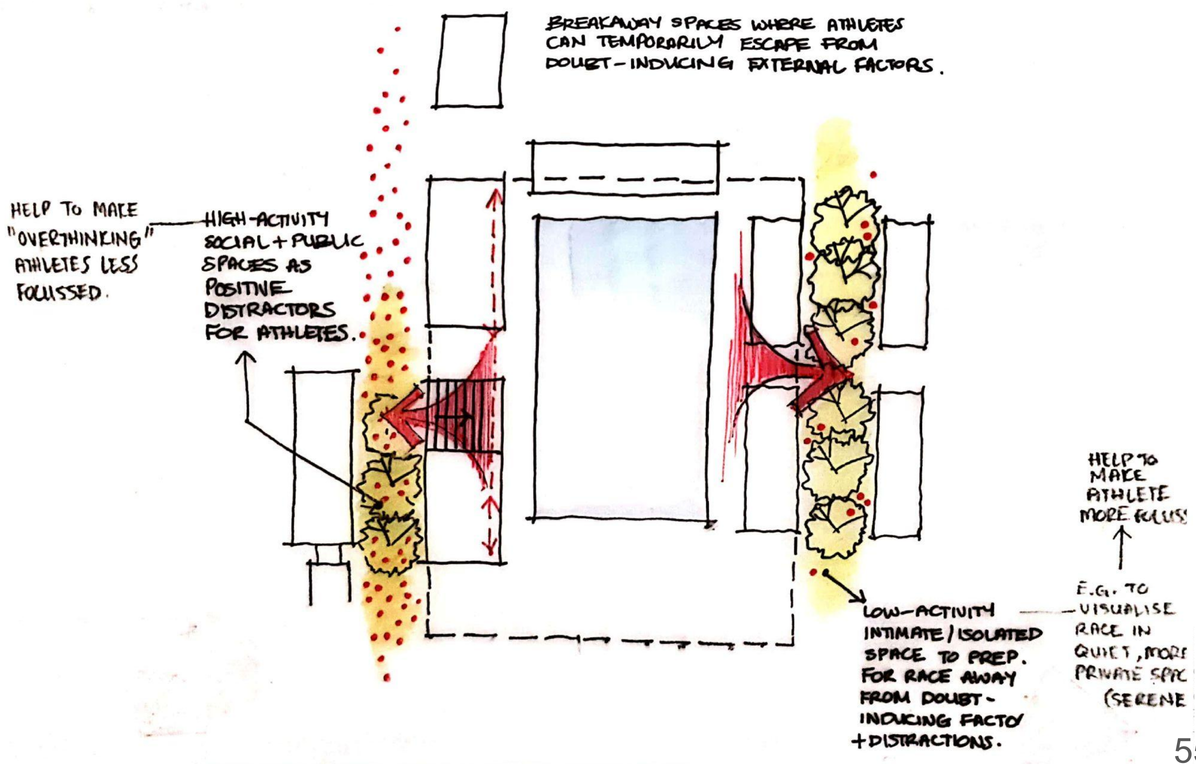


Figure 83: High-activity versus low-activity breakaway spaces (Author, 2021)

Break-away spaces
Protecion from doubt inducing
external factors
((Winkel and Holahan 1986 in Malkin: 2008, 8))

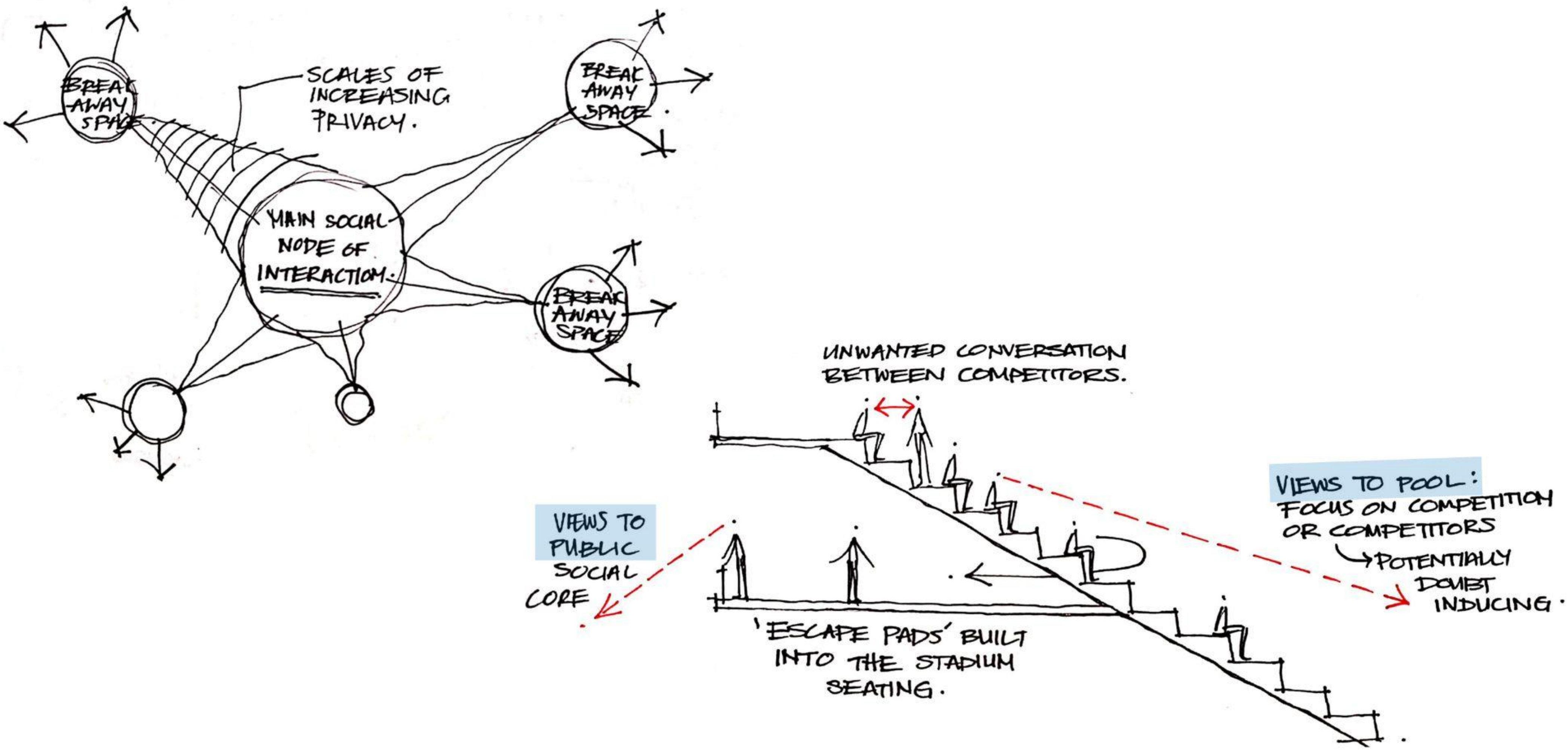


Figure 84: Incorporating break-away spaces to escape negative distractions (Author, 2021)

Furthermore, visual access to distractors can be restricted in certain spaces, for example, restricting visual access to the spectators' stands from the marshalling area to prevent athletes from focussing on the expectations of coaches or parents which could place unwanted pressure on the athlete prior to their race (figure 85 and 86).

Where focus on the race is required and athletes need to get in "the zone", evidence based design techniques to enhance concentration can be implemented. Being "in the zone" can be described as the optimum mindset that athletes reach for the best performance outcome. Sports psychologists help athletes to identify what conditions they need to get themselves "in the zone" (Cohn, 2008). Techniques, like imagery, concentration exercises, relaxation and self-talk are used by sports psychologists not only to aid performance enhancement, but also athletes' general wellbeing and improved experience of the sport (Anderson et. al, 2002 in Hagan et. al, 2019: 191). The designer can accommodate this by creating isolated, private seating or lying-down spaces where athletes can confidently undergo these pre-race mental exercises without distraction or interruption (figure 87). Noise reduction and improved quality of light in these spaces can help to boost focus (Malkin, 2008: 8).

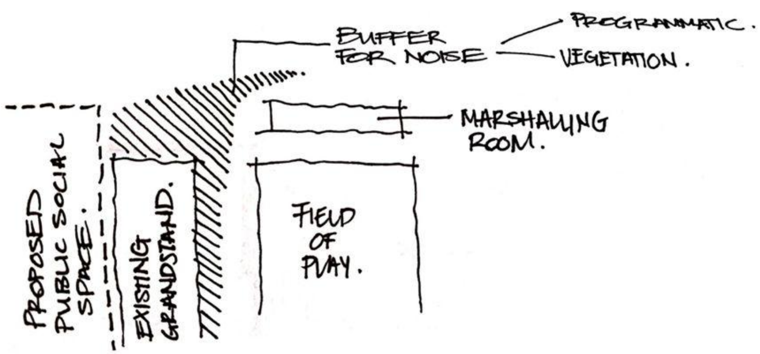
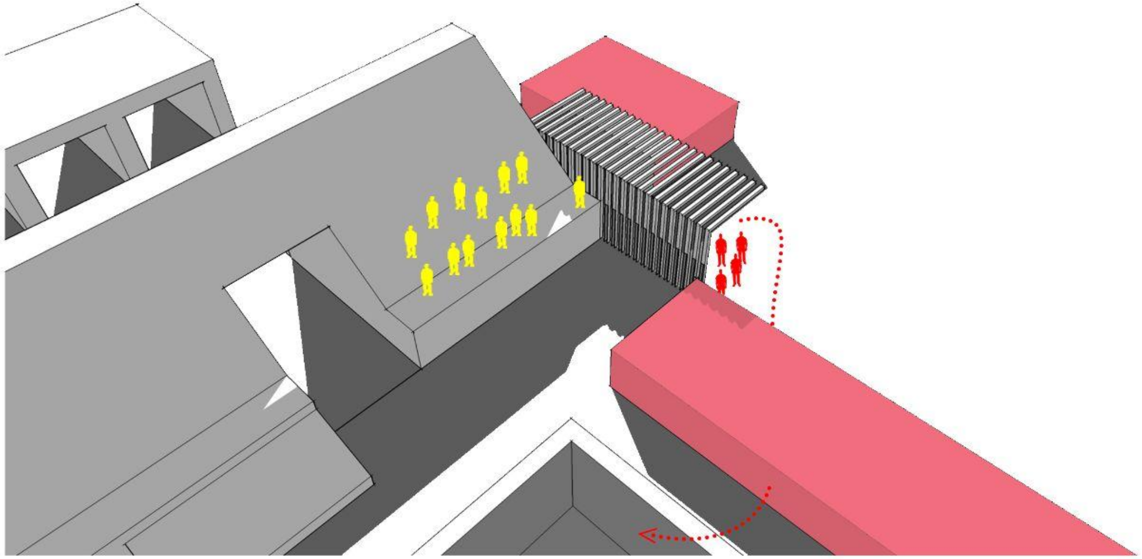
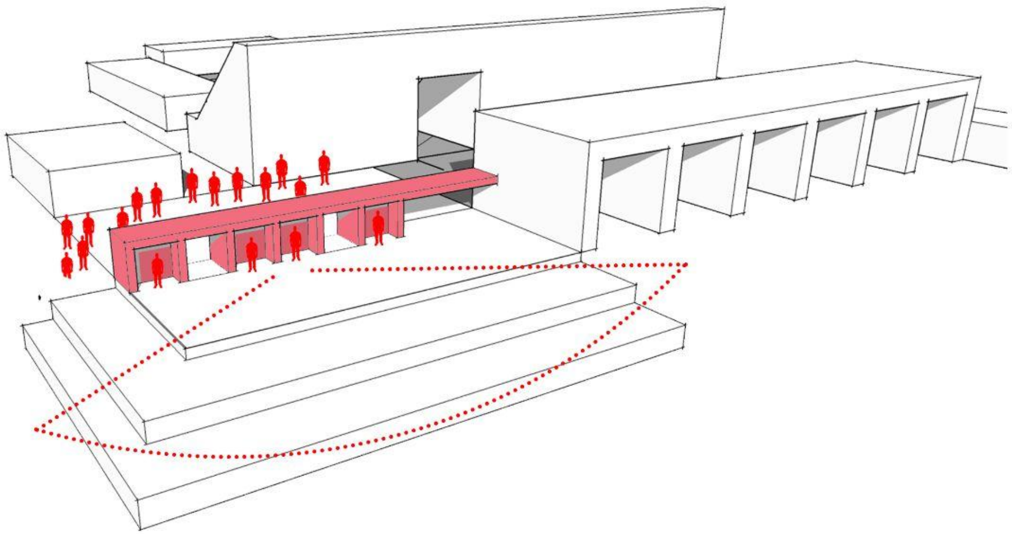


Figure 86: Buffer zones to prevent distractions (Author, 2021)



- Restricting views to the pool and to spectator stands to reduce anxiety (self-applied or through parents or coaches)

Figure 85: Restricted visibility to avoid negative distractions (Author, 2021)



- Intimate private spaces where athletes can mentally prepare for their races away from distractions and interruptions,
- Views overloooking nature and the Uitspan dam to reduce anxiety.

Figure 87: Private spaces overlooking nature to enhance internal focus (Author, 2021)

Lastly, it is important to note that athletes need to determine which emotional state best prepares them for optimal performance. Athletes must confidently look forward to, but not be *overly-excited* for a race. When athletes become too "pumped" prior to competing, large amounts of adrenaline move through the body. The result is that very little adrenaline or energy remains when the time for the actual race arrives, leaving athletes feeling drained and even weak (Cohn, 2008). Spatial design principles, such as exposure to nature, that induce feelings of *calm* can be incorporated into the design of spaces which athletes interact with in the lead up to their race; for example, ablutions, stretching areas and marshalling rooms. In addition, the athletes' movement through the marshalling rooms and views to the field of play can be controlled to prevent premature excitement before a race (figure 39).

However, the spatial experience should transform to more dramatic and energy inducing only once athletes walk out onto the field of play (figure 88 and 89). Enhanced sensory experiences can be used to induce energy or excitement (Malkin, 2008: 9) through drastic changes in spatial characteristics. Here, architecture can act as an experiential threshold, immersing the user (spectator or athlete) in an ephemeral condition for a limited period of time, after which they escape back into the 'real world' (Sfinteş, 2012). This is where heightened spatial characteristics are used to enhance this ephemeral condition right before and during a race, after which athletes exit the arena and a new temporary condition is created with the line up of the next group of competitors.

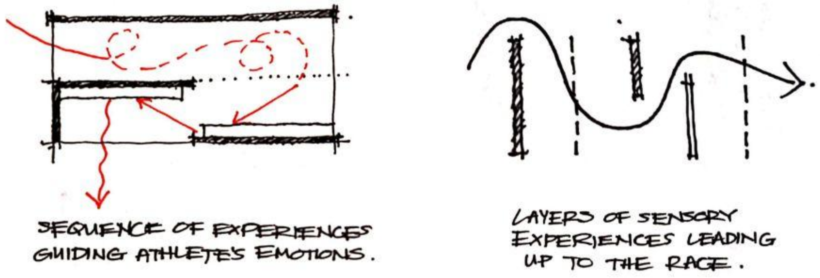


Figure 88: Controlling athletes" movement and views (Author, 2021)

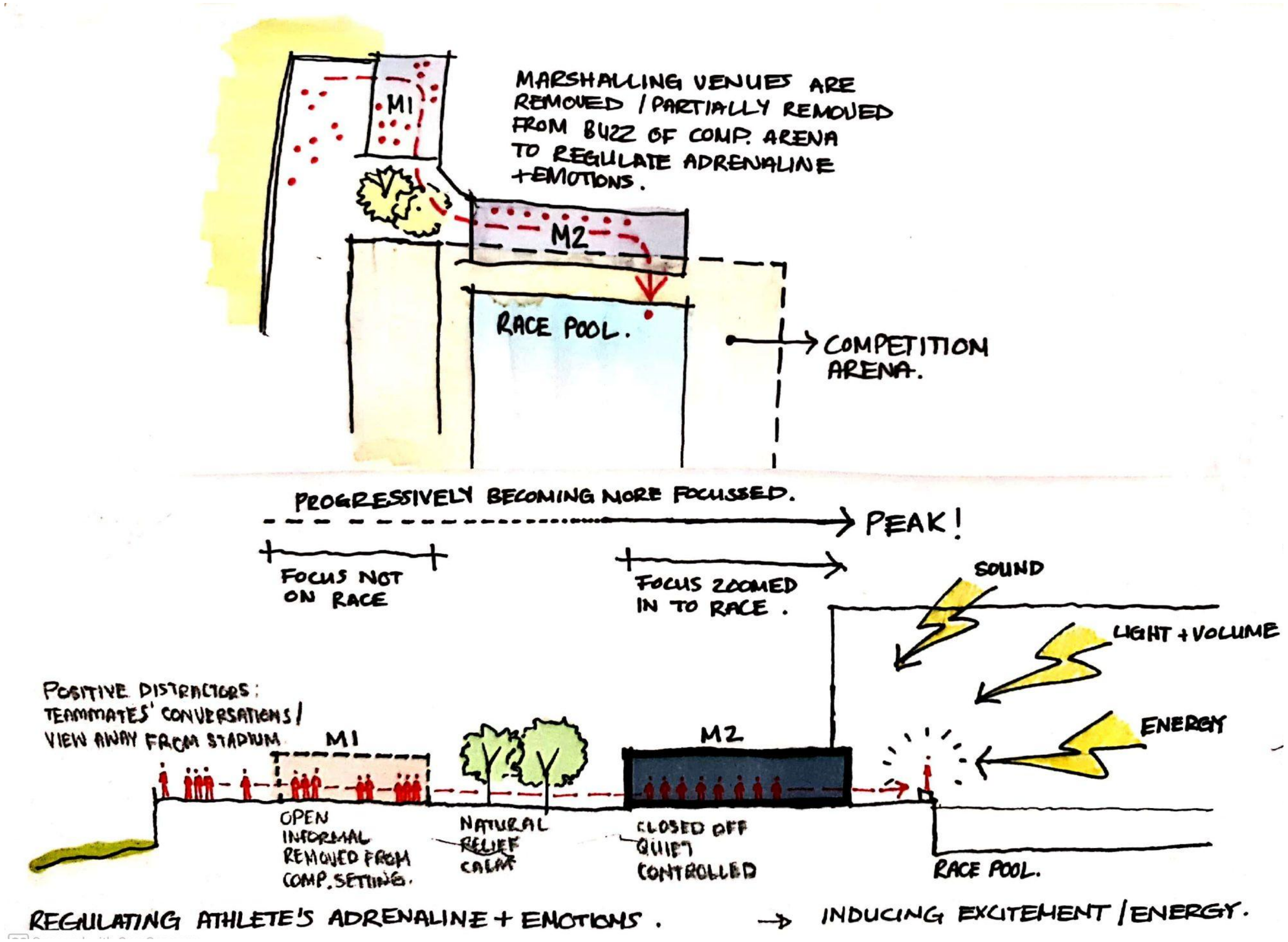
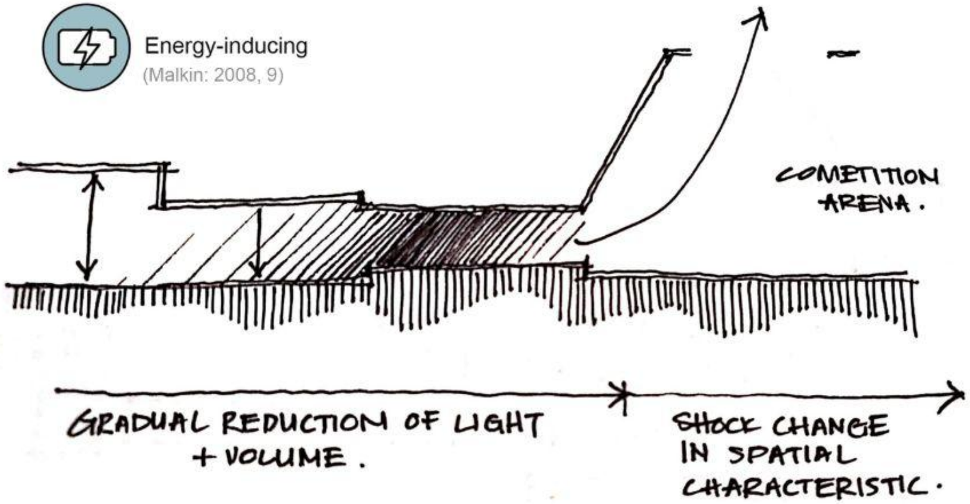
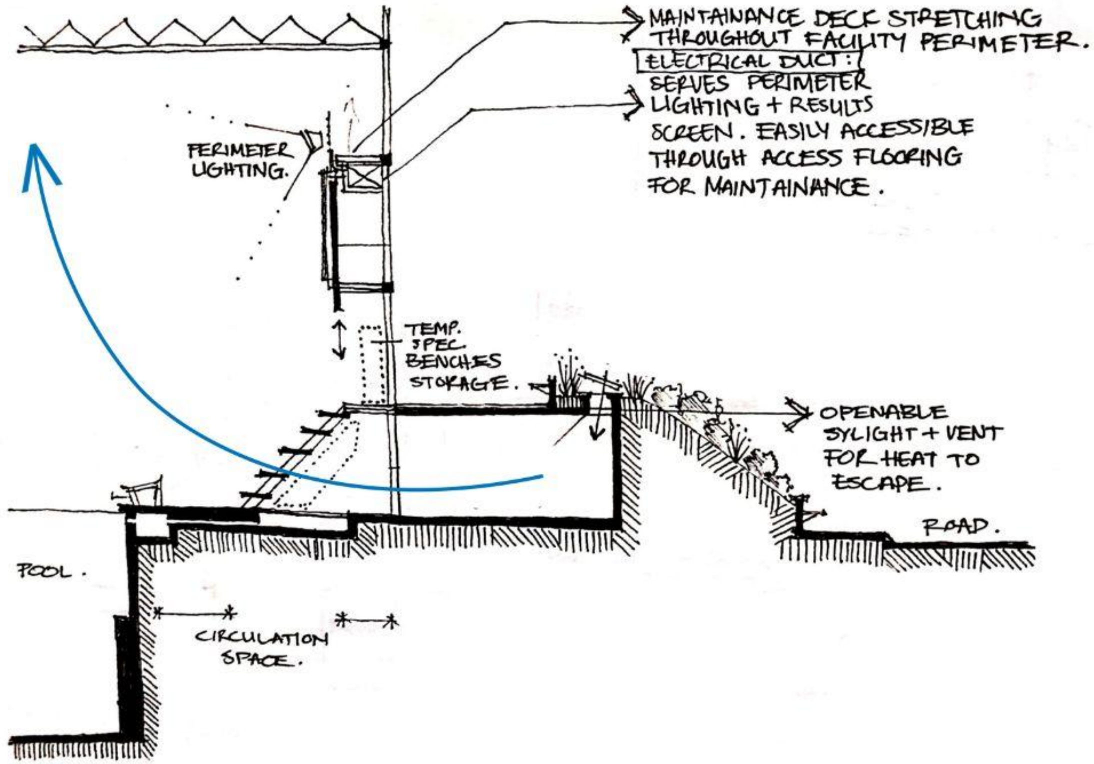


Figure 89: Drastic spatial changes to induce adrenaline in athletes (Author, 2021)

Energy-inducing
(Malkin: 2008, 9)





Multisensory design to induce energy and emotions:
Scales of light intensity and volume (spatial characteristics) regulate the adrenaline levels of the athlete as they approach the pooldeck for their race.

Figure 90: Drastic spatial changes to induce adrenaline in athletes (Author, 2021)

Post-race spatial implications

The post-race effects of space are based on two typical race outcomes: a good performance and a bad performance. Different users may experience different outcomes that need to be accommodated spatially and functionally. Athletes who experienced a positive race outcome may desire social, vibrant and loud spaces where peers, family and teammates can be received and the race celebrated. On the other hand, athletes who experienced less-than-satisfactory results may desire more intimate or even isolated settings where they are able to gather their thoughts and compose themselves away from the crowd before their next race (figure 91 and 92).

Race simulating spaces

Although the training and competition environments for 'pool swimming' seem relatively similar and standardised, professional open-water swimmers have greater trouble preparing for competition conditions. The proposed open water channel is designed to mimic these conditions: Firstly, unchlorinated water, that is rather naturally treated through natural filtration ponds, immerses the athlete in an atypical training environment. Furthermore, the channel is surrounded by a public running route constructed as a jetty system that floats within the channel. The jogging public creates movement over the jetty resulting in waves within the channel. These waves simulate the conditions of dam or sea swimming environments during competitions.

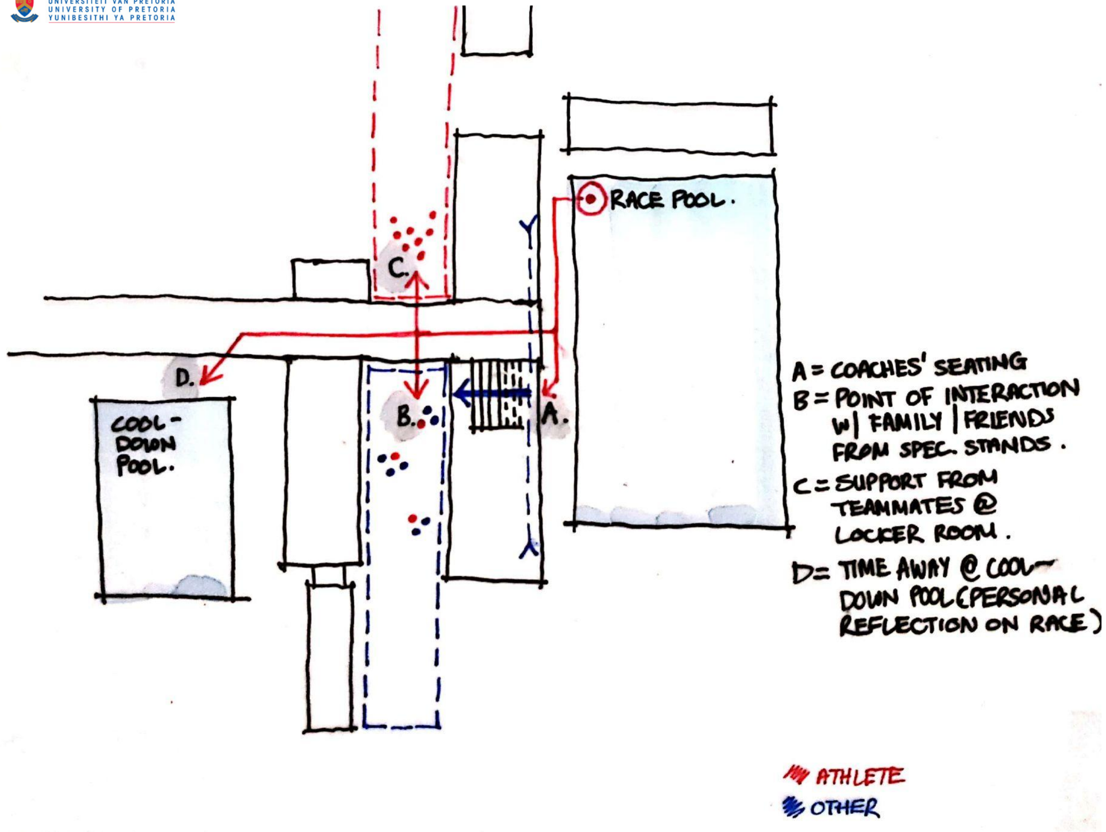


Figure 91: Guiding athlete's interactions post-race (Author, 2021)

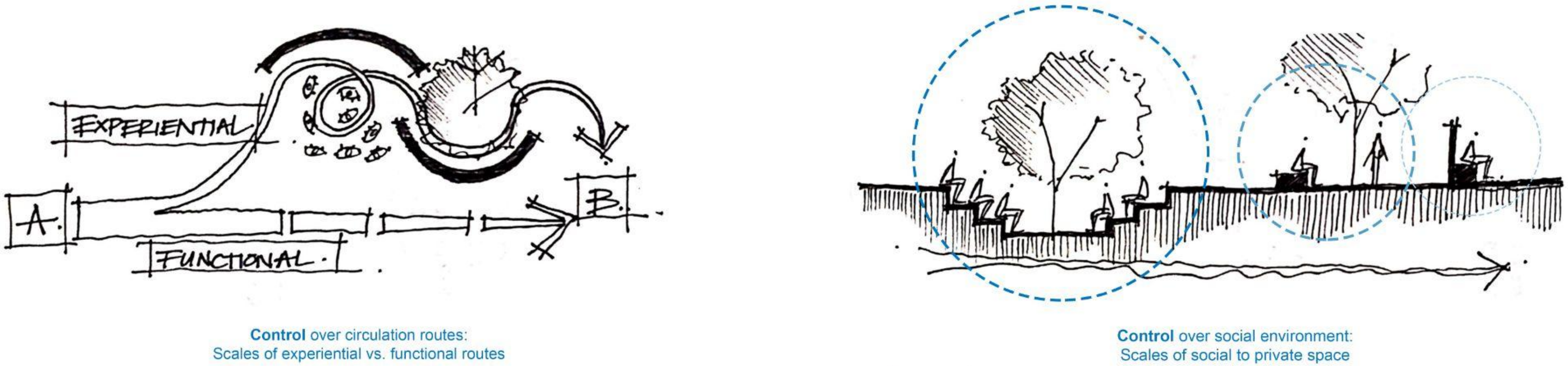


Figure 92: Giving athletes control over their environment post-race (Author, 2021)

Zoning

Sports psychology principles are used to determine the zoning of certain spaces in the sports venue, for example: the coach's office. The coach is located centrally within the facility, accessible to all stakeholders as the primary point of communication for all athlete-related matters (figure 93).

Spirituality related design drivers

For years, nature, light and water have been acknowledged for their calming abilities on the human psyche (Ulrich, 1984 in Malkin, 2008: 8). Spaces are identified within the facility where athletes may experience the highest levels of anxiety, for example: the marshalling room, physiotherapy rooms where athletes may be struggling with injury, or sports psychology consultation rooms (figure 94). These spaces are sensitively designed with these evidence-based design principles in mind.

Spiritual practices and performances, like dance or psyching verses are often performed during sporting events (de Witte: 2008 in Hagan et. al: 2019, 189) . Players are also often observed to be praying before a race for divine assistance during the competition, for example: drawing the cross with their finger and pointing their finger towards the sky (Hagan et. al, 2019: 191). Similar performances can be seen by the All-Blacks rugby team when they perform the *haka* before every match. Including spirituality into athlete-centred models - in this case design models - has the potential to benefit not only athlete performance, but also personal enhancement and development. Competitive sport can be understood through a more holistic approach that includes the moral, psychological, intellectual, emotional and social aspects of an athlete's life Miller et. al: 2002 in Hagan et. al: 2019, 191). The design should cater for space where athletes can express themselves through performance, for example, a social performance space for team war-cries before a competition as an excitement-inducing activity.

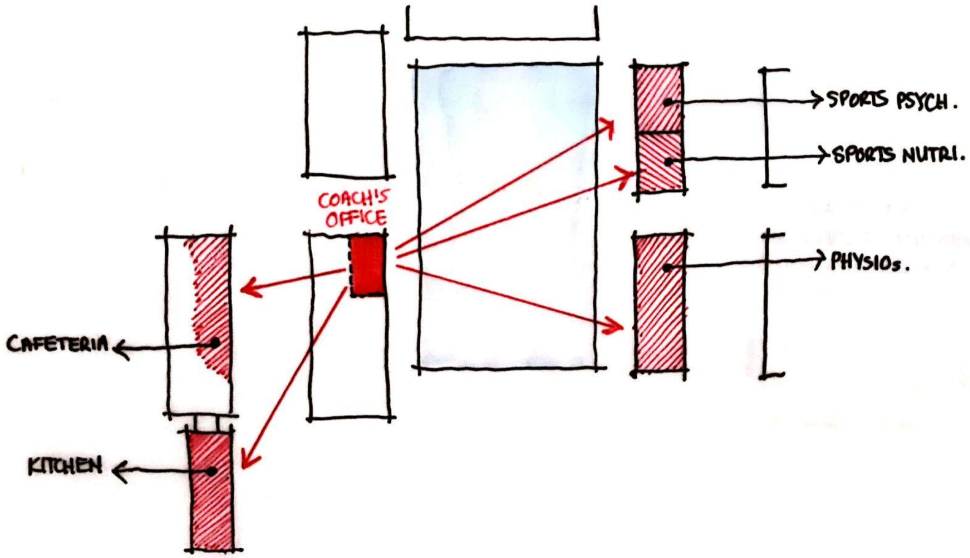


Figure 93: Zoning of the coach's office in relation to other stakeholders (Author, 2021)

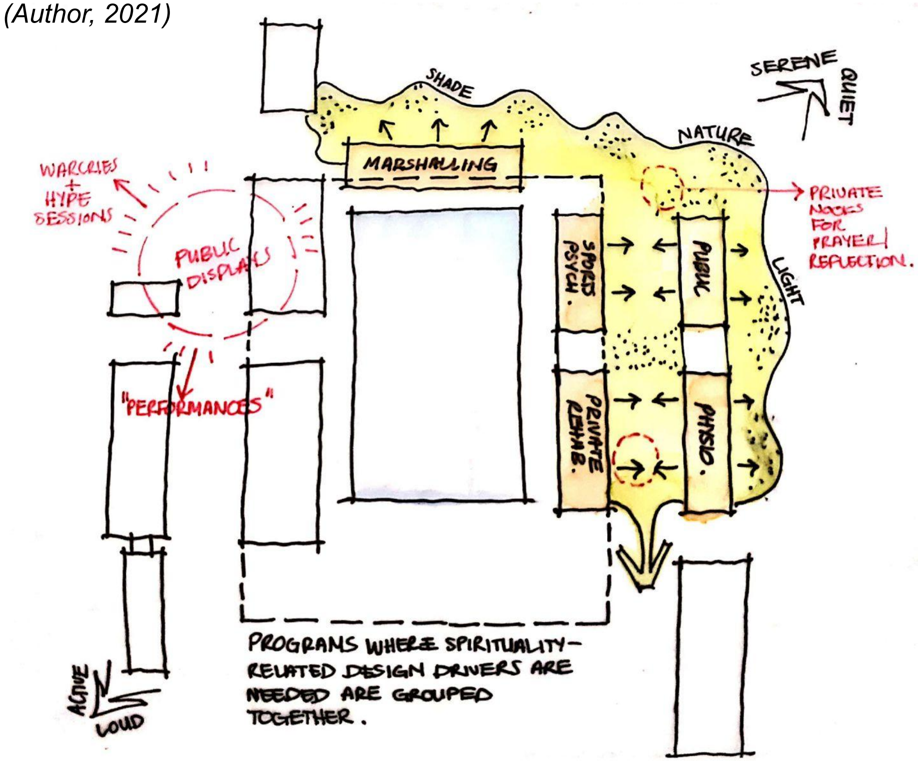


Figure 94: Incorporation of spirituality-related drivers in key-areas (Author, 2021)

Reducing the impact of external and internal stressors

A common external stressor experienced by athletes is that of changing weather conditions. Design flexibility in the sports venue is used to aid athletes in altering their environmental conditions through a retractable roofing system to protect the interior from rain and cold or to expose the interior to welcomed sunlight and fresh air (figure 95).

Common internal stressors are the mental impacts of injuries (Cohn, 2008). The design can address this by creating transparency in physio and rehabilitation spaces where athletes can witness, first hand, how their teammates are recovering, improving and getting stronger during and post-injury. Giving athletes visual access to this process of recovery can help them to believe in the process's success for themselves, should they become injured.

Additions to the program

Athletes whose motivation for performance is due to external factors, like pressure from parents, often tend to have fluctuating levels of motivation (Cohn, 2008). External motivators need to be identified, for example: athletes who compete in elite-level sports due to pressure from their parents. Extracting these athletes from their straining home environments and placing them in more positive living environments such as an athlete-residence can help them to let go of their parent's expectations and compete at a healthier, more personal level.

Furthermore, many professional athletes train with the assistance of bursaries as student athletes. These student athletes fight the daily struggle of attempting to juggle both professional sports and full-time studies. This oftentimes overwhelms athletes when they need their mental energy and focus the most. The issue can be addressed by including study and work facilities integrated into the design of training facilities, where student-athletes can study before and after training in an attempt to optimally manage their time with the resources and facilities they are given. Therefore, the sports venue, as a *holistic* spatial solution to athletic performance enhancement, can include multiple functions, including an athlete residence and study spaces.

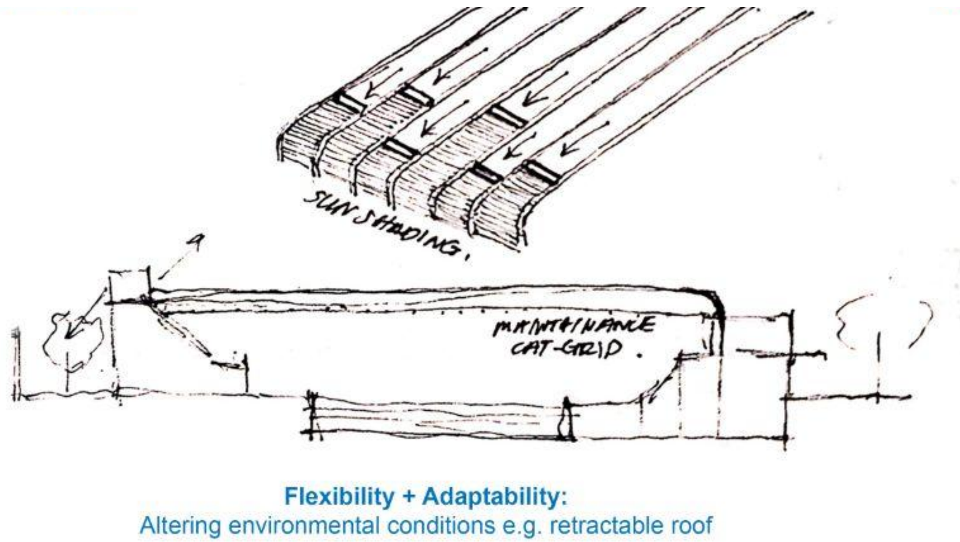


Figure 95: Retractable roof to mitigate the impact of unfavourable weather (Author, 2021)

Precedent studies and design informants

Ancient Greek Sporting Facilities

The first evidence of sport originated around 2500 B.C. in Crete. Although not much is known about the sporting history of these Aegean civilisations, more in-depth evidence lies in the competitive sport of **ancient Greece**, circa 776 B.C. - the year of the first Olympic Games (Deimary et. al: 2019, 2180). Through investigation into the functioning of the ancient Olympics, one is able to identify inherent characteristics of ancient sports as well as potential **design drivers** which could root from these characteristics.

A variety of **typologies** emerge when researching sports and athletics in ancient Greece. Some of these typologies are directly linked to the functioning of sport while others hold looser connections to physical activity in the ancient Hellenic society. These typologies include: **Agoras**, **stadiums**, **gymnasia** and **palaestrae**. A thorough understanding of the evolution of these typologies has allowed me to create a summarised timeline of the advancement of sports design and architecture in the ancient times (figure 98). Design drivers that further aid in design decisions are taken from these informants.

Figure 96: Acrobats play with a large cow, potentially a symbol of Zeus in Knossos, Crete (Deimary et. al: 2019, 2180).

Figure 97: Two Acroterion boxers wearing gloves (Deimary et. al: 2019, 2180). (Deimary et. al: 2019, 2180).

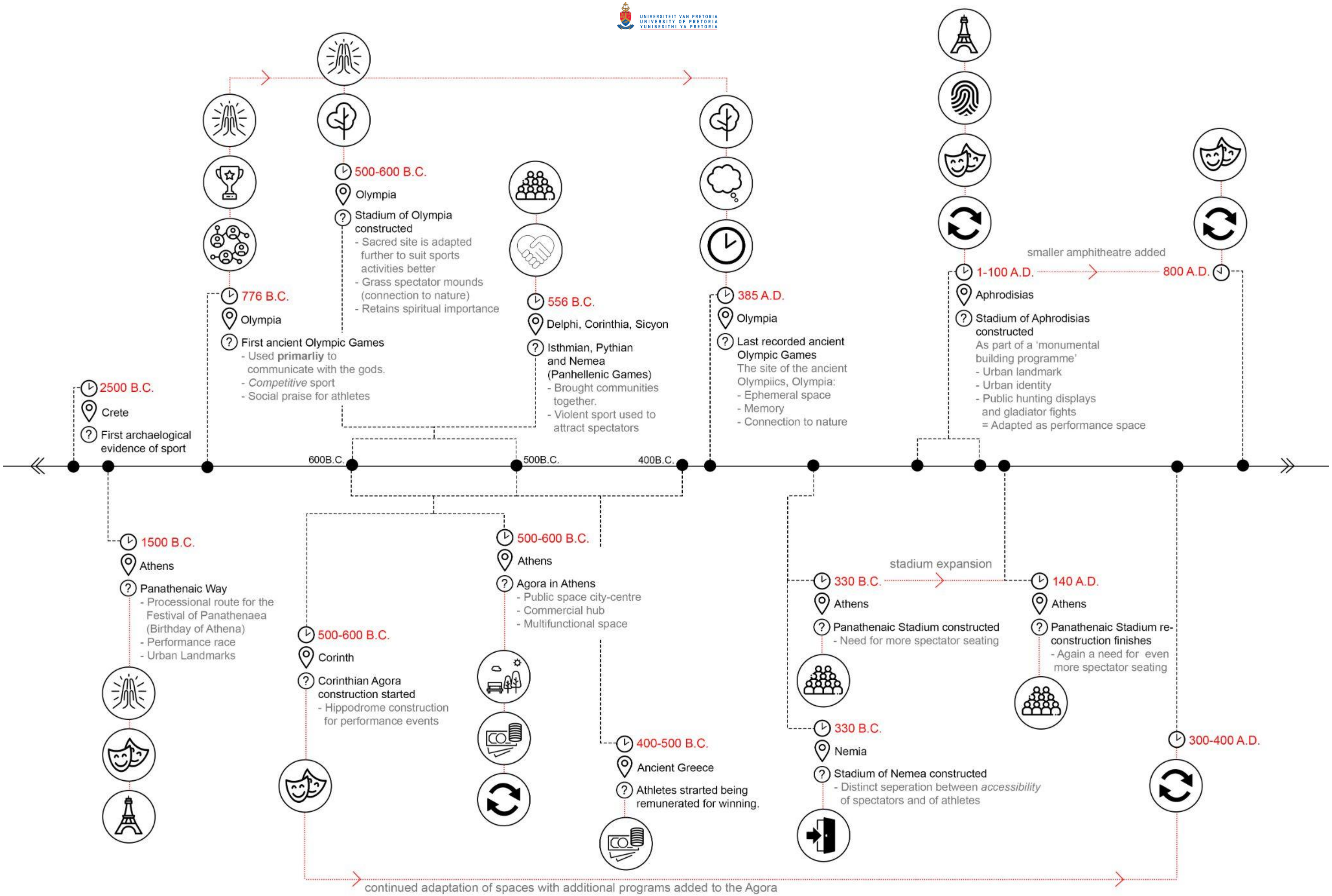


Figure 98: Timeline showing the evolution of sports architecture in ancient Greece (Based on Deimary et. al: 2019).

Relevant sporting authorities

In terms of the focus sport of this research study; competitive swimming (pool and open-water), 4 main sporting authorities presently govern the sport: **FINA**, **SSA**, **IOC** and **SASCOC**.Their histories and organisational objectives are analysed to identify other key drivers that could aid as design informants. These are summarised in the diagram (FINA: 2018; SSA: 2015; IOC: 2021; SASCOC: 2020) (figure 99):

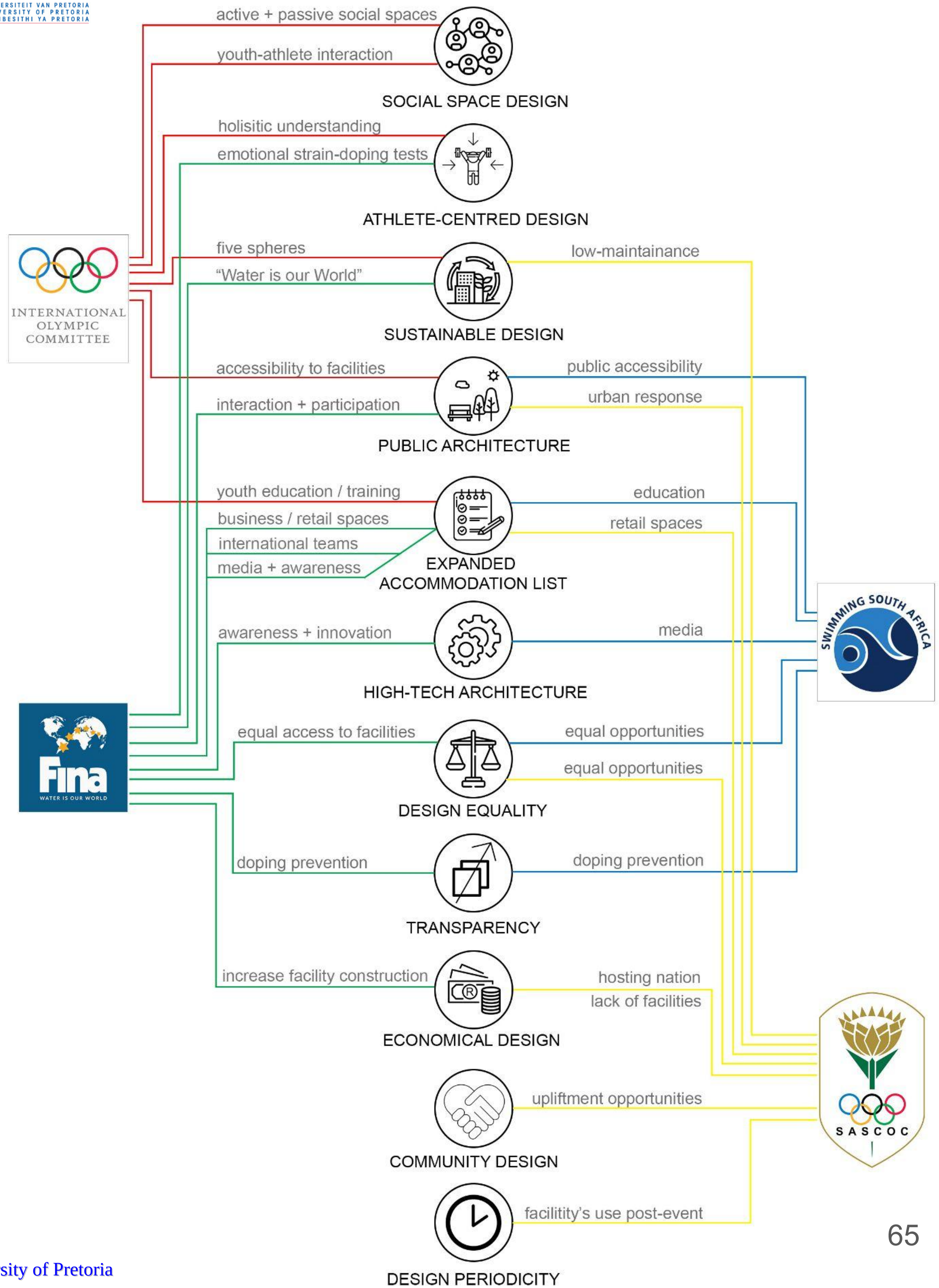


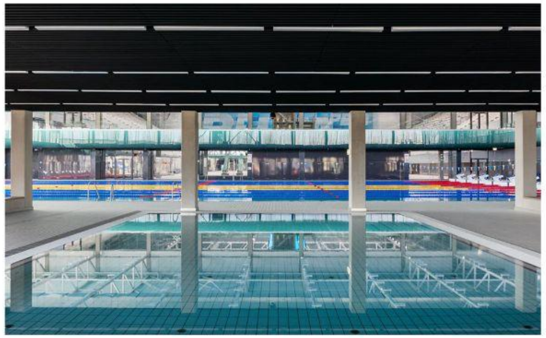
Figure 99: Shared objectives of sporting authorities and their relation to design (Author, 2021)

Duna Arena by NAPUR Architects

The steel structure attempts to reflect the movement and undulating light quality of the adjacent river.

Layered facades step down towards the street edge, bringing the large mass to a more human scale.

The facade facing the river edge, however, stands tall and proud - acting as a landmark for boats passing by.



Continuity of internal spaces is created linking water elements to one another.

Social spaces for user interaction edges the perimeter of the field of play.

Transparency at ground level attempts to reduce the structural density of the arena and allows visual access to the internal activities.

Figure 100: Images and relevant characteristics of the Duna Arena (Lomholt, 2019)

[The adjacent figures explain how lessons learnt from this precedent have been translated into my design]

The Duna Arena, completed in 2017 in Budapest for the FINA World Championships, is an example of an international competition venue that caters for public functions and continuity of use (figure 100). Designed with all FINA and IOC professional sporting standards in mind, the arena catered for more than merely professional athletes, opening its doors to the wider public and youth for recreational and social training opportunities. Flexibility became a vital principle in the design to allow the building to alter itself as needed, depending on the function it was serving - be it competition or public use. The roof height was raised to accommodate spectator stands for over 15000 spectators which would be dismantled after the event had ended. Furthermore, the three pools are designed with adaptability in mind, allowing them to be covered to create floor space for land-sport events or concerts. Upon entry, the scale of the large structure is mitigated through the layering of facades that bring the large mass down to human-scale as the building approaches the street edge (figure 102). However, the facade facing the river edge stands tall and proud, acting as a landmark in the city (figure 103). Furthermore, due to the highly multifunctional nature of the facility, transparent surfaces are used to prevent overly-densified internal spaces. Continuity of internal spaces is created, linking the water elements with one another (figure 104).

The arena is conveniently located near the northern gateway to the city and along the Danube River. This makes the facility easily accessible to most bus, tram, metro and boat routes (figure 105), connecting the facility to its wider context. Also relating the building to its context, a large terrace on the western facade visually connects the venue with urban landmarks such as the Hungarian Parliament Building and the Visegrad Mountains. Lastly, through the alternating sheet profiles of the facade, the building attempts to mirror the adjacent river. The steel sheeting alters the perception of the building depending on the weather: during sunny days, the facade sparkles and reflects the vibrant river edge, while during overcast weather, it blends into the surrounding fog and grey tones of the Danube (Lomholt, 2019).

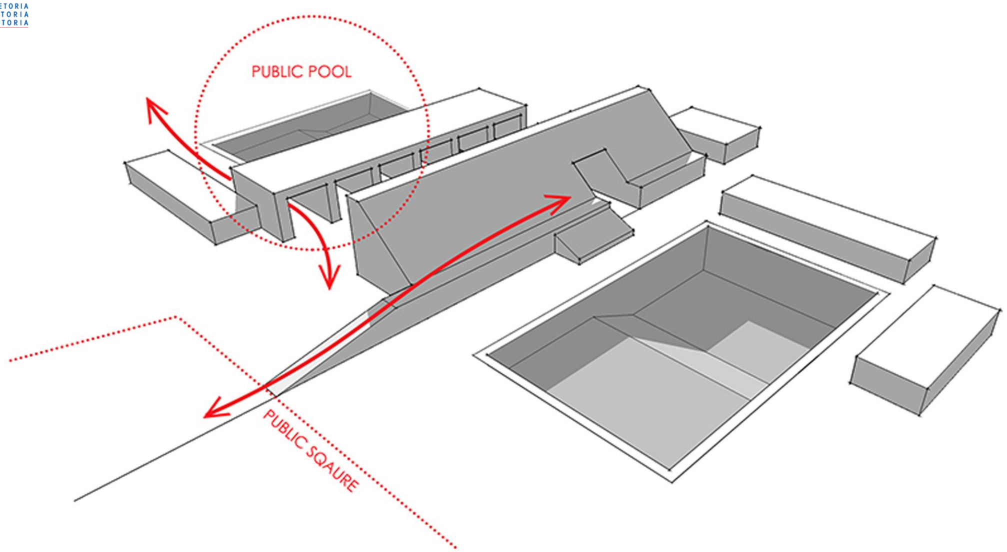


Figure 101: Continued use through public integration (Author, 2021)

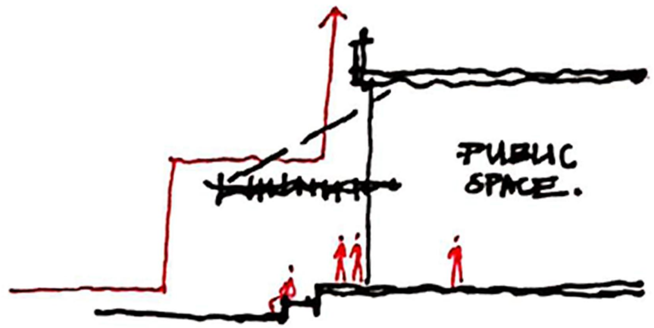


Figure 102: Stepped facades mitigate the building’s scale (Author, 2021)

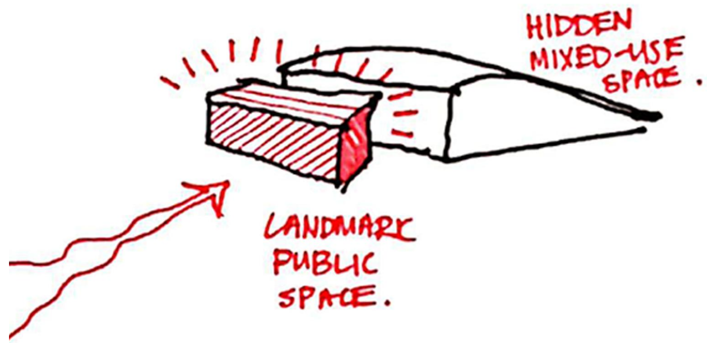


Figure 103: A landmark on the campus vs. a hidden facility (Author, 2021)

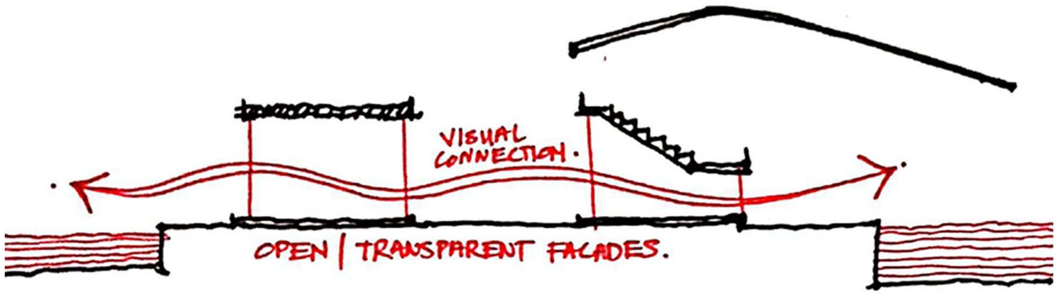


Figure 104: Water bodies are linked to one another (Author, 2021)

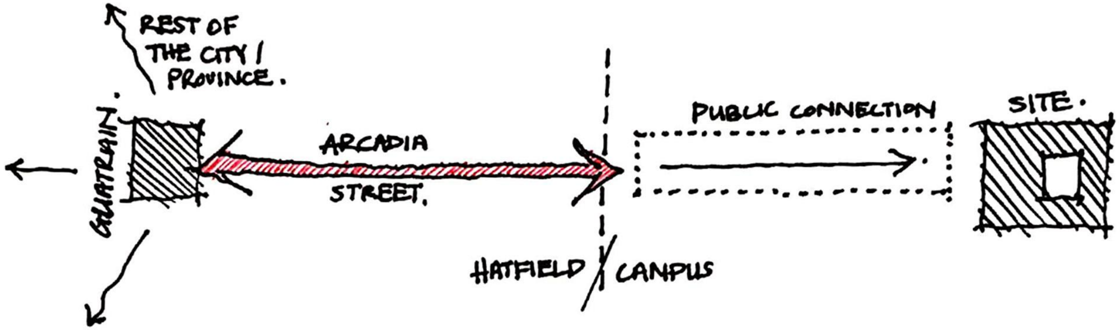


Figure 105: Linking the Gautrain, Arcadia Street and the site to enhance access to the facility and encourage continued use (Author, 2021)

The Duna Arena, along with personal experiences of both local and international sporting and swimming arenas has allowed me to draw up a detailed program list:

Category	Room name
Swimming training	50m swimming pool
	Open water channel
	Ablutions (wet and dry)
	Changing rooms
	Locker rooms
	Wetbag storage
	Pre-session stretching
	Team talks
	Coach's office 1
	Shared coach's office 2 + 3
	Aministrator's office
	Gym receptionist's office
	First-aid room
	Security house
	Parking lot
	Emergency pickup point
	Recovery quarters
	Physiotherapy consultation
	Nutritionist consultation
	Sports psych. consultation
	Support facility's reception
	Support facility's waiting area
	Gym
	Athletes' social space
	Athletes' living quarters
	Athletes' cafeteria + kitchen
	Maintainance + equip. storage
	Electical control room
	On-deck showers
	Staff breakroom
	Auditorium
	Pool covers storage

Category	Room name
Swimming competition	Spectator seating
	Temporary food stands
	Permanent cafe' / snack shop
	Temporary product stands
	Tickets booth
	Additional / separate ablutions
	25m cool-down pool
	Podium / performance platform
	Doping control room
	Dryland warmup space
	Media room
	Post-race interview space
	Race-suits changing rooms
	Marshalling venue 1
	Marshalling venue 2
	Officials meeting room
	Coaches' seating
	Starter's platform
	Timekeeper's seating
	Technical officials clear route
	Commentator's room
	Administrator's office
	Storage for comp. equipment
	Results wall

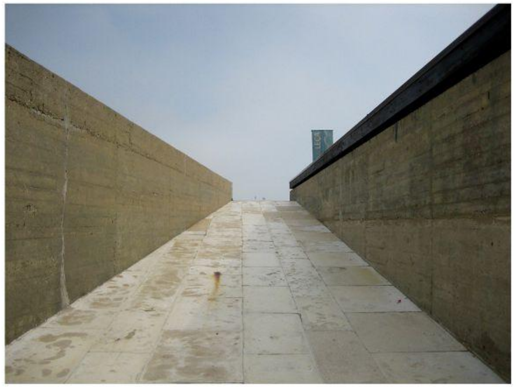
Category	Room name
Public spaces	Food court
	Kitchen
	Service and delivery
	Outdoor braai area
	Indoor braai area
	Events space
	Temporary market space
	Informal play space
	Recreational training pool
	Recreational social pool
	Changing + locker rooms
	Ablutions (wet and dry)
	Lifesaver's bench
	Public jogging / cycling route

Figure 106: Accommodation list for the new TuksAquatics Complex (Author, 2021)

Leça Swimming Pools by Álvaro Siza Vieira

The man-made structure of the pools lie sensitively between and against the natural rock formations, merging the building with its context.

The view from the street edge is retained as passers by look over the new building.



The ramp immerses users into a space with no views, heightening their auditory experience of the ocean.

Function is not forgotten amidst all the sensory experiences: seen in the practically designed wet-to-dry transition of the changing rooms.

Sharp changes in direction create climax moments where views to the ocean are exposed.

The building, experienced in full height upon exiting the change rooms.

Figure 107: Images and relevant characteristics of the Leca Swimming Pools (Balters, 2011)

Leça Swimming Pools by Álvaro Siza Vieira (continued…)

[The adjacent figures explain how lessons learnt from this precedent have been translated into my design]

The construction of the swimming pool makes constant reference to the existing rocky coast of Matosinhos, Portugal. The raw concrete with its exposed formwork markings mimic the rough rocky outcrop on the surrounding beaches. Immediately, the facility is blended into its natural surroundings (figure 108). Situated between the ocean and the street edge, the building is almost fully hidden by sinking it below the street level (figure 109). Furthermore, the views to the ocean from the street are retained. A hybrid setting exists where the natural rock pools of the Portuguese coast merge with the rigid man-made pools (figure 110).

Siza plays on the senses of the user by sinking the entrance ramp below street level and behind the changing rooms. The view of the street and the ocean are lost here, where one instinctively picks up on the audible sounds of ocean waves crashing against the rocks. He uses this sensory experience to mediate between road and beach (like the call-room transition). As one exits the changing rooms (one level below the street) the building is finally seen in full-height, creating a welcomed boundary to the street edge. Lastly, a sharp turn in the walkway to the beach finally exposes panoramic ocean views. Siza carefully directs the views and sensory experiences of the user, creating calm and climax moments throughout the building (Balters, 2011) (figure 111).

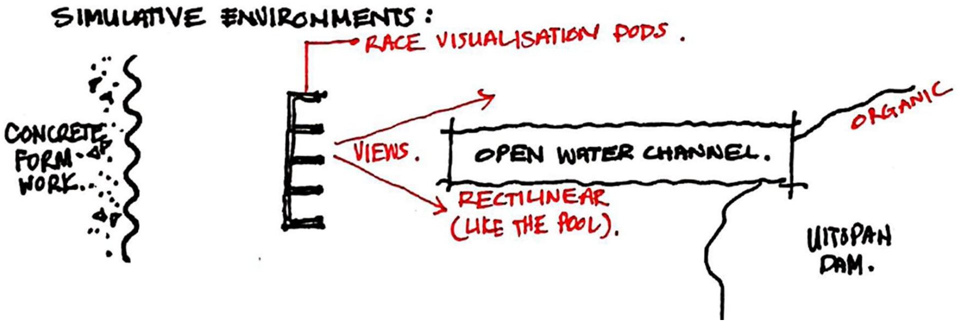


Figure 108: The building elements mimic those of nature (Author, 2021)

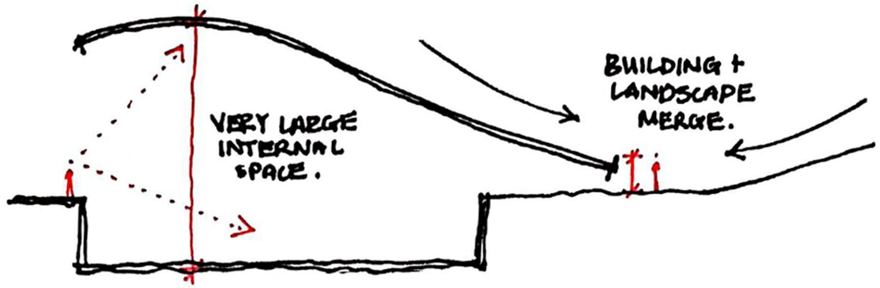


Figure 109: The change in level distinguishes the swimming pool complex from the surrounding urban infrastructure, acting as a more natural element in the landscape as opposed to built structure (Author, 2021)

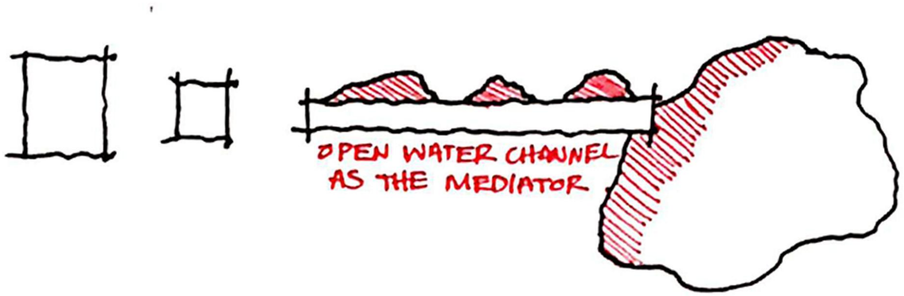


Figure 110: Linking the man-made and the natural water bodies across the site (Author, 2021)

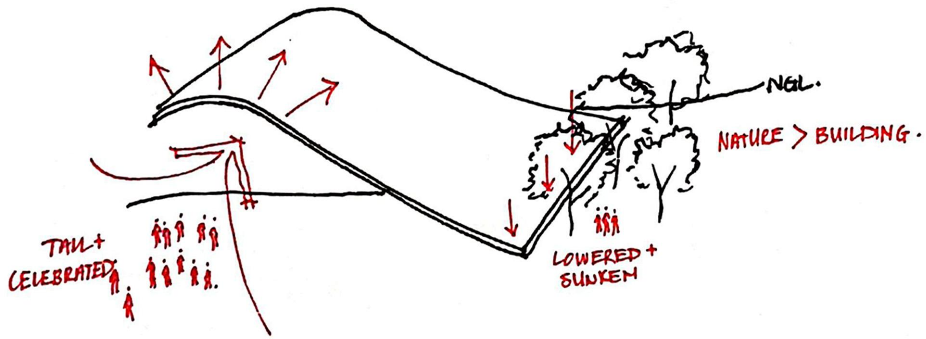


Figure 111: Calm private moments where nature dominates structure and climax public spaces where structure stands tall and celebrated (Author, 2021)

Conclusion

The typical stadium typology is inverted from an inward focussed *destination* typology to an outward focussed segment of a larger urban scheme. Sports architecture as a private monument becomes public architecture that houses both public and private sporting functions operating in harmony with one another. Not only do the new public functions add to the sustainability of the design by responding to the need for continuity in sports design, but the public also play vital roles in supporting the athletes by enhancing their psychological resilience, and as a result, their physiological well-being. The architecture responds to the athlete's psyche through evidence-based design interventions at various scales, attempting to contribute to the athletic performance enhancement of the diverse range of athletes, their mindsets and their approaches to their sport.

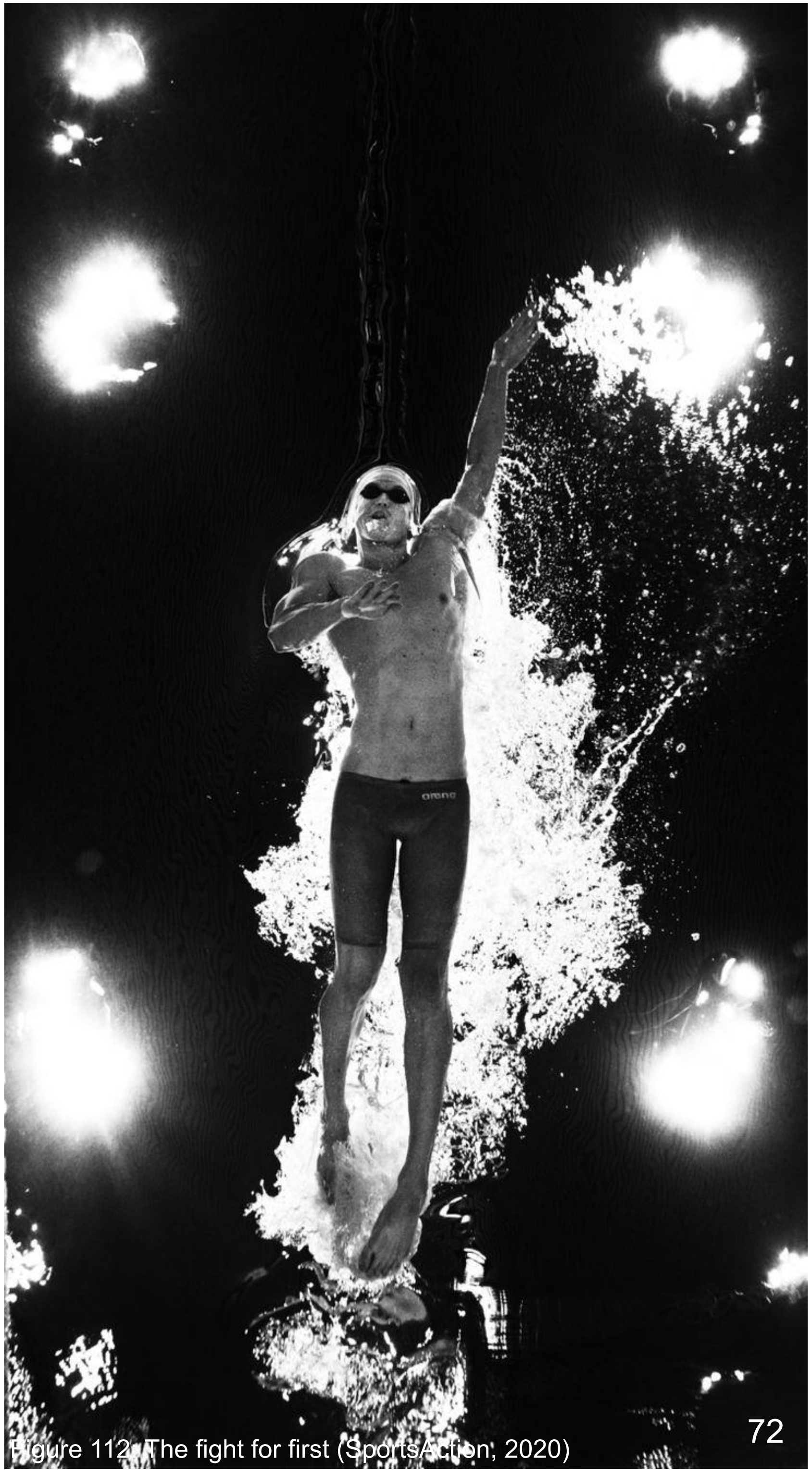


Figure 112: The fight for first (SportsAction, 2020)

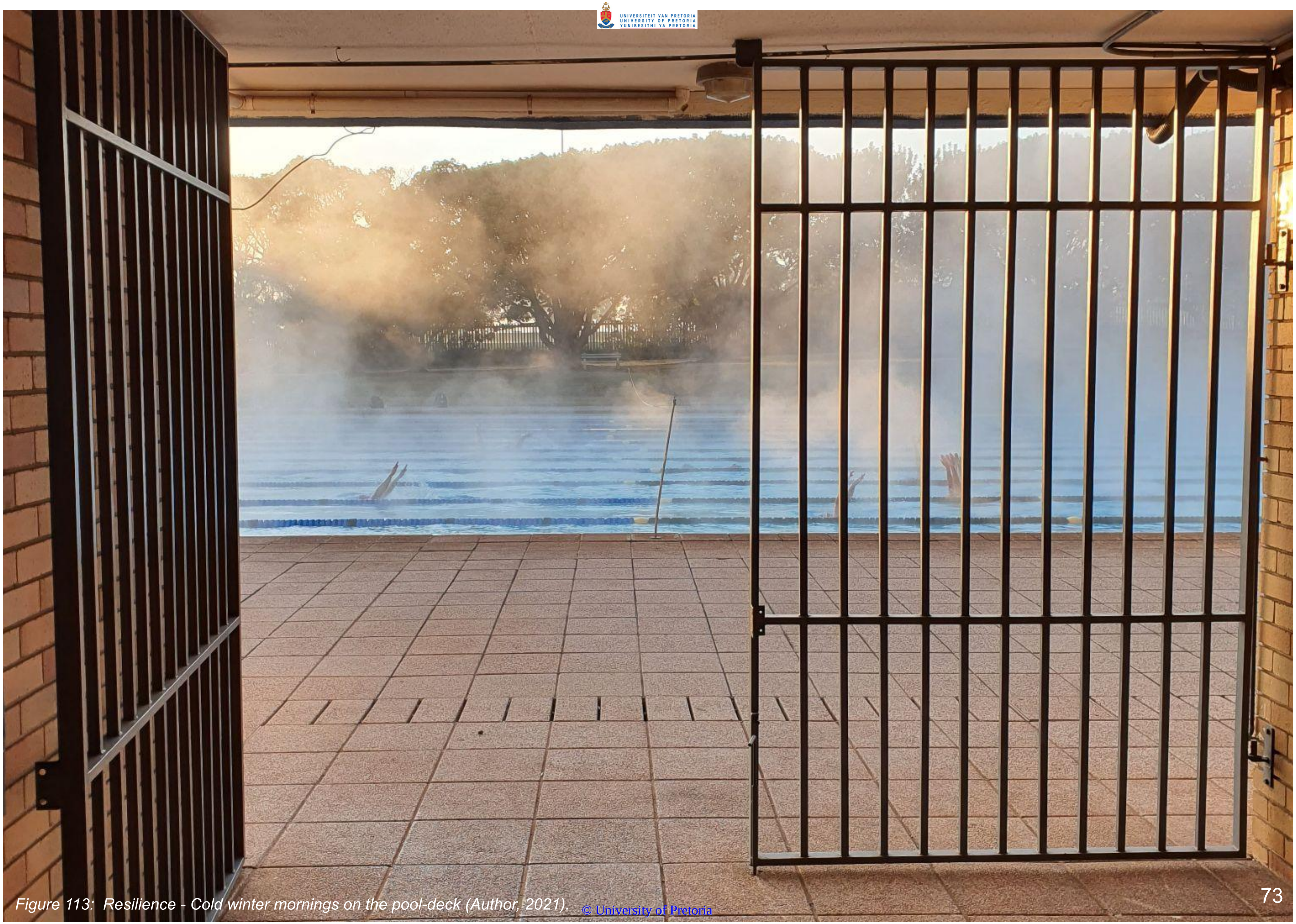


Figure 113: Resilience - Cold winter mornings on the pool-deck (Author, 2021).

Part 3: Synthesis

Introduction

In this chapter, the intentions for technology in design are expressed. A material pallet, summary of the proposed structure along with four main structural languages shape the technical resolution of the design that was discussed in chapter 2. Various precedent studies further enforce the resolution of technology-related decisions. Lastly, the role of sustainability in sports architecture is discussed along with its impact on technical design decisions.

In the research proposal of this mini-dissertation, the connection between sport and architecture was made evident by comparing both to a form of spatial organisation and expression (Cleary, 2017). The commonalities exist in that both sport and architecture generally have a frame - be it formal or informal, permanent or temporary - and within this frame, a performance by or experience of the user. The merging of the frame and the performance it accommodates is what transforms generic space into 'place' (Cleary, 2017). Noting that the frame impacts the performance (hence, architecture can impact the athletic performance of an athlete), it is vital that this frame needs to be clearly defined. Generally, the frame in sport exists as the field of play itself: the boundaries of the soccer pitch, the painted line on a tennis court or the carefully demarcated lane-lines of a swimming pool. In architecture, this frame can be extended past merely the field of play, encompassing the surrounding and supporting spaces that house and accommodate this field of play and the athletes within it as well. This architectural frame becomes defined through its *structure*, *materiality*, *form* and *technological functionality*. Ideally, these aspects should work together in harmony to create pleasant and, ultimately, athletic performance enhancing experiences for the athletes and other users.

Figure 114: The current TuksAquatics Complex (Slechter, 2021)

Intentions for technology in design

The second portion of the original research question states: “How can the design of sports architecture be improved to benefit and enhance the performance of the professional athletes it serves?” Relating this to the architectural issue of *functionality* being favoured over *experience* in sports design, it becomes clear that the frame of sports architecture cannot be a generic formal, structural, material or technological solution. Instead sports venue designers must merge technological thinking with experiential design intentions to ensure that the athletic performance enhancing potential of sports architecture is maximised.

In order to achieve this, the design is divided into four main *design languages* that guide the technological, formal and structural resolution of the larger sports venue. These four languages are based on previously discussed principles of environmental psychology in design that enhances the experience and performance of the user (figure 115).

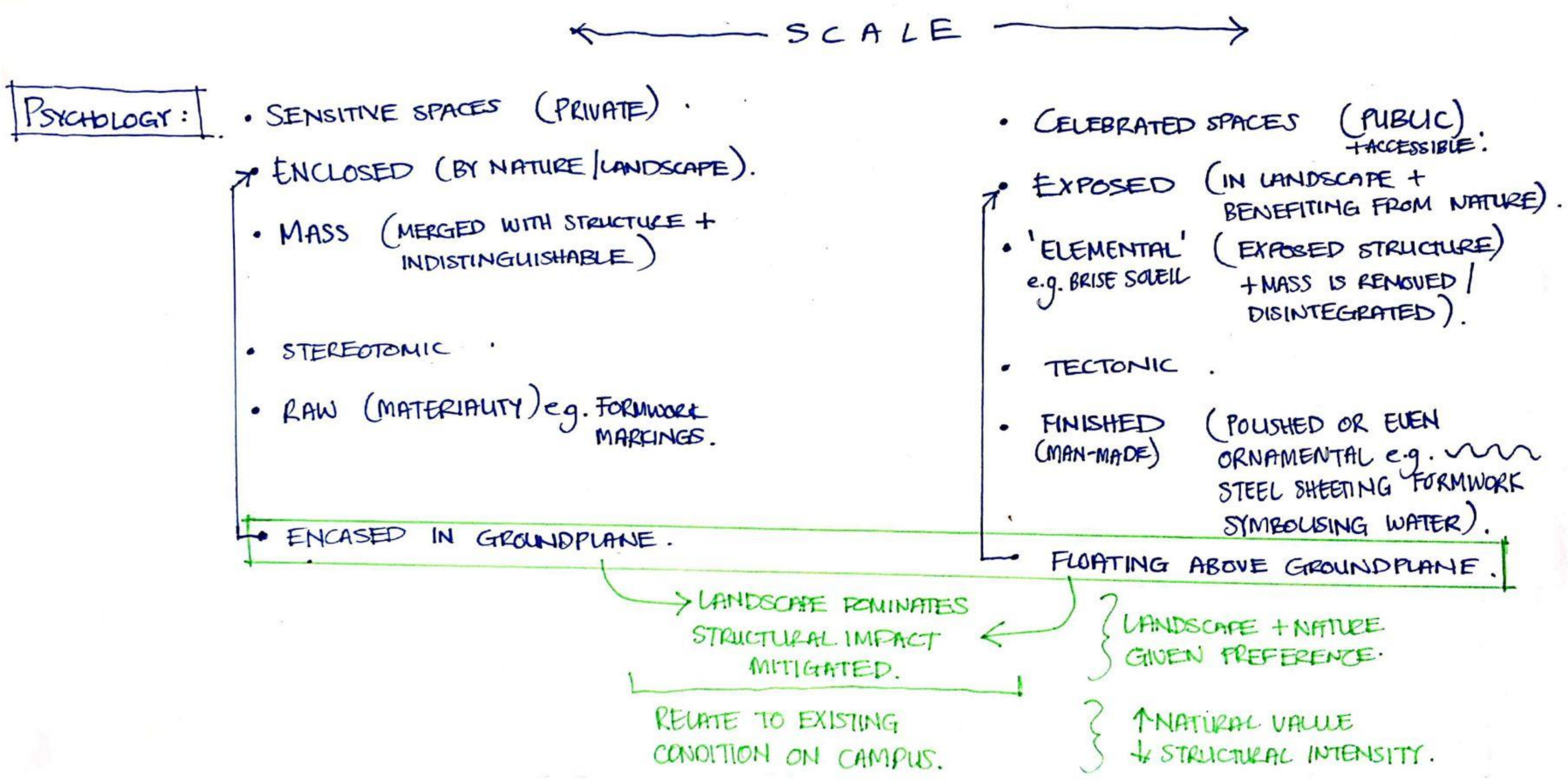


Figure 115: Scale of structural languages in terms of previous psychological findings Author, 2021)

The materiality of each language is based on a response to the features of the existing building and the larger sports campus. The buildings on campus employ varying methods of construction, materiality, architectural style and form. However, an overarching theme exists in the high natural value and low structural intensity of the Hillcrest campus (figure 116). Landscape and nature are given preference over built structure - a theme that has been explored in the earliest stages of the design and that contributes to psychologically supporting environments for athletes.

The roof form acts as an extension of the existing landscape at the east of the site (figure 117). Man-made structures and functions are housed beneath the raised earth and roof. Hence, the materiality of the roof and the structures beneath and beside it differ. The roof of the arena, as a new element that belongs to the landscape, is constructed with natural materials such as timber (treated plywood that is locally sourced). Along with slanting green roofs and translucent polycarbonate, the roof mimics the light, airy and tranquil vegetation of the rest of the campus. Polycarbonate is used due to its high insulative properties that prevent condensation in the roof interior of often-humid spaces like indoor swimming pool facilities. Furthermore, the translucent light transmission allows natural daylighting without allowing too much heat gain in the interior of the arena. Green roofs also allow natural insulative properties, creating more comfortable indoor environments at the offices and consultation rooms.

On the other hand, the man-made structures below and beside the roof are constructed of typically man-made materials, related to the materials chosen for the existing building (old squash courts) and spectator stands. This includes: exposed reinforced concrete as a dominant structural material as well as yellow facebrick as a dominant infill (and sometimes structural) material. Facebrick is favoured over plastering and painting walls to relate back to the existing building as well as to reduce the maintenance that will be needed on the building in the future.

Figure 116: Low structural density on campus (Adapted from GoogleEarth, 2021)

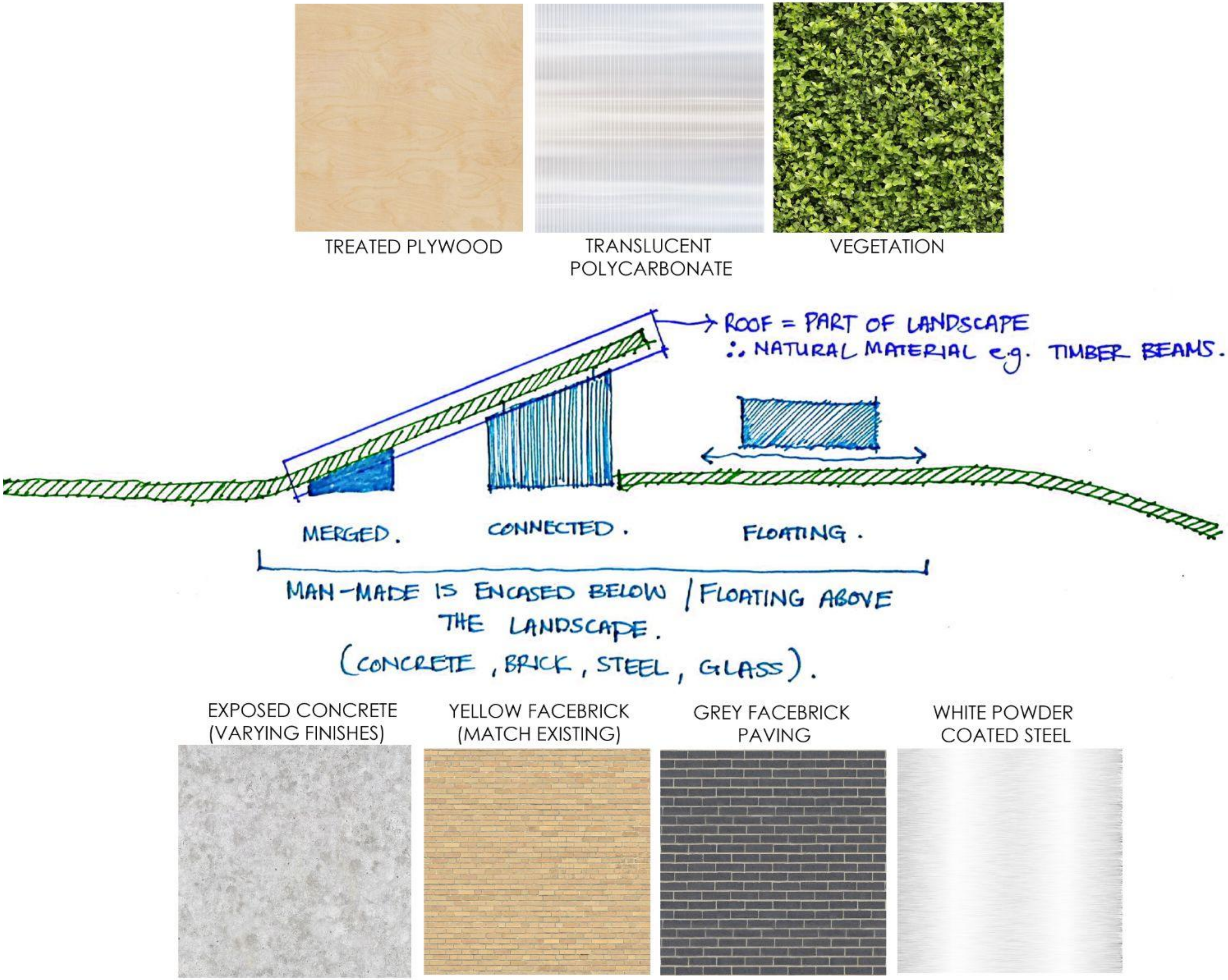


Figure 117: Materiality concept (Author, 2021)

Four Languages for technology in design

Language 1: Enclosure & extending the ground plane

Sensitive spaces in the facility, such as sports psychology and nutritionist offices and injury rehabilitation spaces are enclosed beneath the roof, creating a private and secure environment for athletes. The roof, acting as an extension of the landscape, encases the athletes in nature. The structural make-up of these spaces enhances the theme by using concrete as the dominant material. Structure, infill and even furniture are merged into a single concrete mass, giving the impression of protective spaces that are carved out of the landscape and enclosed within it. These spaces, being completely separate from the existing buildings on the opposite side of the swimming pool, take on a new design and structural language. This even translates to the treatment of the concrete at this portion of the site, where concrete formwork marks are left exposed, to give the impression of natural, unfinished carvings in the earth. The new language of spatial organization can be seen on the plan (figure 121).

As this portion of the arena is enclosed and tightly fitted beneath the landscape (and its extension into the roof), the connection between the roof structure and the concrete masses below become an important element to resolve. The intention is that the roof and landscape join seamlessly with one another so as to create a continuous landscape that stretches up and over the arena, blending the arena in with its surroundings (Seen in the iterations of figures 120-128).

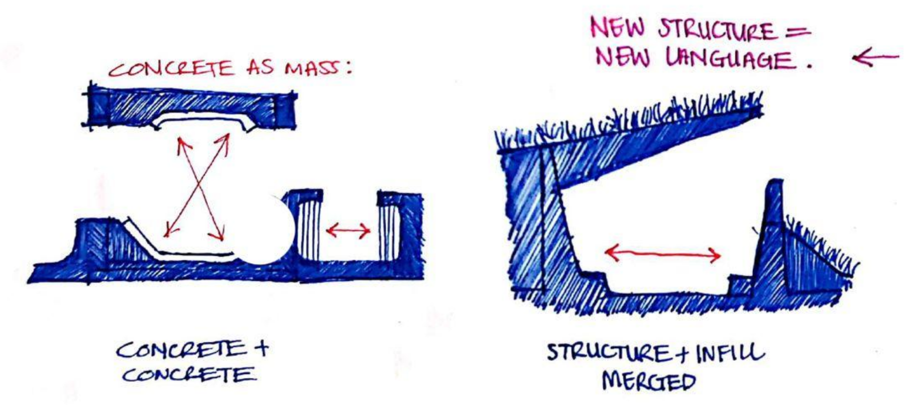


Figure 118: Language 1: Enclosure (Author, 2021)

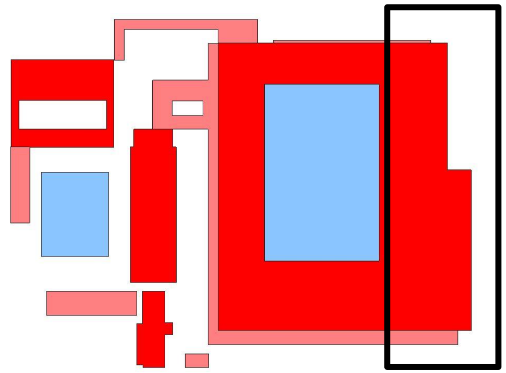


Figure 119: Supporting site diagram to show locality (Author, 2021)

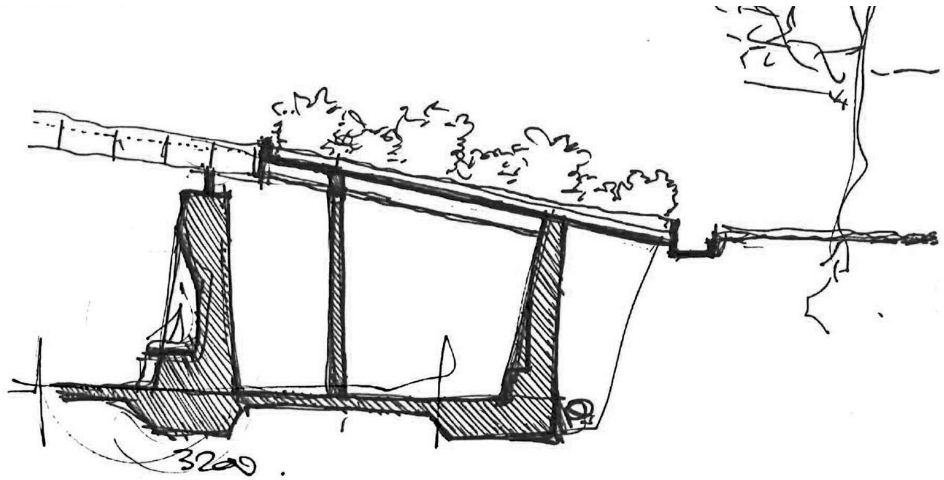


Figure 120: A seamless extension of the landscape (Author, 2021)

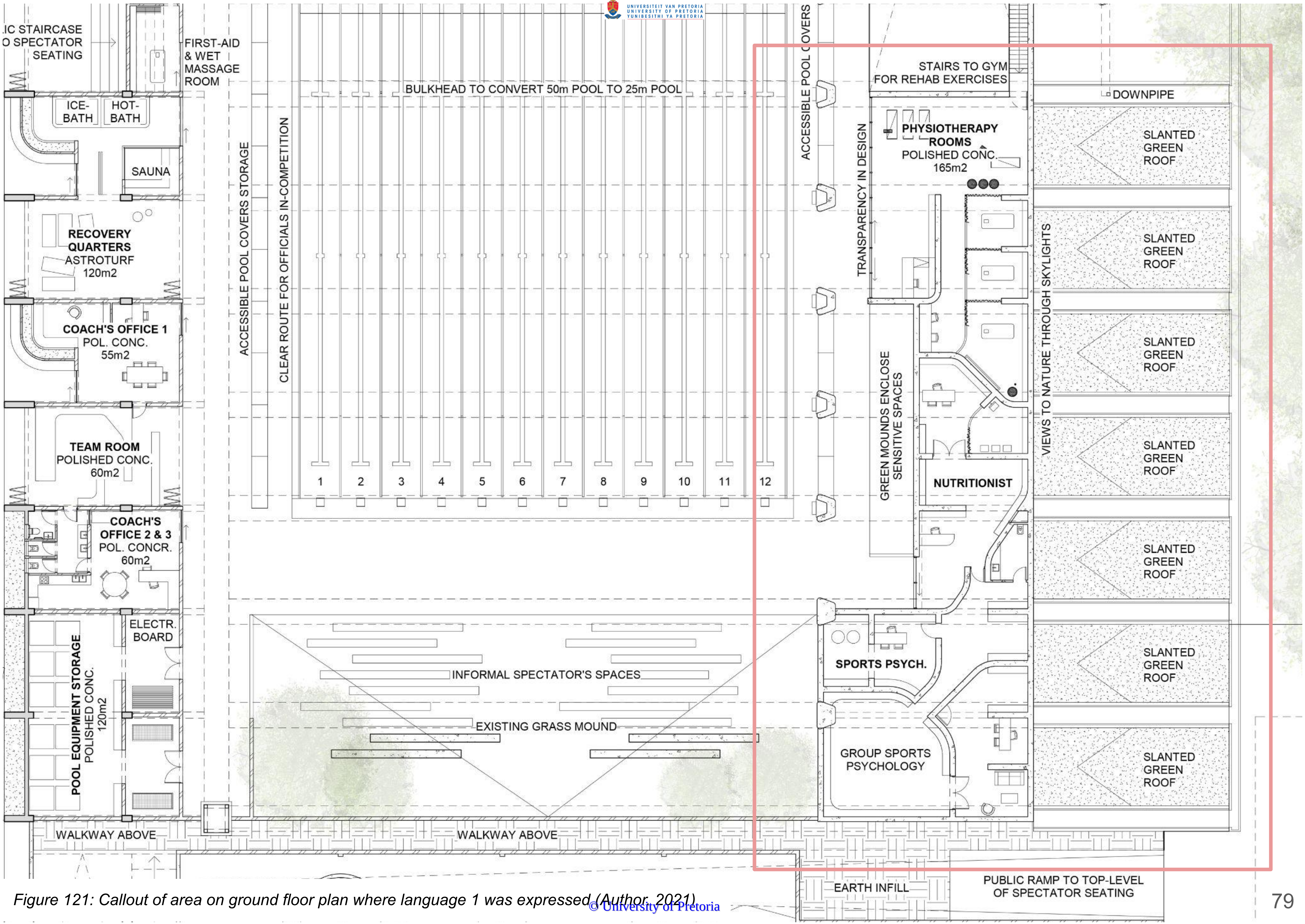


Figure 121: Callout of area on ground floor plan where language 1 was expressed (Author, 2021)

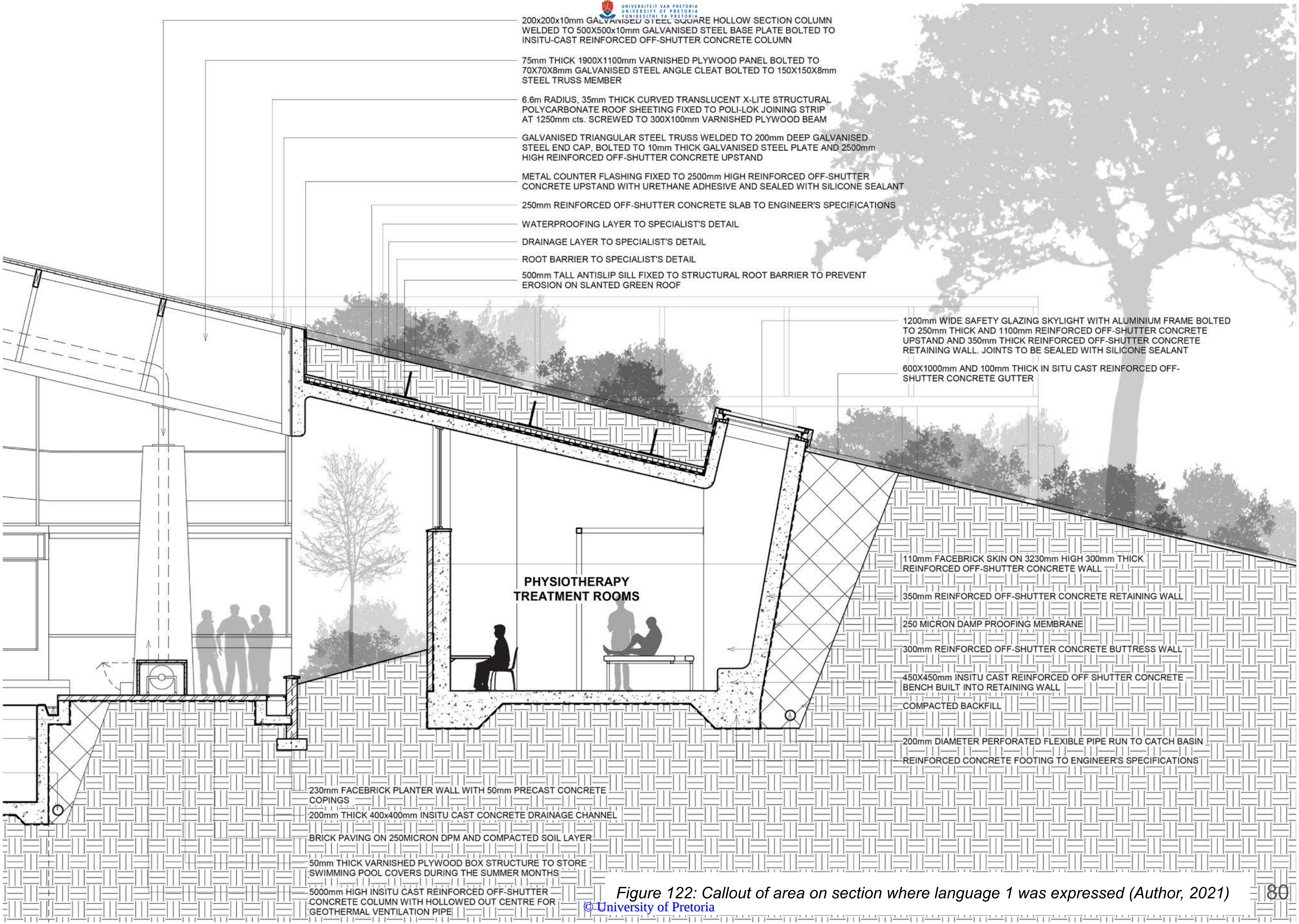


Figure 122: Callout of area on section where language 1 was expressed (Author, 2021)

DETAIL 1: CONNECTION BETWEEN ROOF, CONCRETE AND LANDSCAPE.

AIM: SHOW SEAMLESS CONNECTION + CONTINUATION OF NATURAL MATERIALITY THROUGH ONTO THE ROOF.

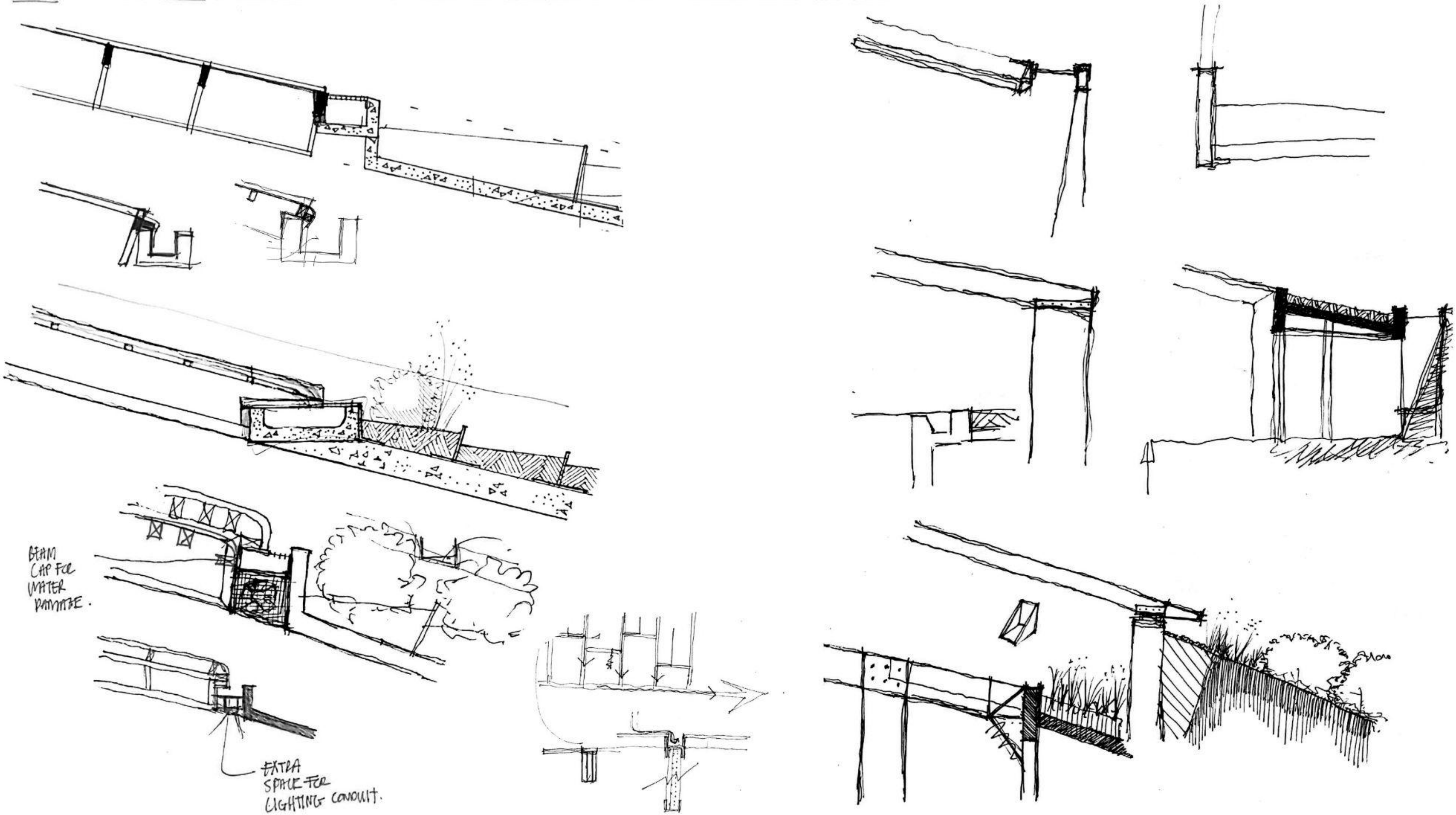


Figure 123: Iterations attempting to create a seamless connection between roof and landscape (Author, 2021)

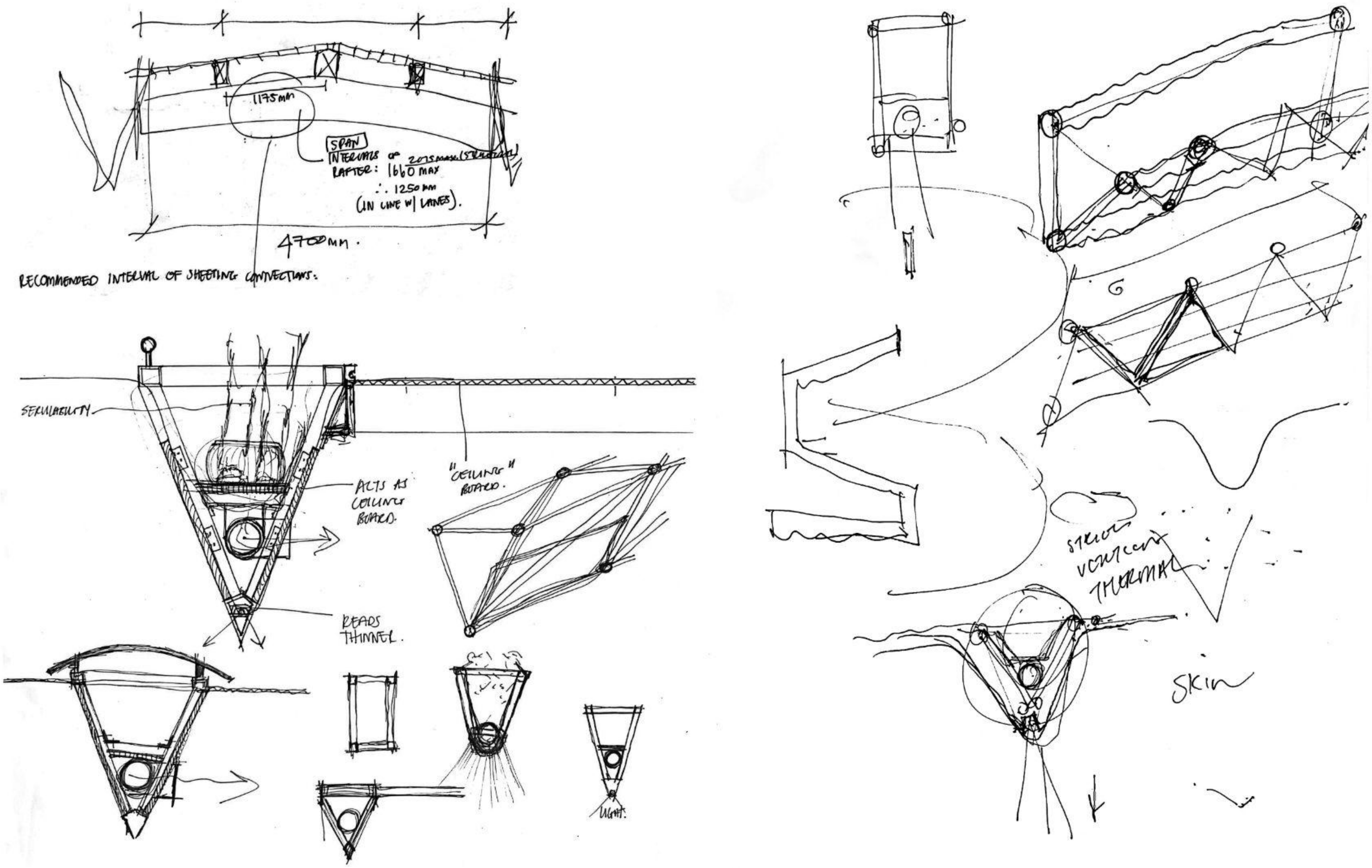


Figure 124: Iteration of the roof structure to determine how the roof and landscape will merge (Author, 2021)

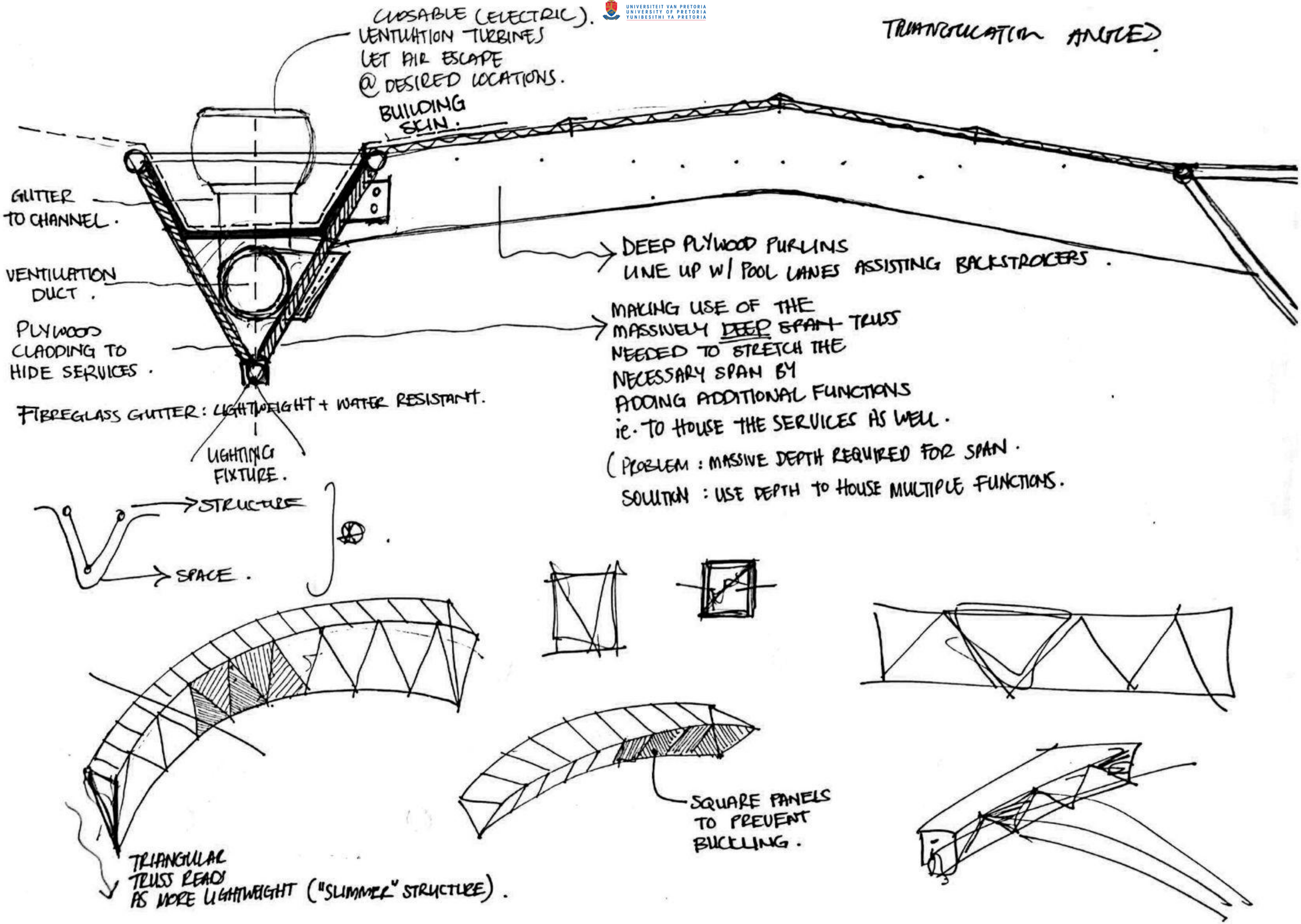


Figure 125: Iteration of the roof structure to determine how the roof and landscape will merge (Author, 2021)

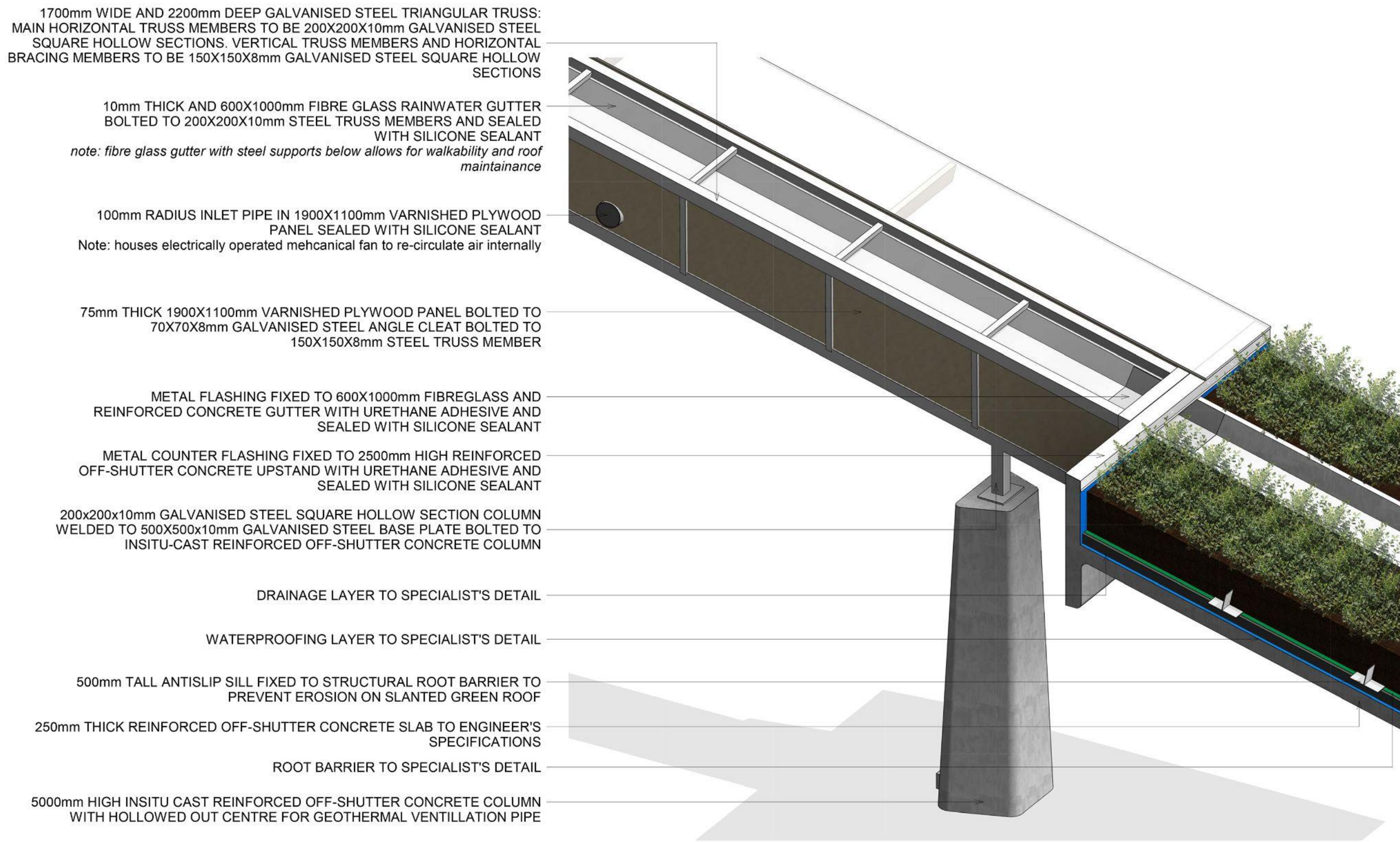


Figure 126: DETAIL A1 (Author, 2021)

Figure 127: DETAIL A2 (Author, 2021)

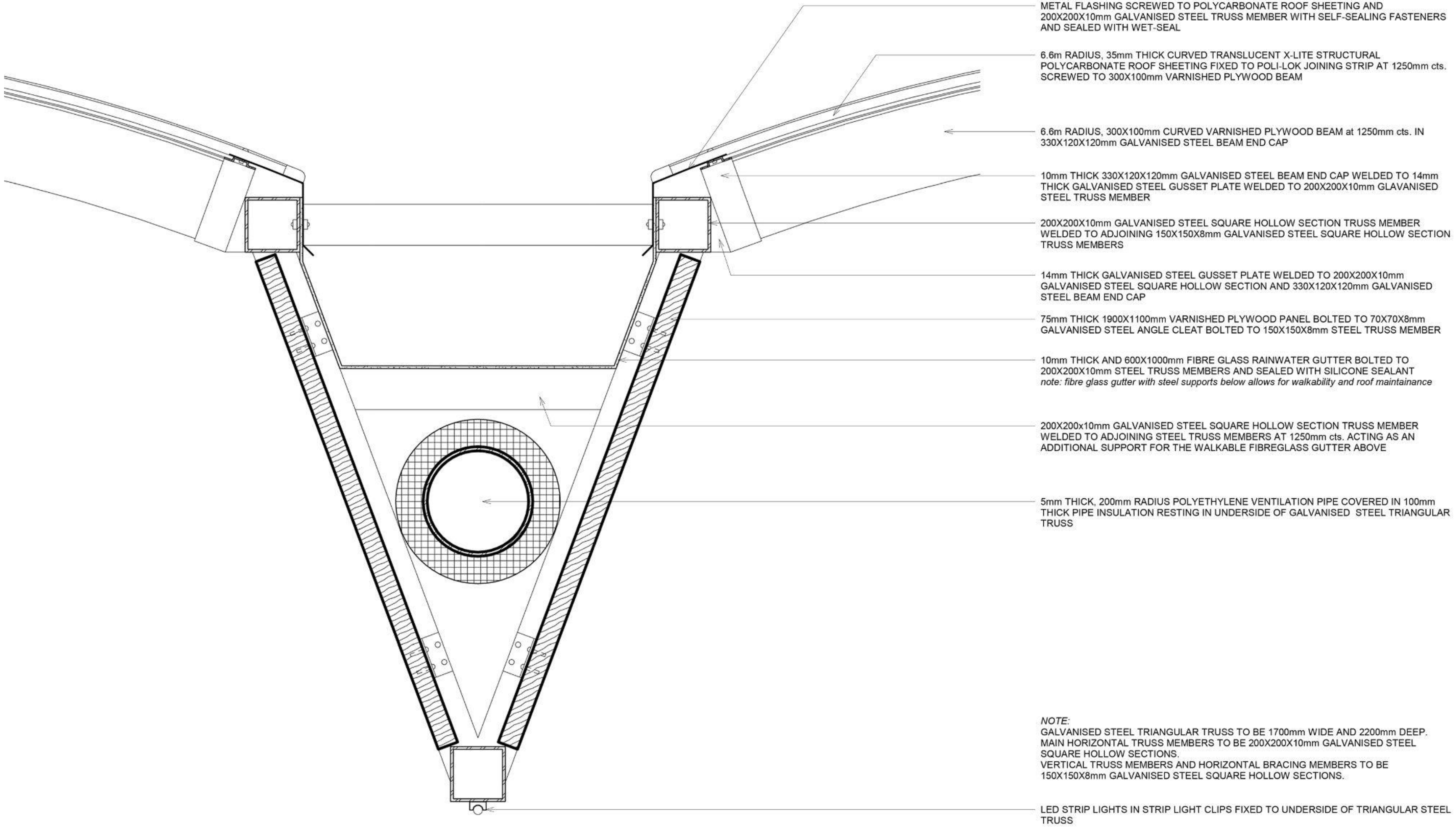


Figure 128: Cross section through triangular roof truss (Author, 2021)

Four Languages for technology in design (continued...)

Language 2: Enhancing the existing / functional

Functionality was largely favoured in the design of the existing building beneath the spectator seating. This was proven in the site analysis, showing long and narrow hallways, hidden entrances, no visibility to the field of play and no interaction between the interior and exterior spaces. The existing structural language exists as a concrete structure that supports the spectator seating above, with full-height yellow facebrick infill and partition walls that close off the internal spaces. In the proposed new language, the concrete structure remains intact as the medium for the infill, but the yellow facebrick infill is altered and redesigned to enhance the experience in the once solely functional spaces. Extensions to the concrete structure are smoothed out to relate the new additions back to the existing building and structure.

In contrast to the first *language* where structure and infill were merged, *language 2* clearly distinguishes the structure from the infill to tie in with the existing. In this sense, the construction becomes more elemental and less mass-driven - each element with an intentional purpose of enhancing the experience of the user and athlete beyond merely satisfying the program. The infill is disintegrated at certain parts where the solid, impermeable facebrick wall is replaced by a yellow facebrick brise soleil partition. This partition enhances visibility to the field of play while allowing some privacy to interior spaces. Furthermore, it helps to allow natural ventilation through the openings in the wall.

(Seen in the iterations of figures 132-136).

In the detail (figure 135-136), the existing solid, impermeable edge condition of the building is transformed into a layered threshold. The line between inside and outside is blurred (figure 131) allowing nature to be drawn in partially into the interior spaces and past the traditional solid wall. This allows athletes to benefit from the psychologically supportive properties of nature through an enhanced experience of the space. Furthermore, openable window sections surrounded by the brise soleil wall allow a lot of ventilation through these internal spaces without compromising on privacy or security.

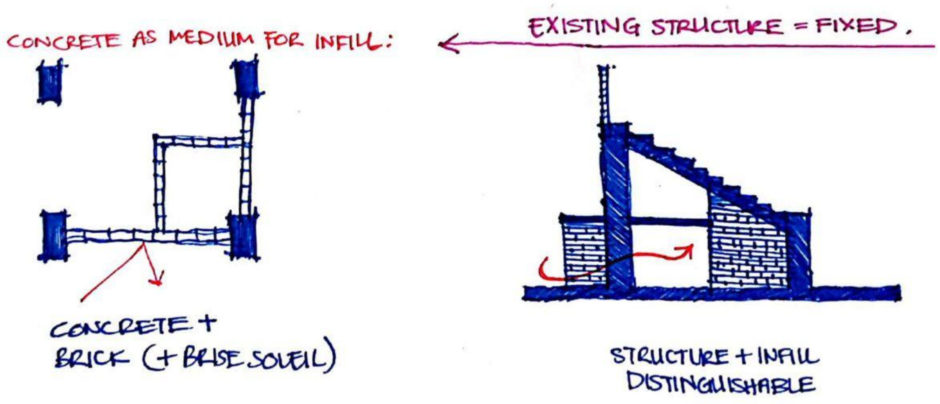


Figure 129: Language 2 (Author, 2021)

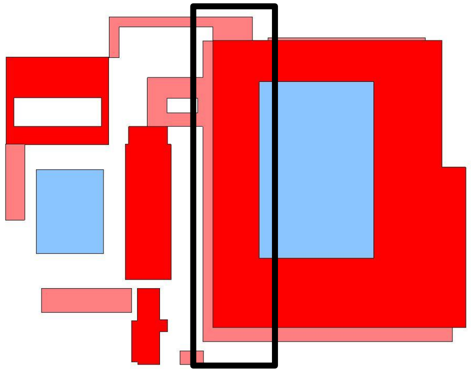


Figure 130: Supporting site diagram to show locality (Author, 2021)

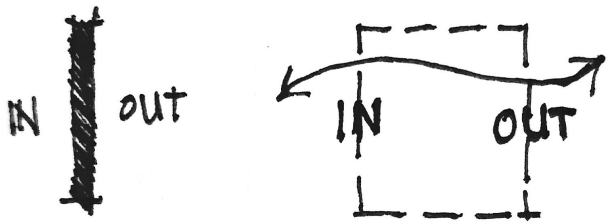


Figure 131: A layered threshold (Author, 2021)

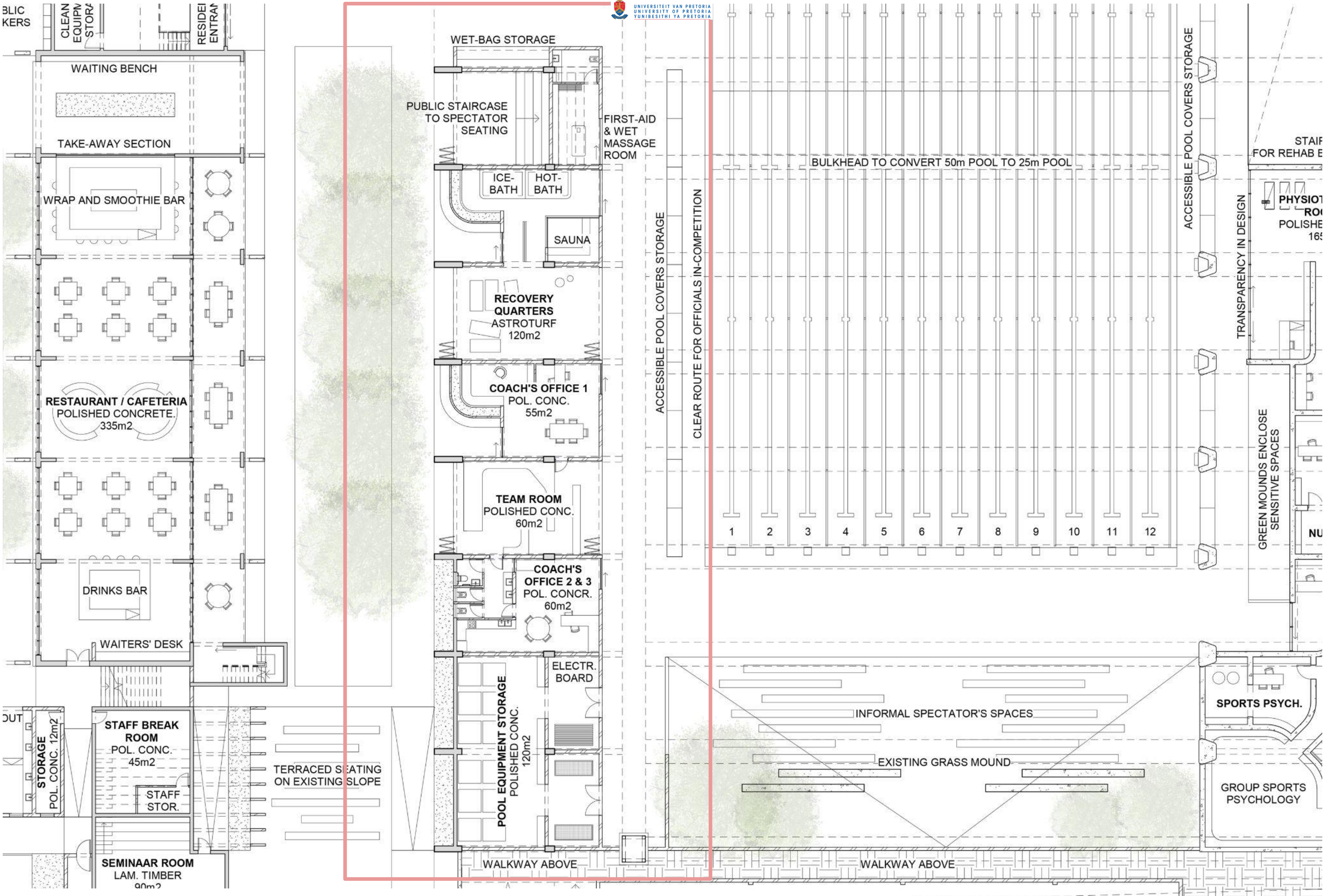


Figure 132: Callout of area on ground floor plan where language 2 was expressed (Author, 2021)

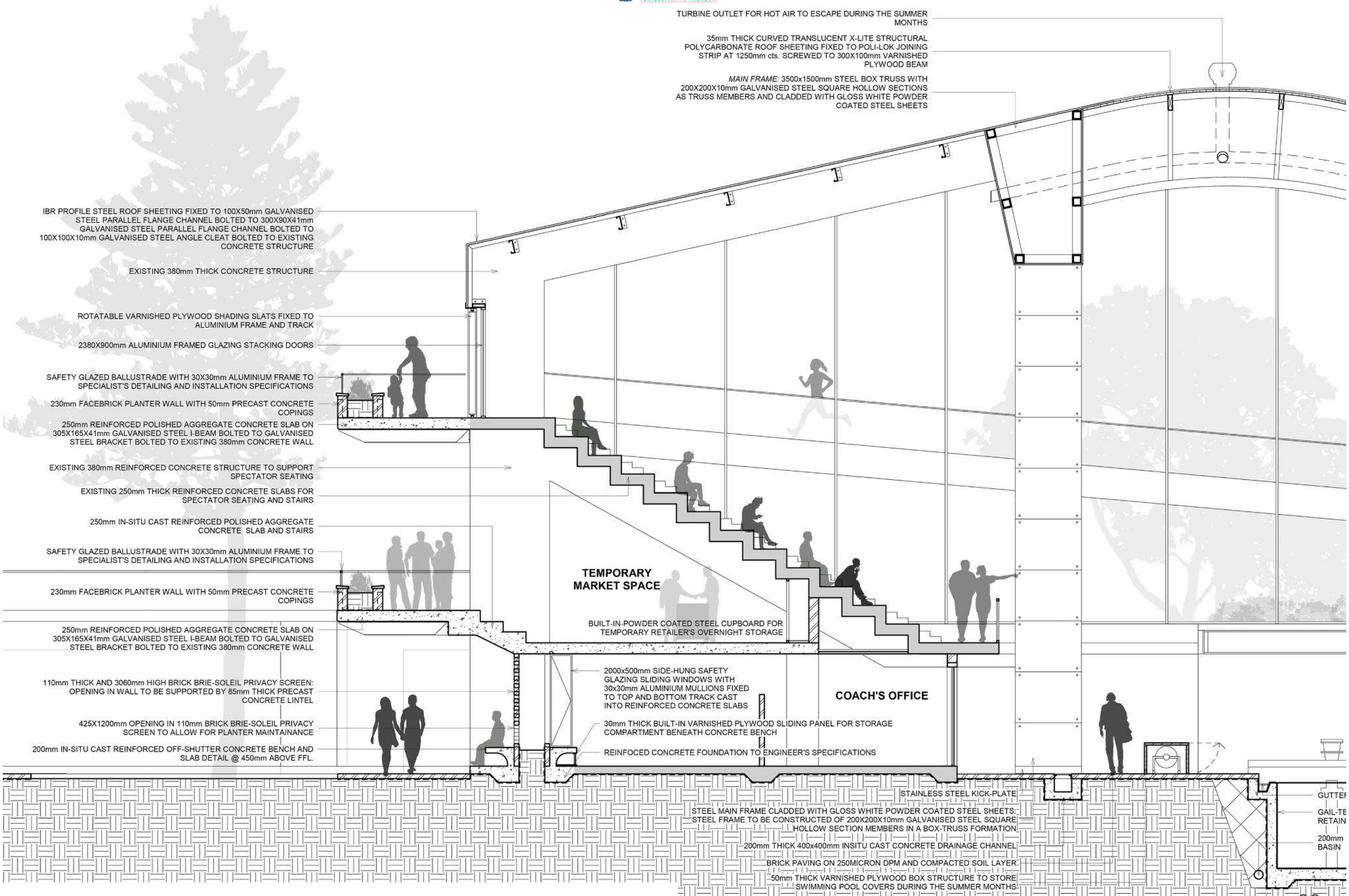


Figure 133: Callout of area on section where language 2 was expressed (Author, 2021)

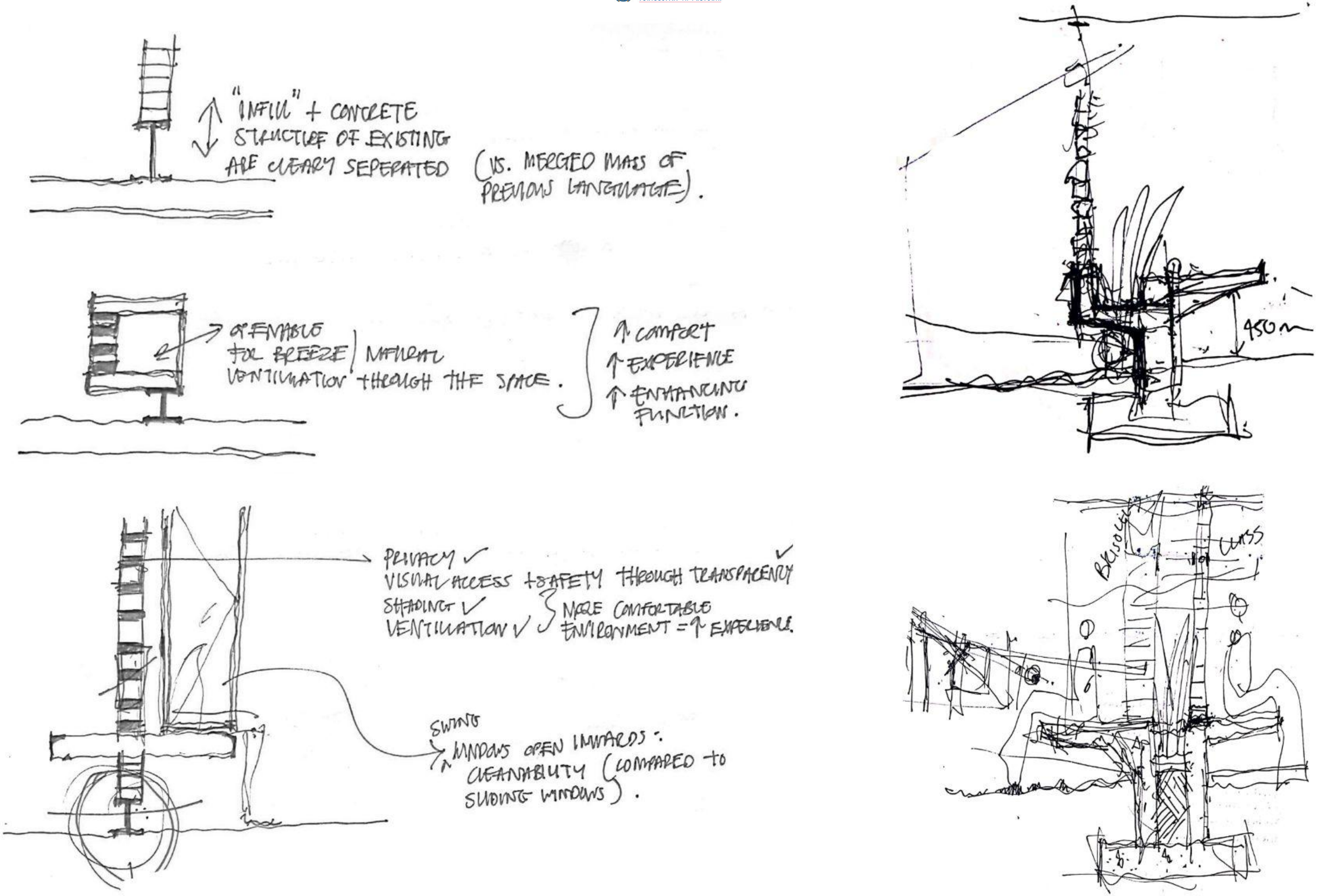


Figure 134: Iterations attempting to blur the threshold to create experientially enhanced functional spaces (Author, 2021)

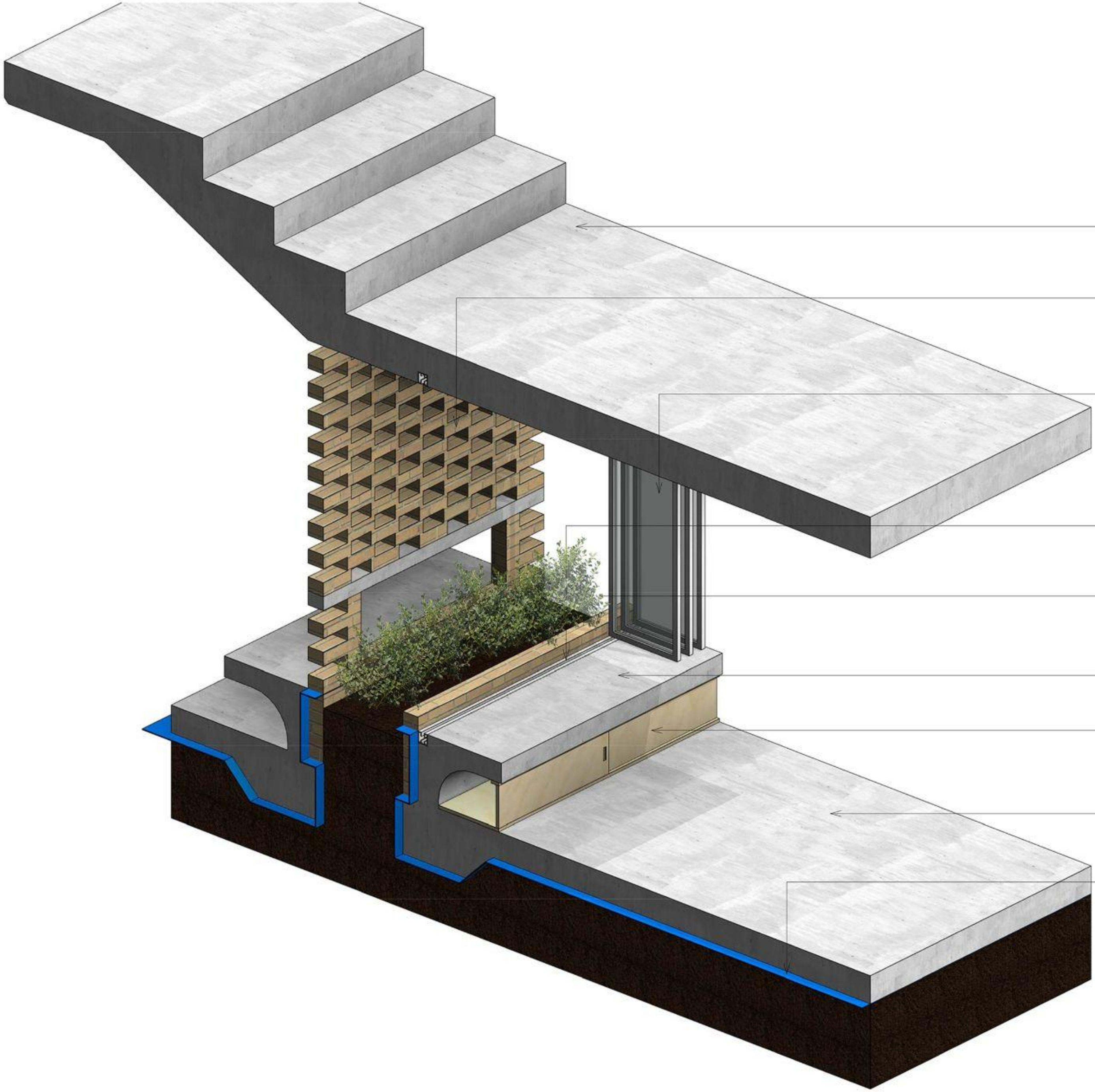


Figure 135: DETAIL B1 (Author, 2021)

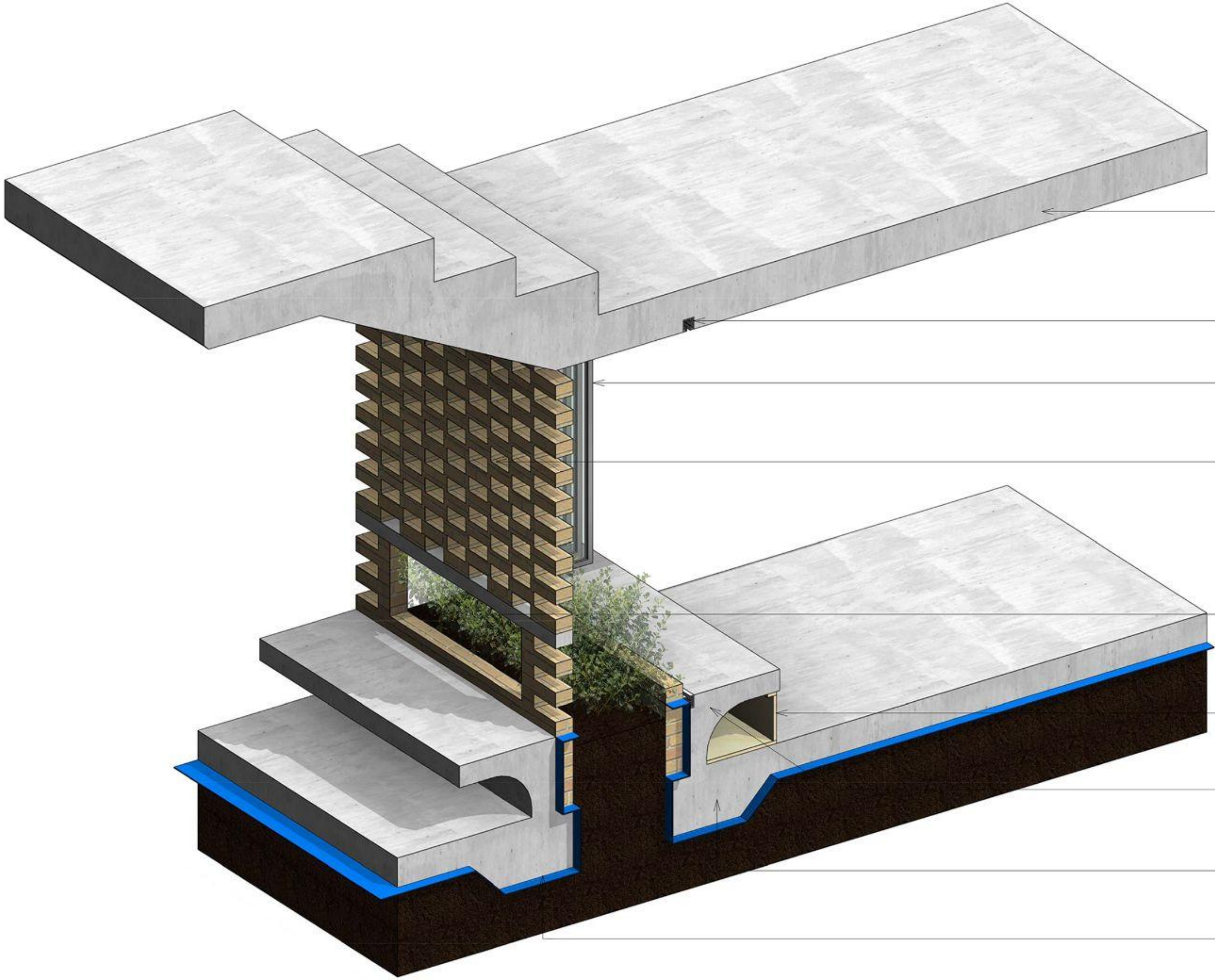


Figure 136: DETAIL B2 (Author, 2021)

Language 3: Enhancing accessibility by removing the infill

As discussed earlier, athletes' support structures - family, friends, coaches and fans - are vital to their success and performance. The site analysis showed the existing squash court building to be a solid, inaccessible mass. By removing the facebrick infill almost entirely and replacing it with openable glazing, the visual and, though controlled, physical access of the space is drastically enhanced (figure 137). Broken facebrick fragments from the demolished wall can be repurposed to fill gabion structures where the gradually sloping landscape needs to be terraced across the site. Furthermore, concrete, smoothed out and rid of its formwork marks, remains as the primary structure, but is now left exposed, isolated and almost entirely stripped of its infill, appearing fully accessible to the public. The smooth concrete is unadorned with the internal spaces being activated by the movement, activity and experience of the users: athletes and their support figures.

Due to the orientation of the existing building, protection is needed to shield the glazed facade from the western sun. Vertical treated plywood louvres supported by a steel framework that encases trees for additional shading softens the facade. The high building gradually steps down to the human-scale as one enters the building, as seen in the section (figure 140).

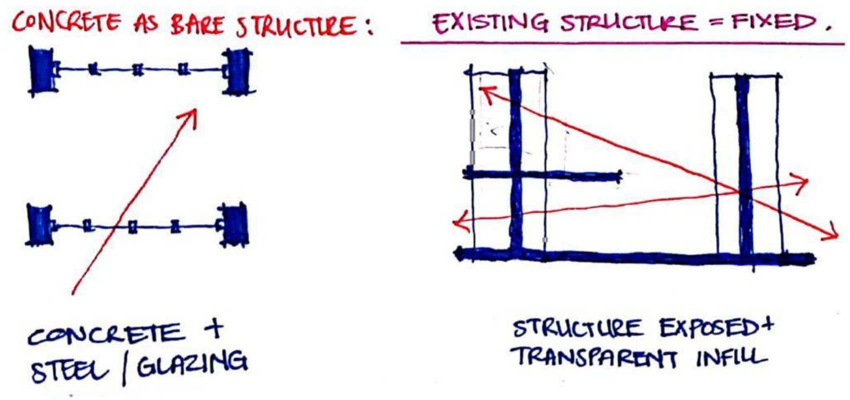


Figure 137: Language 3 (Author, 2021)

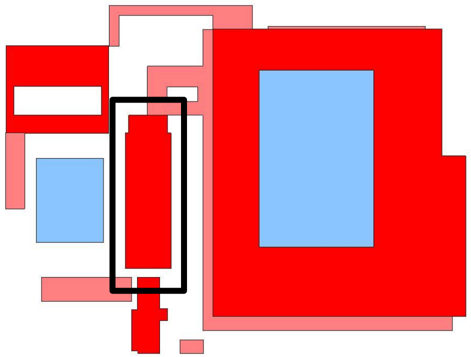


Figure 138: Supporting site plan to show locality (Author, 2021)

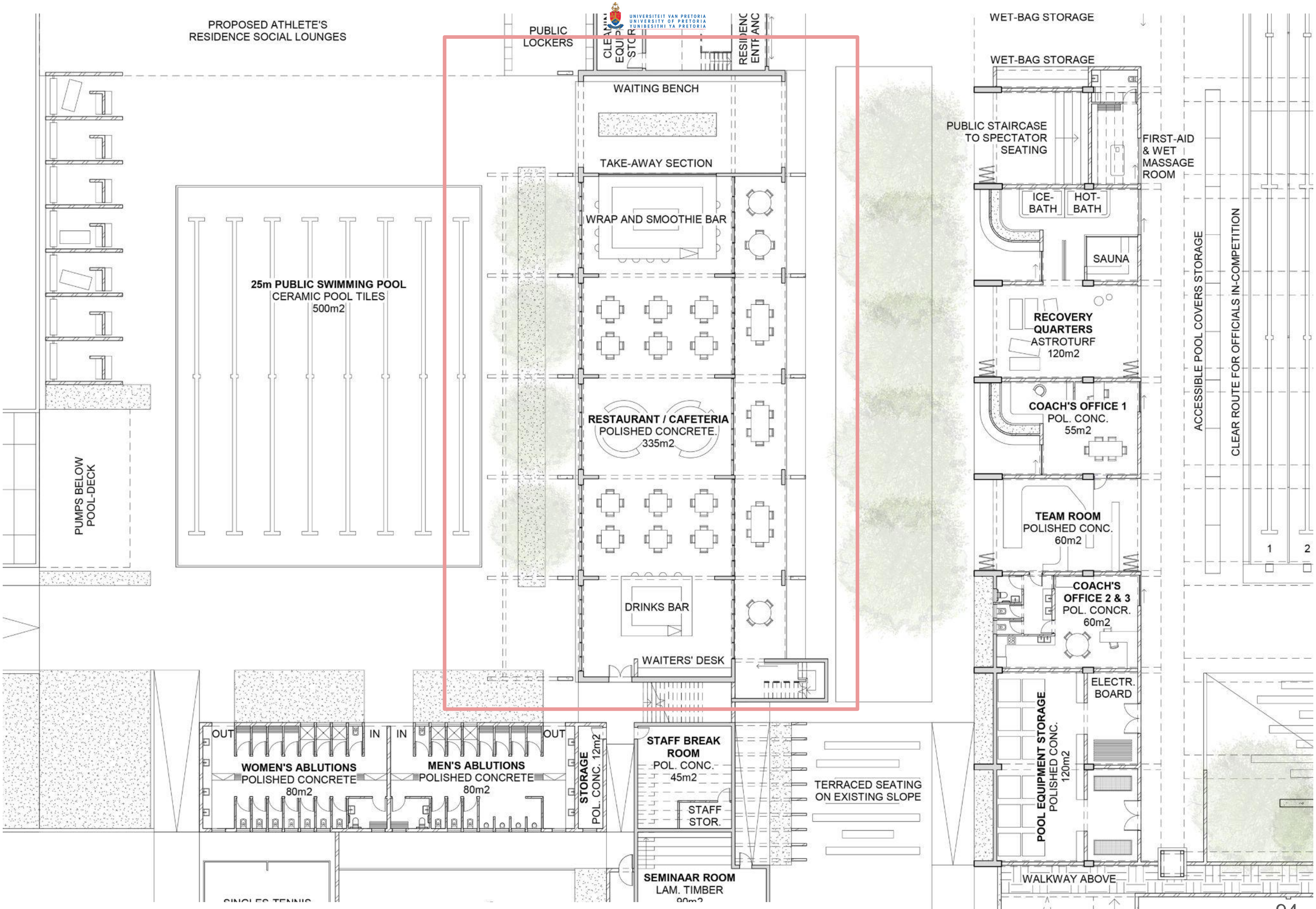


Figure 139: Callout of area on ground floor plan where language 3 was expressed. An enhanced accessibility (Author, 2021)

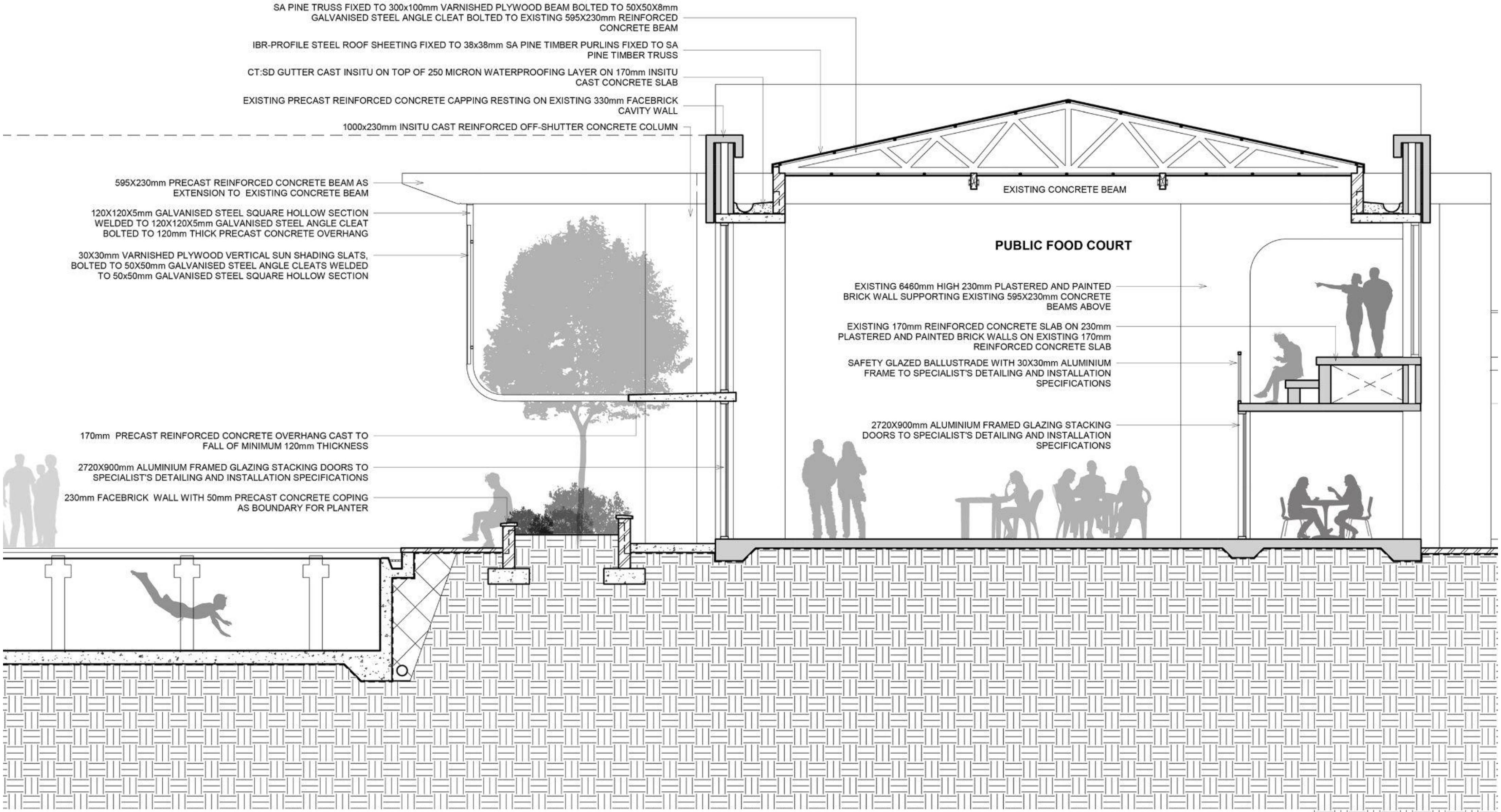


Figure 140: Callout of area on section where language 3 was expressed: Section through the food hall showing the stepped facade and shading (Author, 2021)

Four Languages for technology in design (continued...)

Language 4: Simulative environments

Language 4 is primarily used in the design and construction of the race visualisation pods that athletes use before and after their races. Athletes can use these private and intimate outdoor spaces to practice their sports psychology routines prior to or after a race. These new additions to the facility exist completely detached from the existing building, taking on their own new design and structural language. Progressing from *language 3* where the brick infill was stripped away, *language 4* uses nature and landscape as the infill to enhance the experience of the athlete in these spaces.

The concrete structure exists as secondary, keeping nature at the forefront of the design to tie the structures in with the low structural intensity of the surrounding campus. Prioritising nature as an infill also allows for the creation of a psychologically supportive environment for the athletes where they can benefit from the calming properties of nature. The concrete structure of the floor, wall and roof are now separated by steel supports, submitting to the desired openings, outward looking views and nature (figures 145-149). The seemingly floating concrete structures give the impression of a minimally invasive intervention.

Furthermore, the formwork used for the reinforced concrete partition walls is corrugated iron sheeting. This gives a rippled effect that mimics the movement of water. Through texture and form-making, athletes are immersed in a simulative environment that can psychologically aid in their race-imagery exercises before a race (figures 145-149).

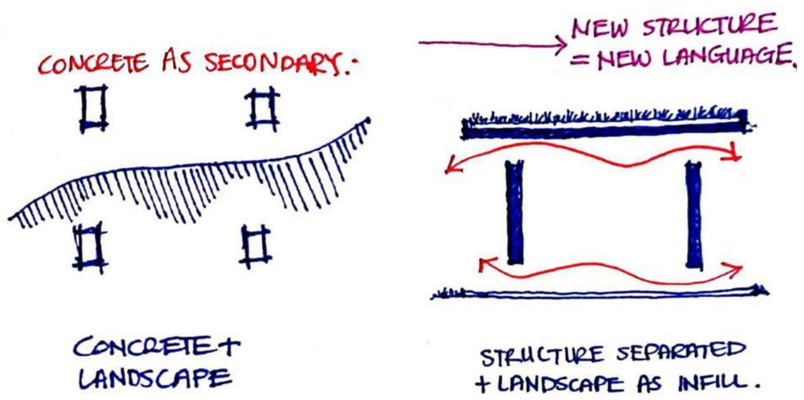


Figure 141: Language 3 (Author, 2021)

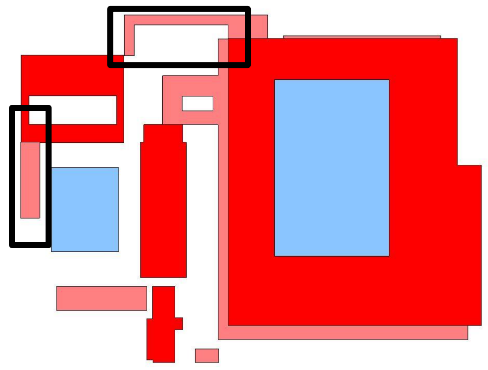


Figure 142: Supporting site plan to show locality (Author, 2021)

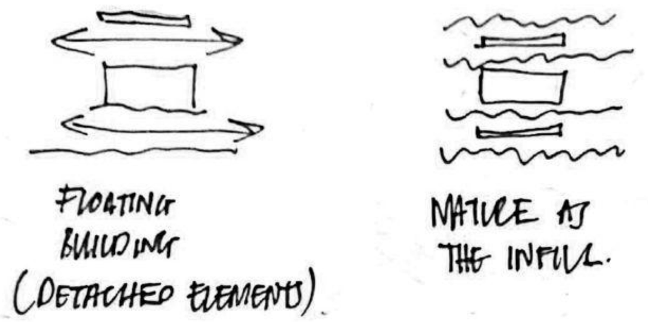


Figure 143: Separated structure and natural infill (Author, 2021)

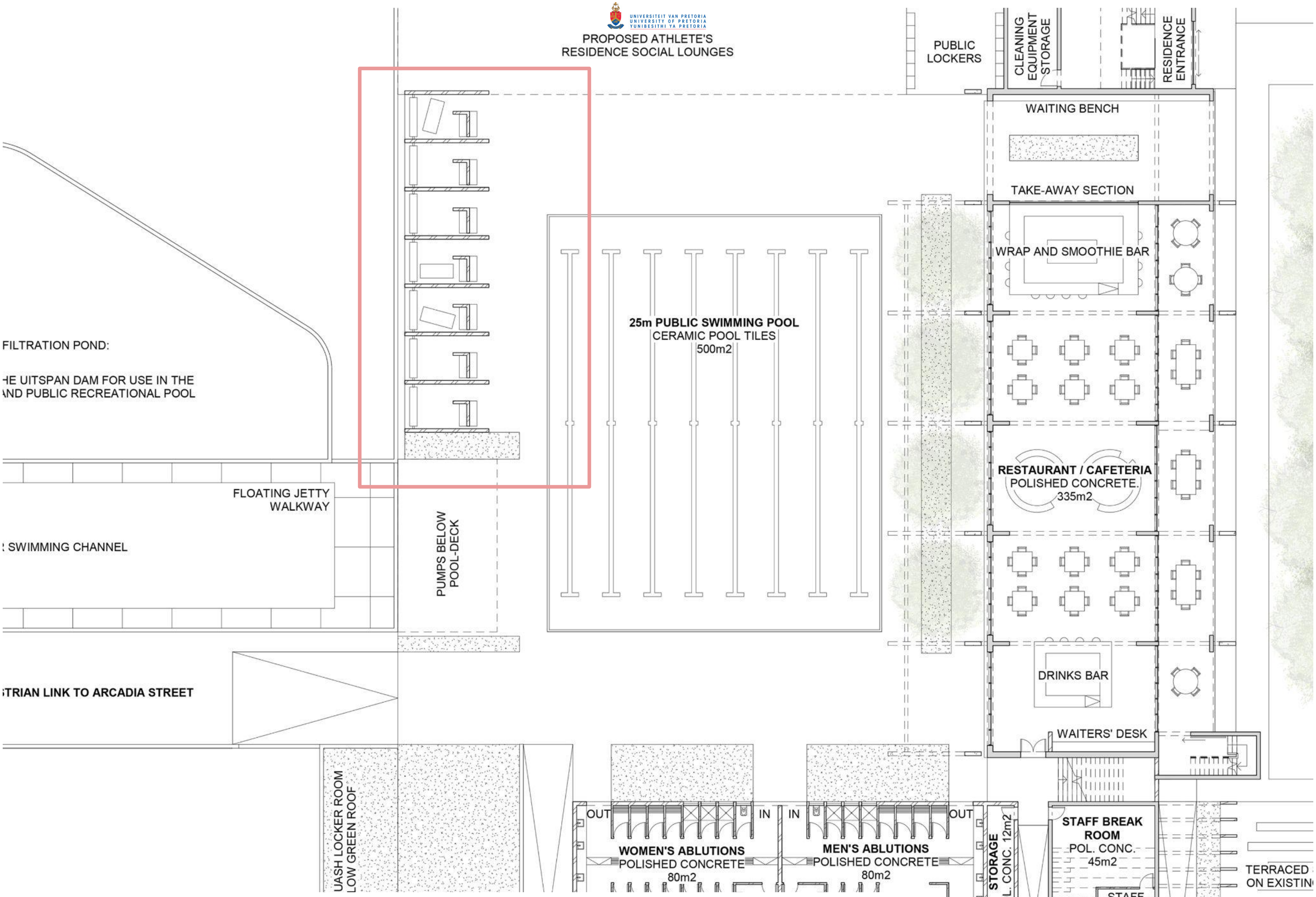


Figure 144: Callout of area on ground floor plan where language 4 was expressed: The race-visualisation pods (Author, 2021)

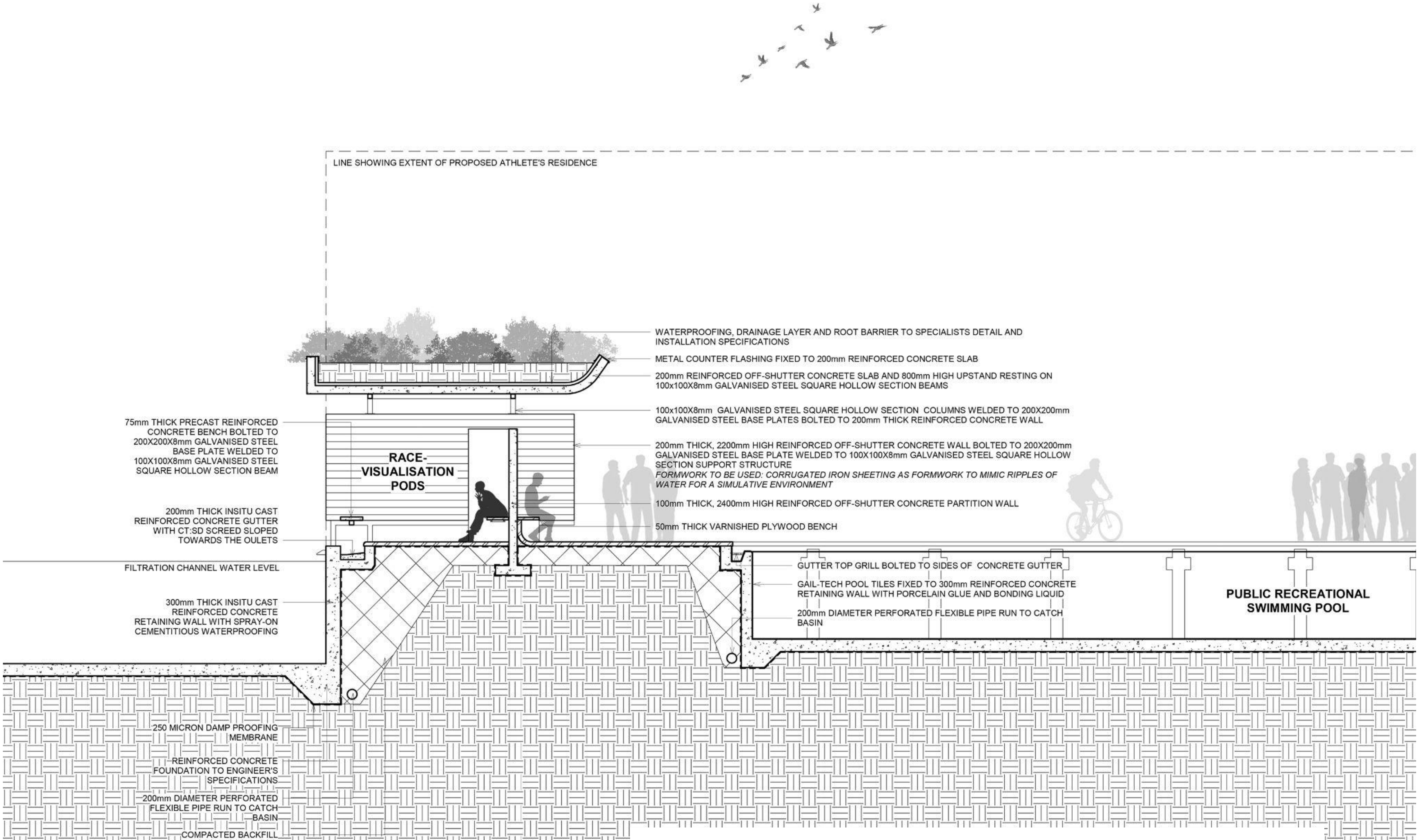


Figure 145: Callout of area on section where language 4 was expressed (Author, 2021)

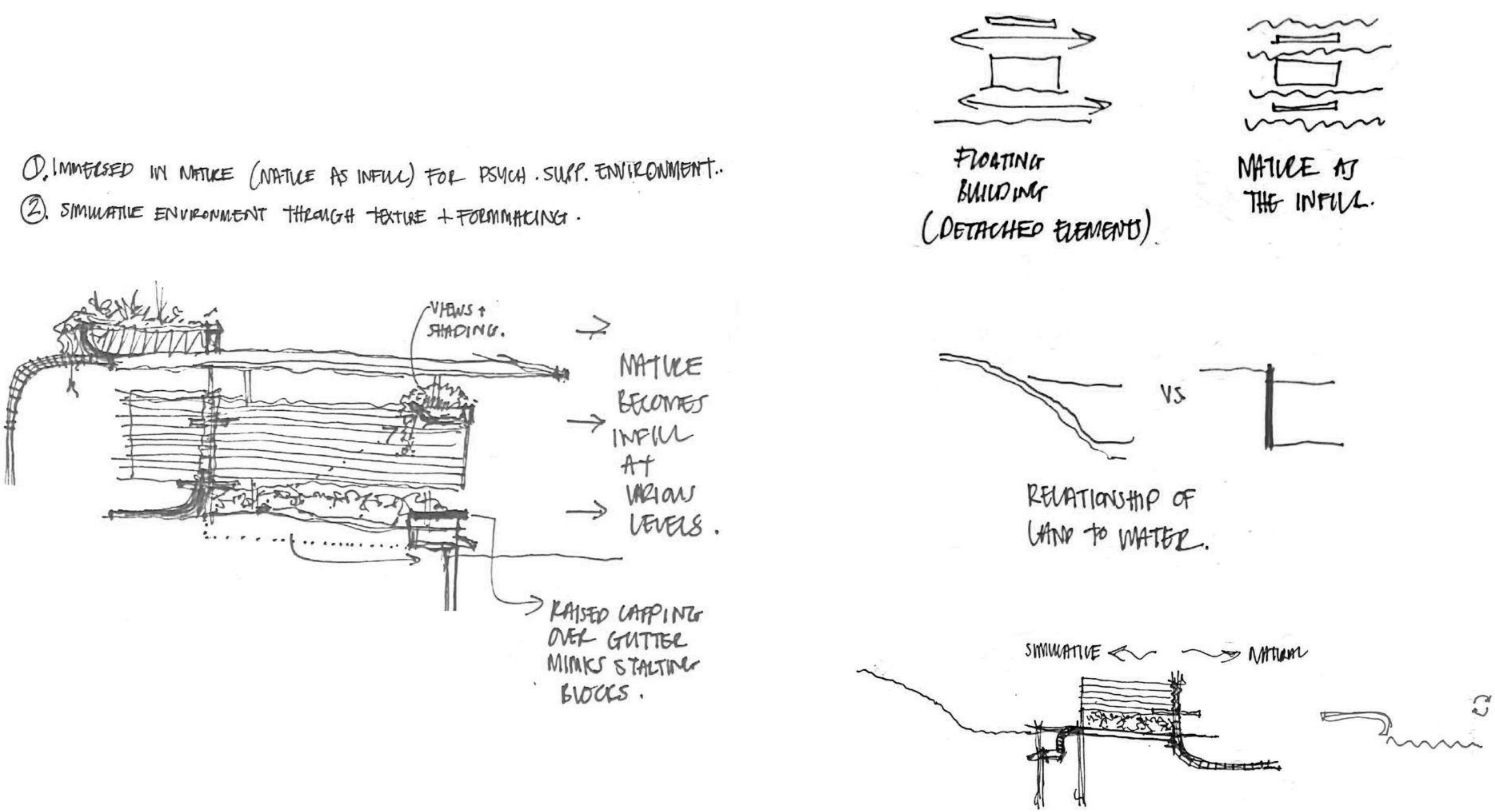


Figure 146: Iterations of detail C (Author, 2021)

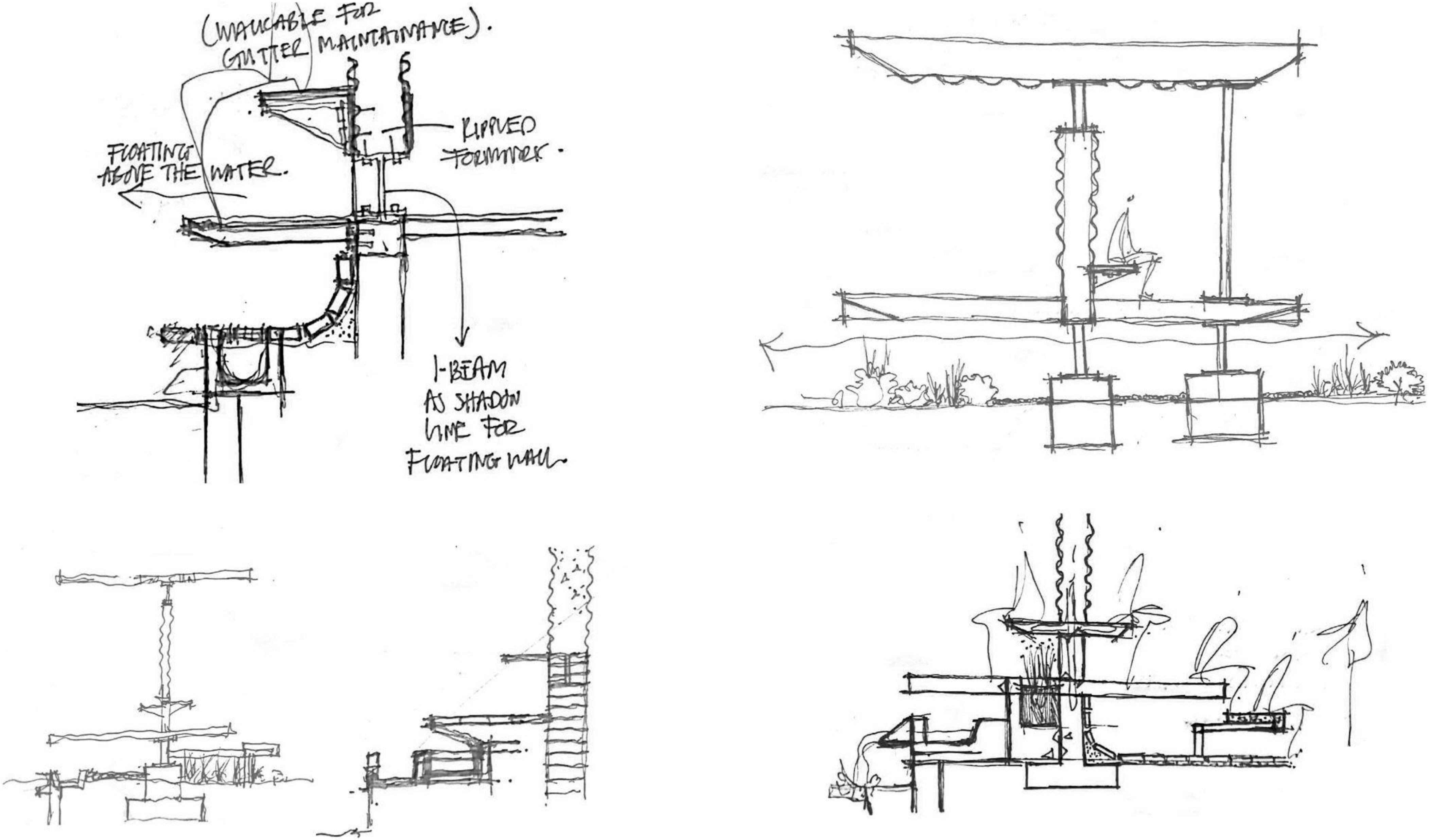


Figure 147: Iterations of detail C (Author, 2021)

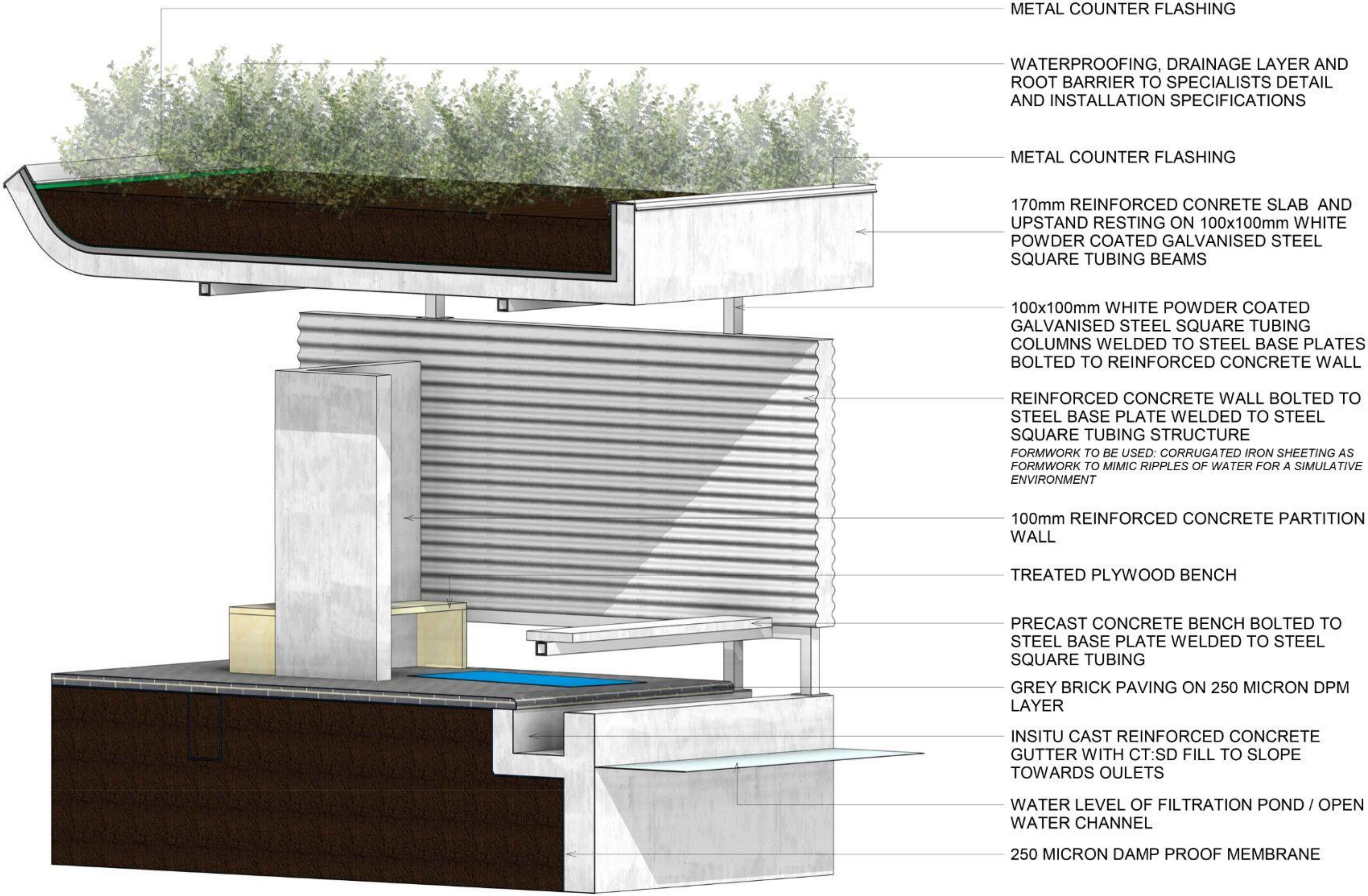


Figure 148: DETAIL C1 (Author, 2021)

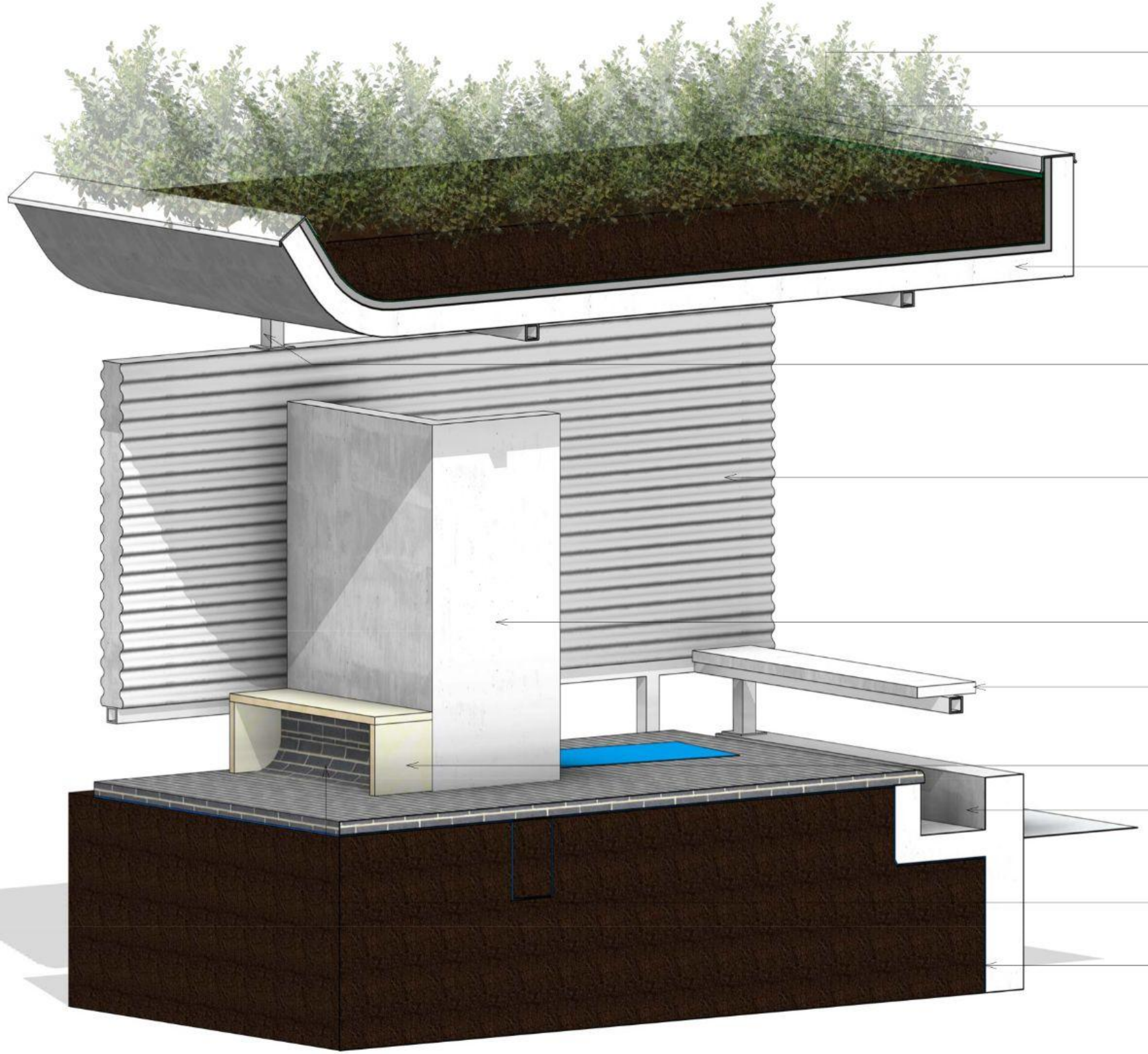


Figure 149: DETAIL C2 (Author, 2021)

Technological precedents

In terms of the roof, as a major element in the design, the span, along with the desired retractability needed to open the venue during the warmer months and close it during cooler months and competitions, created various technical challenges. Precedents were used to inform the chosen solutions:

Kengo Kuma

Due to the desired use of timber as a construction material for the roof ("the roof as an extension of the ground plane"), issues of span and material efficiency arose. Kengo Kuma does a lot of work using timber construction, however, for larger buildings, he resorts to hybrid structural systems where timer and steel are used in conjunction with one another. This creates an efficient solution where steel as the primary structure allows for the desired large spans, and timber as the secondary structure improves the general energy efficiency as well as the aesthetic of the roof. Kuma can be seen using these strategies in projects like those seen below (figures 150-153):

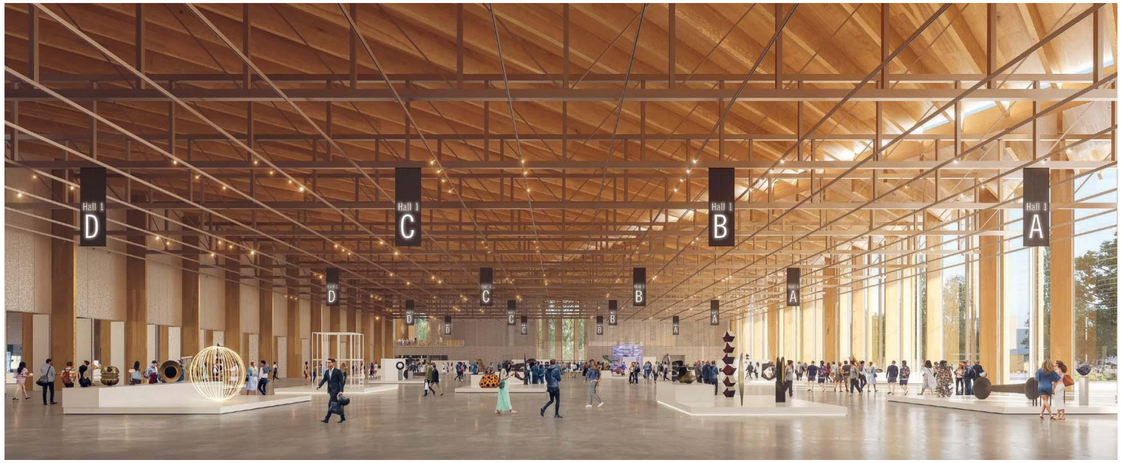


Figure 150: Exhibition Center of Strasbourg, Kuma and Associates, 2018 (arquitecturaviva, 2021)

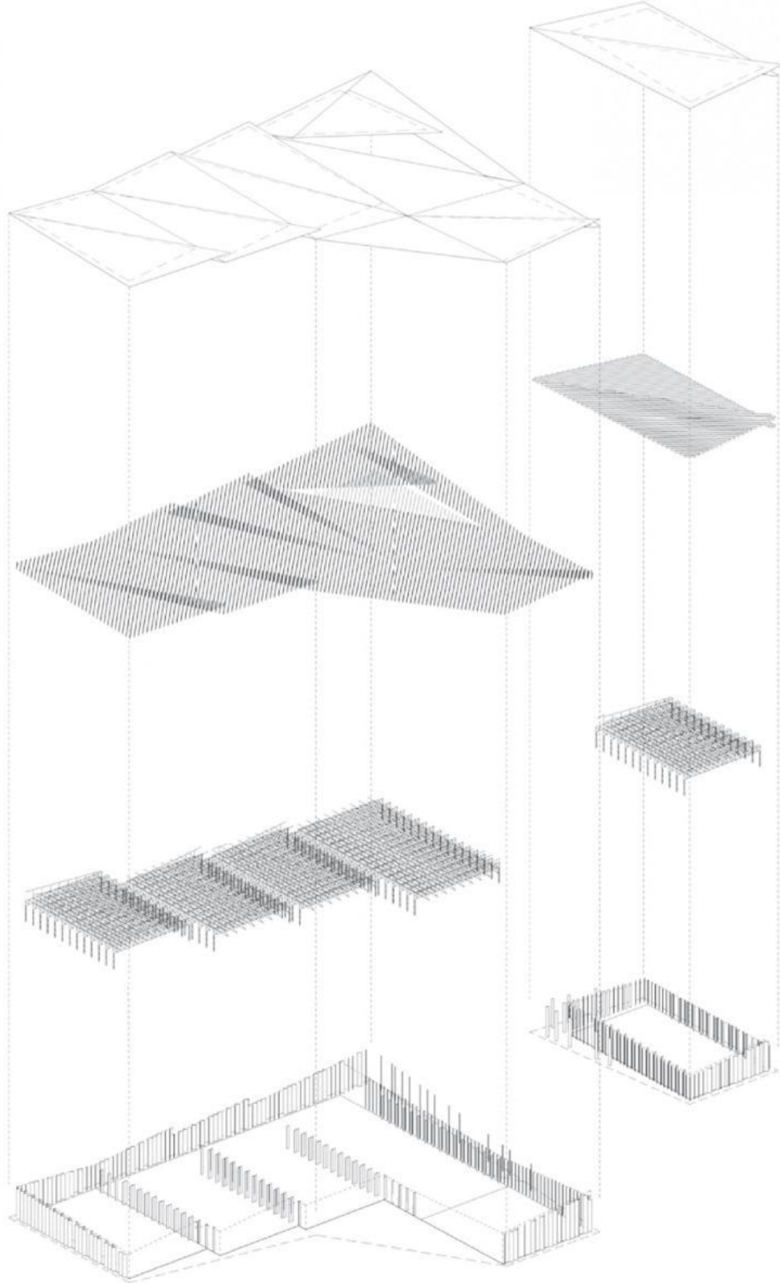


Figure 151: Exhibition Center of Strasbourg, Kuma and Associates, 2018 (arquitecturaviva, 2021)

Figure 152: Japan National Olympic Stadium, Kuma, 2016-2019 (Lynch, 2016)

Figure 153: Japan National Olympic Stadium, Kuma, 2016-2019 (Lynch, 2016)

Wimbledon Centre Court, Populous Architects, 2015

Retractable roofs have become common features in architecture. However, at larger spans like those needed to house sporting facilities, they become more challenging. The Wimbledon centre court employs a retractable roof that operates similar to a stacking door or concertina. The roofing material (translucent Tenara fabric), held by large steel trusses, stacks away to open up the space above the tennis court (McManus et. al, 2021). However, in order to reduce the amount of structure that is needed to achieve this, the retractable roof in my scheme is broken into segments; each segment running on its own set of tracks, which is fixed to the steel trusses that run across the swimming pool. This breaks up the heavy weight of the retractable members, requiring less structure and creating a better aesthetic.

Figure 154: Open view of the Wimbledon Centre Court (McManus et. al, 2021)

Figure 155: Closed view of the Wimbledon Centre Court (McManus et. al, 2021)

The need for sustainability

Relating to the first portion of the original research question of identifying how current sports architecture is failing the athletes who use it, the maintainability of sports venues proves to be a key factor. Bad design and difficult maintenance on a building detract from its sustainability, making it impossible for the sports venue to serve future generations of athletes. Waterproofing issues along with damp internal spaces with restricted ventilation prove to be large contributing factors to dilapidating swimming pool facilities, as seen in the images below (figure 156). However, moving beyond mere maintenance, international sporting organisations like the International Olympic Committee (IOC) insist that its sporting venues are designed with strict environmental sensitivity in mind (Sheard: 2001, 60-67) (figure 157).

Issues that are promoted by the IOC include: environmentally friendly construction materials such as locally sourced bricks with low embodied energy, efficient energy usage and waste management, minimising building maintenance and designing contextually sensitive buildings that are responsibly inserted into existing urban structures with the aim of improving and uplifting these structures (Twardowski: 2018, 54).

Sustainable design strongly promotes *self-sustaining* architectural principles. These include energy generation or saving measures and water harvesting (Twardowski: 2018, p.67). Self-sustaining buildings could be a potential solution to the lack of sporting facilities in South Africa - as can be seen in competitive swimming where existing facilities quickly become run-down and uninhabitable due to improper management and neglected maintenance (Imray: 2012).

Figure 156: Waterproofing issues in the existing building (Author, 2021)

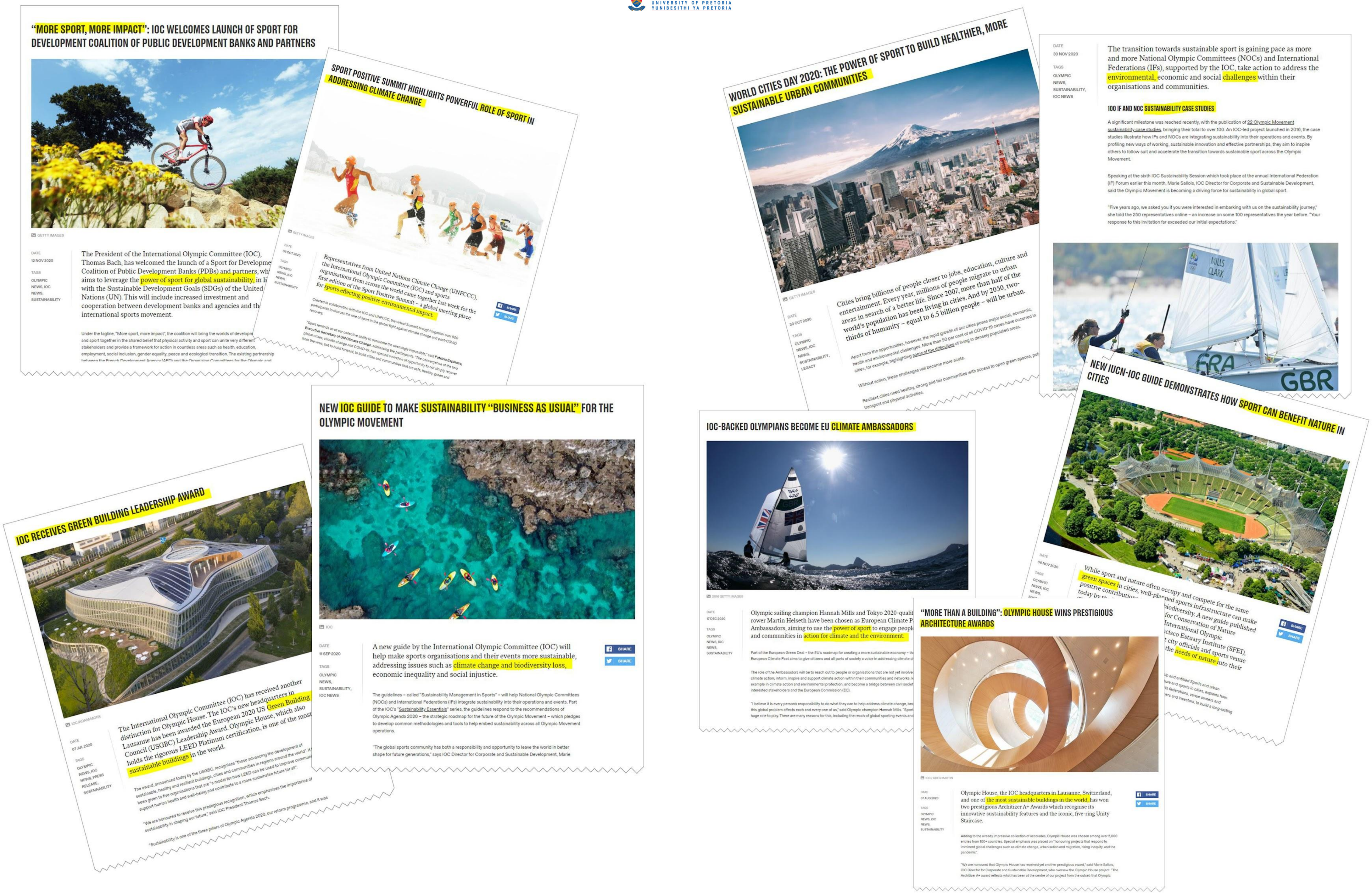


Figure 157: Articles by the IOC regarding sustainability (Adapted from IOC, 2021)

Rainwater harvesting

Making use of the extremely large surface area of the swimming arena's roof, rainwater is harvested. Rainwater collected from the roof surface, along with stormwater from the adjacent parking lot and pavements surrounding the facility are carried by stormwater channels down the natural slope of the land and towards the natural filtration channels. The filtration channel acts as a detention pond for both rainwater and filtered water from the neighbouring Uitspan dam. A pump is used to transport collected water to the ablutions and showers used by the athletes and public. This mitigates the running costs of the facility for the University. Furthermore, the water from the dam is filtered through a two-stage natural filtration process. This filtered water is used to fill up both the open water training channel as well as the 25m public recreational swimming pool, further minimizing maintenance costs for the university (figures 158-163).

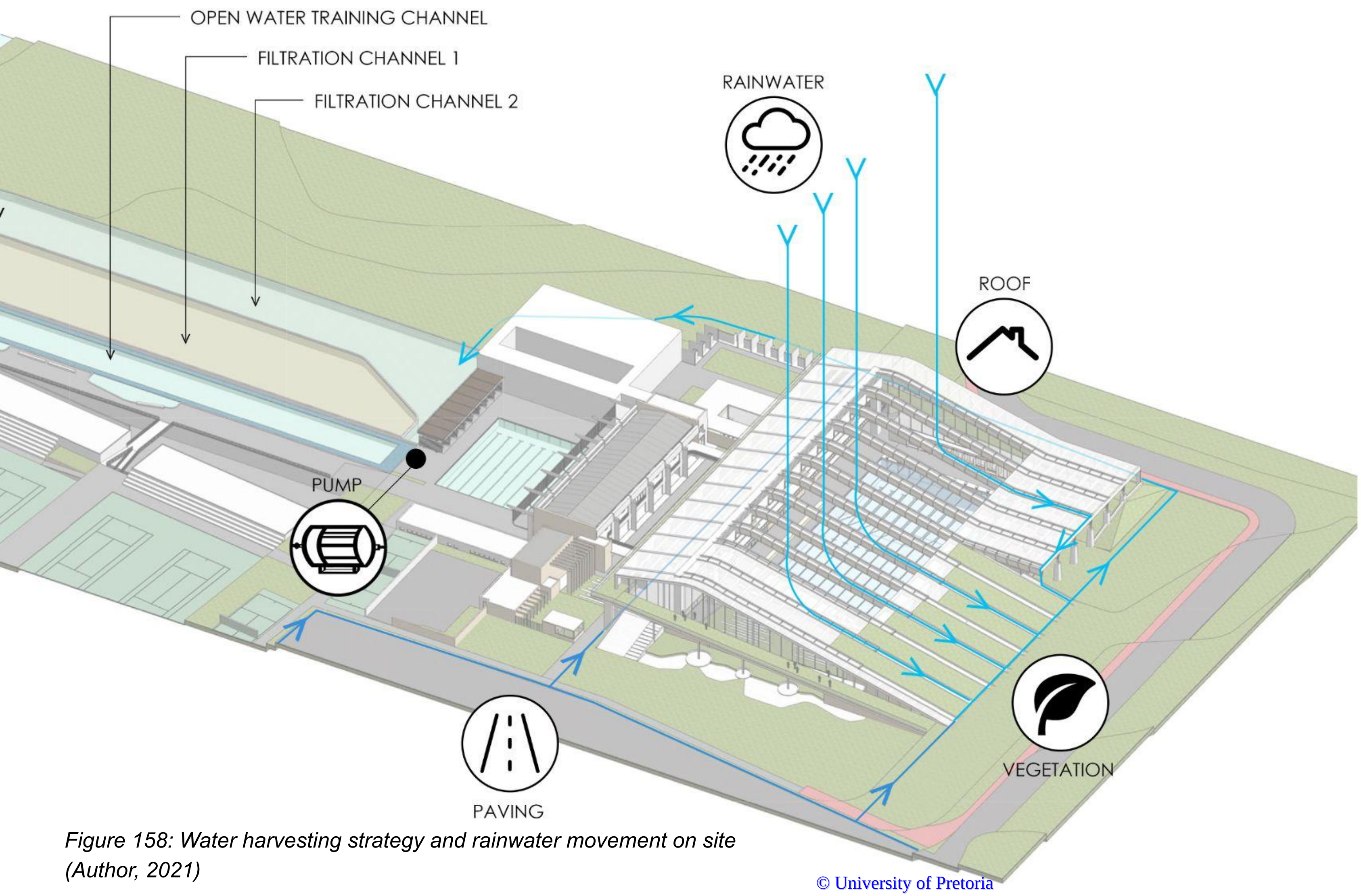


Figure 158: Water harvesting strategy and rainwater movement on site (Author, 2021)

AREA CALCULATIONS

Catchment	Area, A (m²)	Runoff Coefficient,	
Lawn, sandy	3400	0.08	0.01
Roof	6100	0.9	0.30
Paving	7000	0.8	0.30
Veld Grass	0	0.3	0.00
Gravel	0	0.5	0.00
Slope lawn, 25%	1200	0.2	0.01
Cultivated vegetition	740	0.5	0.02
TOTAL	**18440**	3.28	**0.65**

RAINWATER YIELD CALCULATION

Month	Ave. rainfall, P (m)	Yield (m³) (Yield = PxAxC)
January	0.154	**1843.688**
February	0.075	**897.9**
March	0.082	**981.704**
April	0.051	**610.572**
May	0.013	**155.636**
June	0.007	**83.804**
July	0.003	**35.916**
August	0.006	**71.832**
September	0.022	**263.384**
October	0.071	**850.012**
November	0.098	**1173.256**
December	0.15	**1795.8**
ANNUAL AVE.	**0.674**	**8763.504**

TOTAL YIELD

Month	Total Yield (m³/month)
January	**1843.688**
February	**897.9**
March	**981.704**
April	**610.572**
May	**155.636**
June	**83.804**
July	**35.916**
August	**71.832**
September	**263.384**
October	**850.012**
November	**1173.256**
December	**1795.8**
ANNUAL TOTAL	**8763.504**

Figure 159: Calculating rainwater yield (Author, 2021)

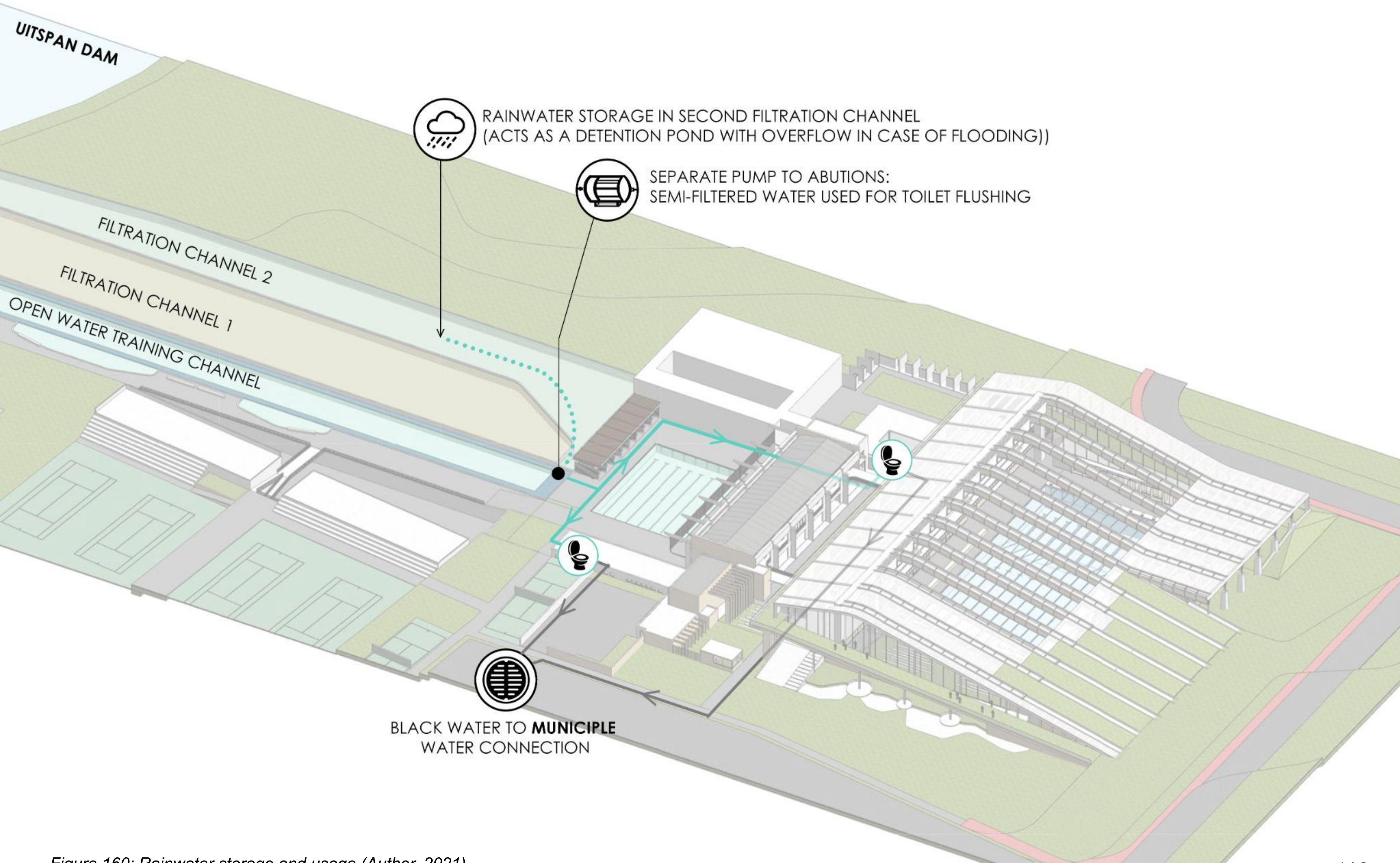


Figure 160: Rainwater storage and usage (Author, 2021)

IRRIGATION DEMAND

Month	Planting area (m²)	Irr. depth / week (m)	Irr. depth / month (m)	Irrigation demand (m³/month)
January	1940	0.05	0.2	388
February	1940	0.05	0.2	388
March	1940	0.05	0.2	388
April	1940	0.04	0.15	291
May	1940	0.03	0.1	194
June	1940	0.03	0.1	194
July	1940	0.03	0.1	194
August	1940	0.03	0.15	291
September	1940	0.03	0.1	194
October	1940	0.05	0.2	388
November	1940	0.05	0.2	388
December	1940	0.05	0.2	388
			ANNUAL TOTAL	3686

ALT DEMAND

Month	Entity (Persons ?)	Entity demand / day (l)	Alt demand (m³/month)
January	500	15	232.5
February	500	15	210
March	500	15	232.5
April	500	15	225
May	400	15	186
June	400	15	180
July	400	15	186
August	400	15	186
September	500	15	225
October	500	15	232.5
November	500	15	225
December	300	15	139.5
		ANNUAL TOTAL	2460

TOTAL DEMAND

Month	Total demand (m³/month)
January	620.5
February	598.0
March	620.5
April	516.0
May	380.0
June	374.0
July	380.0
August	477.0
September	419.0
October	620.5
November	613.0
December	527.5
ANNUAL TOTAL	6146.0

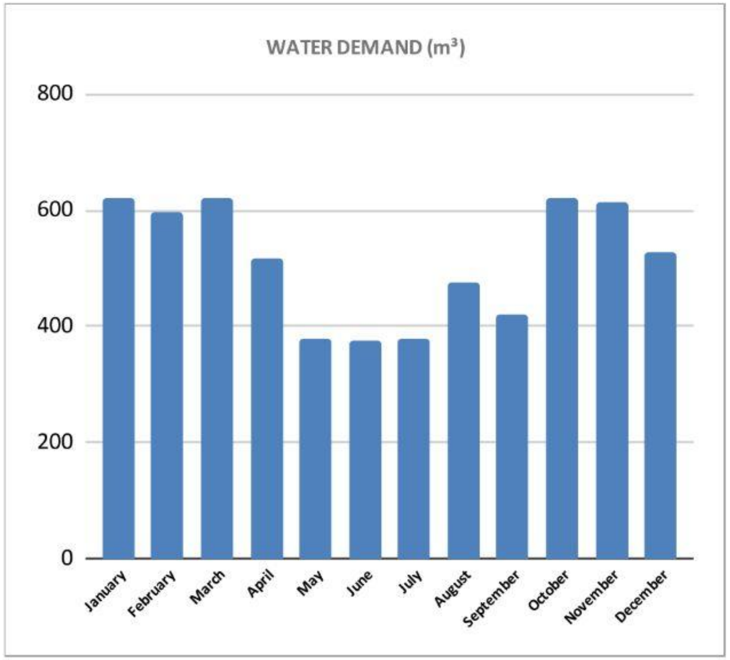


Figure 161: Water demand calculations (Author, 2021)

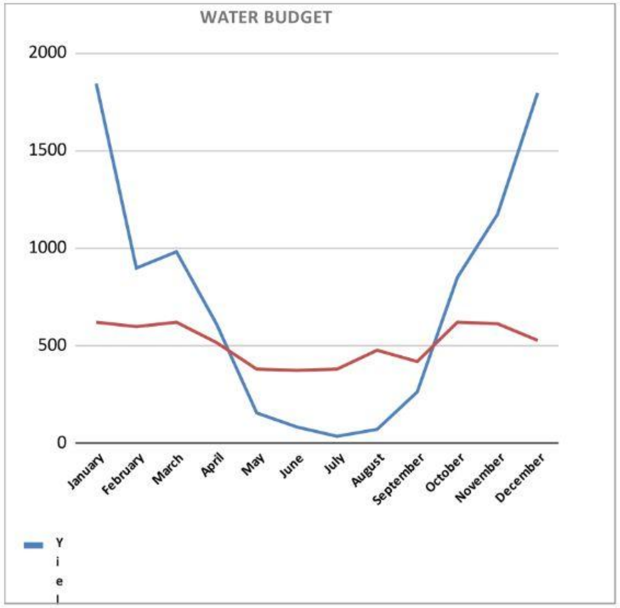
WATER BUDGET

Month	Yield (m³)	Demand (m³)	Monthly balance
January	1,843.7	620.5	**1,223.2**
February	897.9	598.0	**299.9**
March	981.7	620.5	**361.2**
April	610.6	516.0	**94.6**
May	155.6	380.0	**-224.4**
June	83.8	374.0	**-290.2**
July	35.9	380.0	**-344.1**
August	71.8	477.0	**-405.2**
September	263.4	419.0	**-155.6**
October	850.0	620.5	**229.5**
November	1,173.3	613.0	**560.3**
December	1,795.8	527.5	**1,268.3**
ANNUAL AVE.	8,763.5	6,146.0	2,617.5

WATER BUDGET (ACCUMALATIVE)

Month	Yield (m³)	Demand (m³)	Monthly balance	Vol. added water in reservoir (m³)
January	1,843.7	620.5	1,223.2	3,051.70
February	897.9	598.0	299.9	3,351.60
March	981.7	620.5	361.2	3,712.80
April	610.6	516.0	94.6	3,807.40
May	155.6	380.0	-224.4	3,583.10
June	83.8	374.0	-290.2	3,292.90
July	35.9	380.0	-344.1	2,948.80
August	71.8	477.0	-405.2	2,543.60
September	263.4	419.0	-155.6	2,388
October	850.0	620.5	229.5	2,617.50
November	1,173.3	613.0	560.3	560.3
December	1,795.8	527.5	1,268.3	1,828.60
ANNUAL AVE.	8,763.5	6,146.0	2,617.5	

	AREA (m2)	**REQUIRED AREA** FOR FILTRATION POND (m2)
25m SWIMMING POOL	500	1000
OPEN WATER TRAINING CHANNEL	2300	4600
	TOTAL	5600
REMAINING BALANCE OF HARVESTED RAINWATER		3800
TOTAL SURFACE AREA OF FILTRATION CHANNEL NEEDED		9400



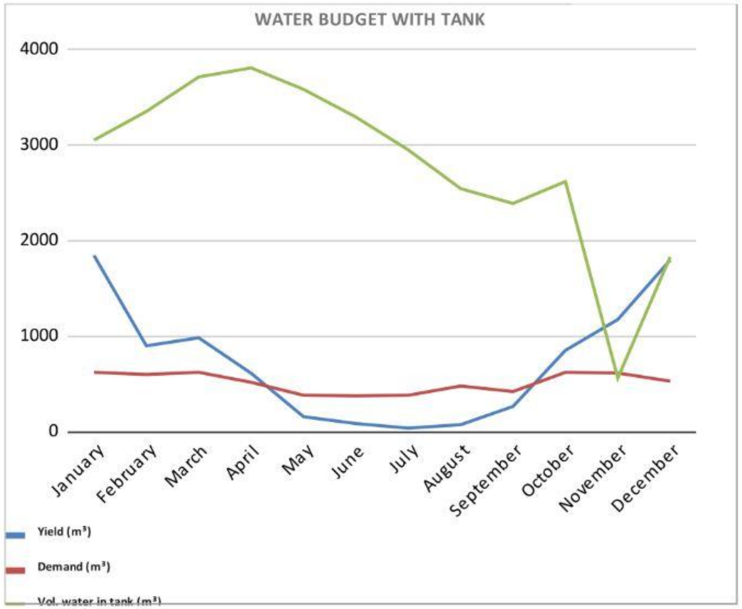


Figure 162: Water budget calculations (Author, 2021)

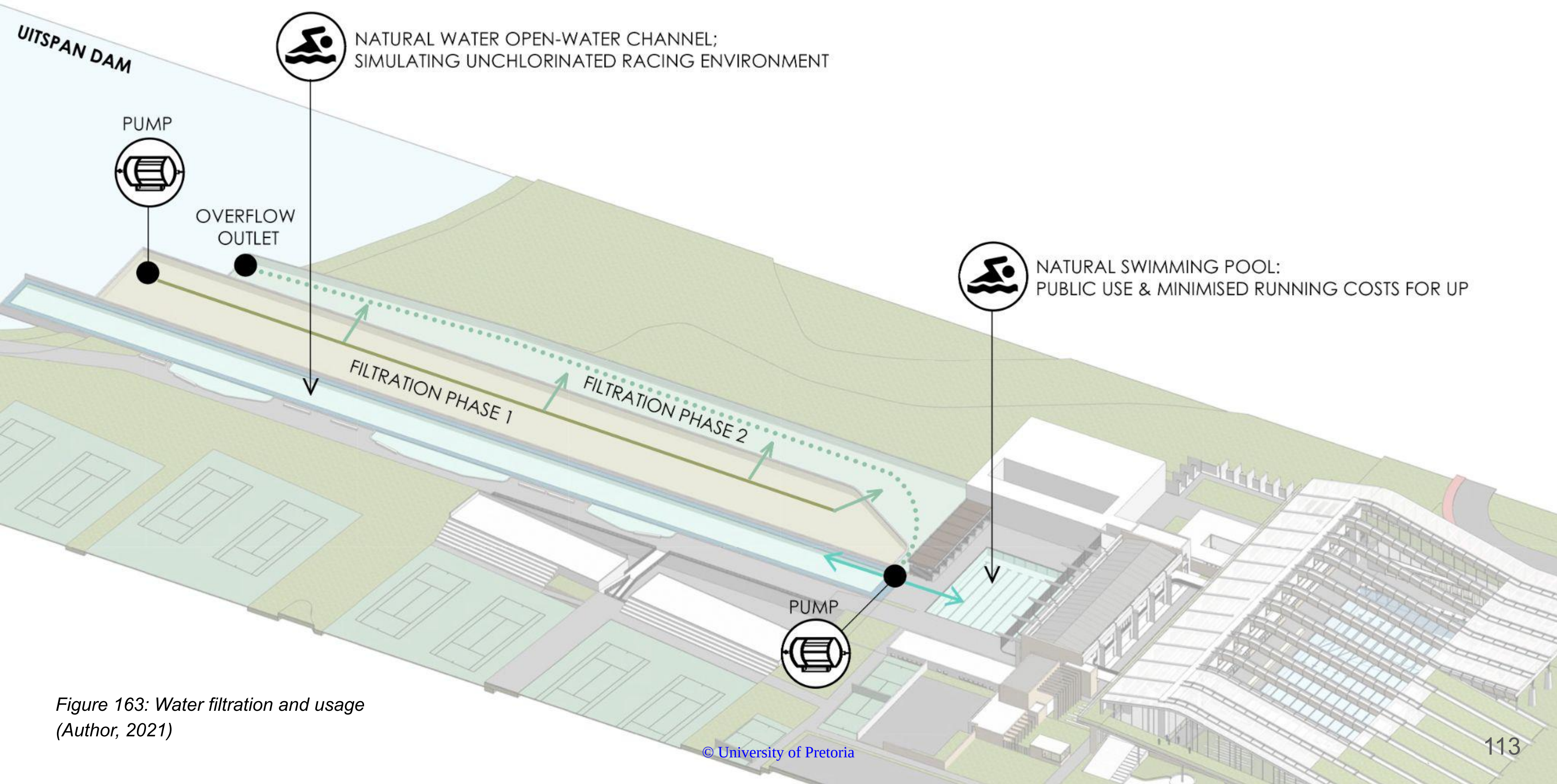


Figure 163: Water filtration and usage (Author, 2021)

Geothermal heating and cooling

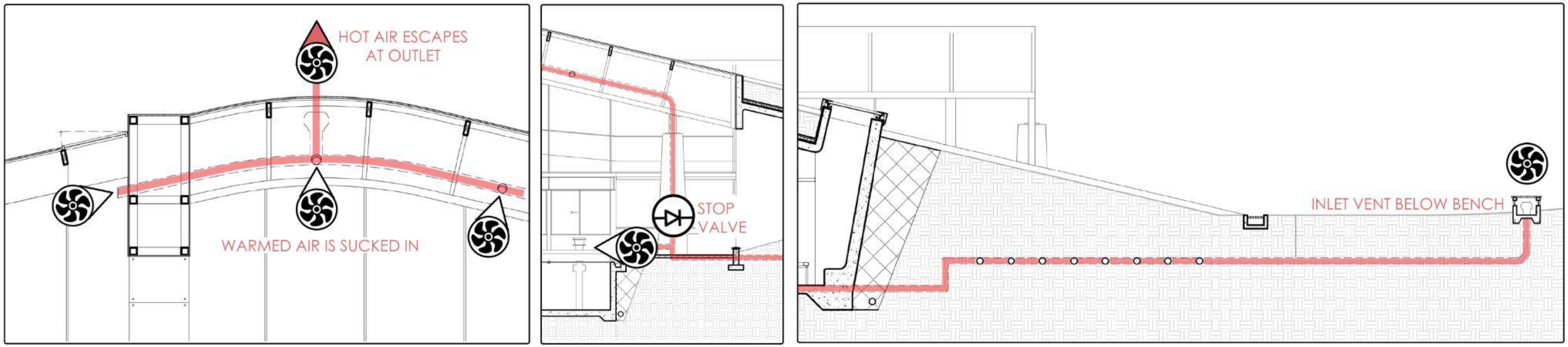
Keeping indoor temperatures at a comfortable level is an important factor when considering athletic performance enhancement. Too cold or overly warm environments can detract from athletic performance (figure.164).

An asset of the campus is its large amount of natural open space (figure 165). This open space can be utilised for geothermal heating and cooling strategies. Due to the significant heat build-up by large groups of spectators during sporting events, paired with the humidity of indoor swimming pool facilities, low energy heating and cooling strategies becomes a key feature of the technological resolution of the design.

Figure 164: The effects of poorly heated or cooled spaces for athletes (Author, 2021)

Figure 165: The large amount of natural open space on the UP sports campus (Caldecott, 2019)

In the summer, warm air is sucked in by the inlet turbine, where it travels through pipes that coil 2m beneath the natural ground level. The consistent cool temperature of the soil cools the air in the pipes. This cooled air is released into the building at ground level. As this cooled air becomes warmer it rises until, along with heat generated by large crowds in the spectator stands, it is able to escape through the outlet turbine at the highest point of the building (figure 166).



WARMED AIR IS COLLECED AT THE HIGHEST POINT AND ALLOWED TO ESCAPE THROUGH THE TURBINE

STOP VALVE PREVENTS WARM AIR FROM RECIRCULATING

GEOTHERMAL PIPING COILS ACROSS THE OPEN LANDSCAPE AT MIN. 2m DEPTH BELOW THE GROUND LEVEL TO COOL THE WARM AIR

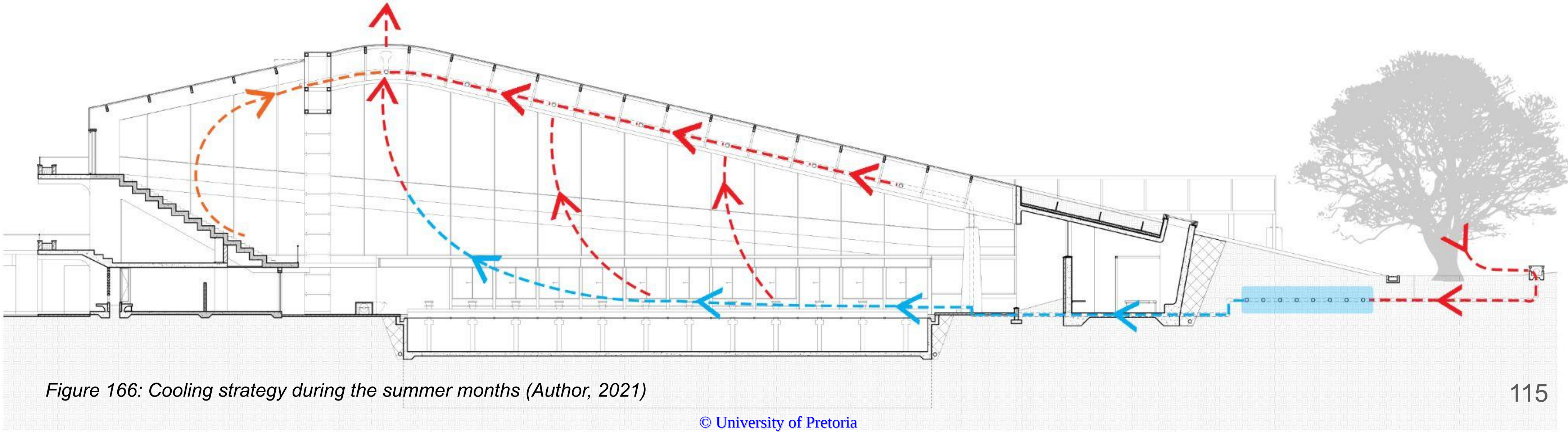


Figure 166: Cooling strategy during the summer months (Author, 2021)

In the winter time, cool outside air is sucked in through the inlet turbine, this time heated by the warmer temperatures of the soil. The warmed air is released into the arena where it rises and is sucked into the ventilation pipes that are stored within the roof trusses. A stop valve prevents the warm air from escaping the building, as desired, allowing it to be recirculated to keep the interior at a more comfortable temperature (figure 167). The turbines and stop valves are to be controlled electronically.

Due to the strict guidelines for water temperatures by aquatic sporting authorities, where water needs to remain at a constant temperature, solar heating strategies that fluctuate during overcast or rainy days would not prove effective. Instead, the existing electrical heating system is maintained. However, due to the swimming pool now being housed indoors, the heat loss that is experienced during colder months becomes significantly less, reducing the load required to keep the pool at the required temperature.

Conclusion

The technical resolution of the design remains highly important to the outcome of the final product and its performance enhancing impact on the athlete. If the technical resolution remains generic and standard, sports venue designers run the risk of compromising on the experiential quality of a space. Spaces that are too generic and standardised become purely functional. However, by detailing the construction in unique ways and over a scale of interventions as seen in four the structural languages that were discussed above, the design intervention is granted a richness of changing experiences that could contribute to an athlete's performance. These experiences, along with sustainable design features such as water harvesting and filtration systems and energy-saving geothermal heating and cooling strategies, allow the sports facility to better serve the athletes who use it at present and for years to come.

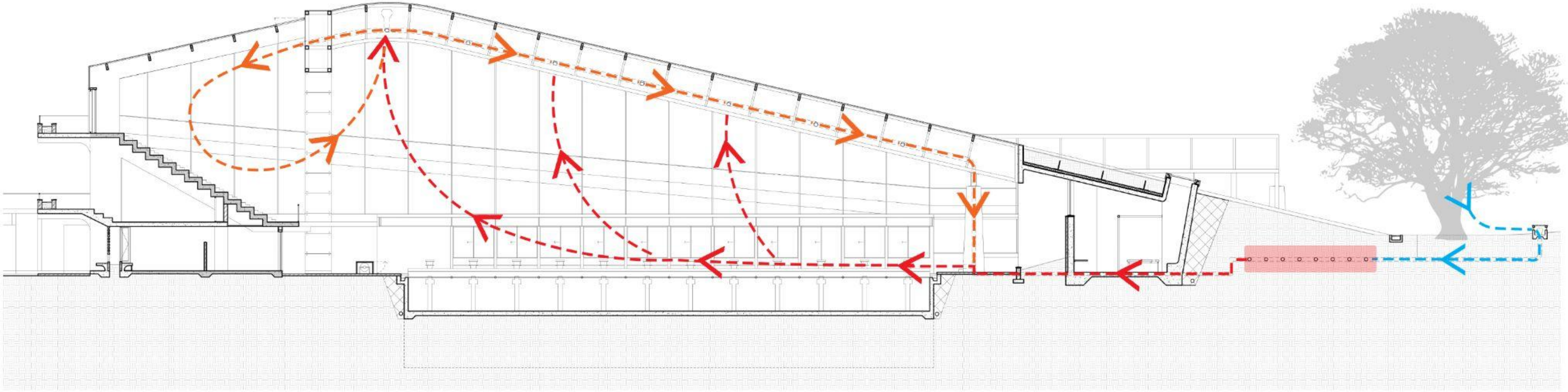


Figure 167: Heating strategy during the winter months (Author, 2021)

The final product

The following pages contain the final product of the design with its technological integration (figures 168-195). The following images take the format of the final exam poster layout.

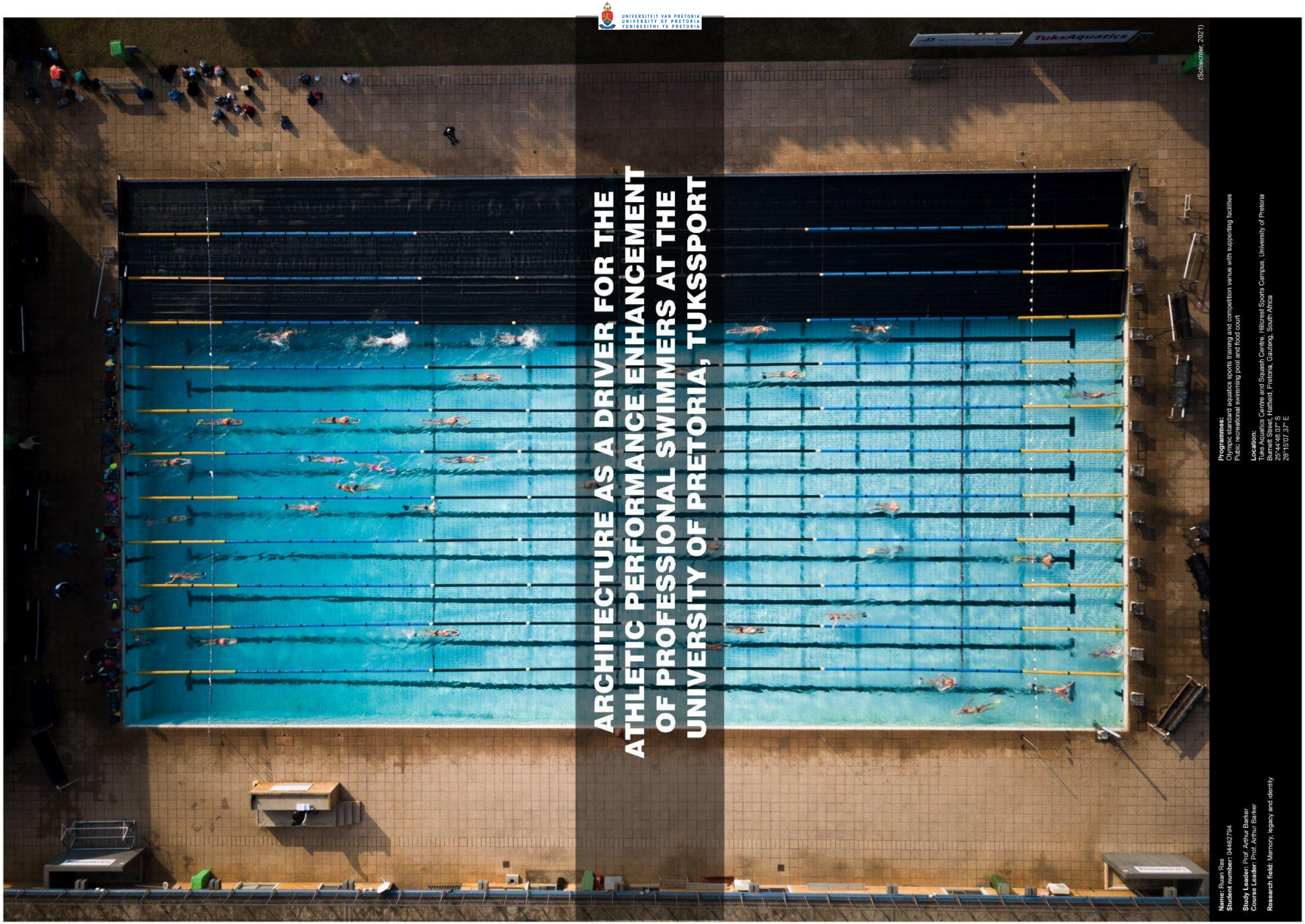


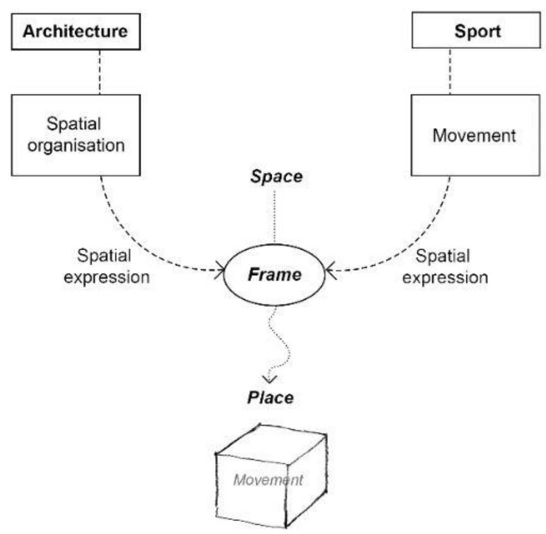
Figure 168: Title page (Author, 2021)

1

THEORY

PROJECT DEVELOPMENT

"Sport is a kind of architecture on the field. It is about movement but still it is about space, about organizing space." - David Winner.



Sports design therefore has an effect not only on the **physical structure** of a facility, but also on the **performance of the athletes** using it - the frame impacts the performance.

The **frame** describes the physical layout and structure of the playing field.

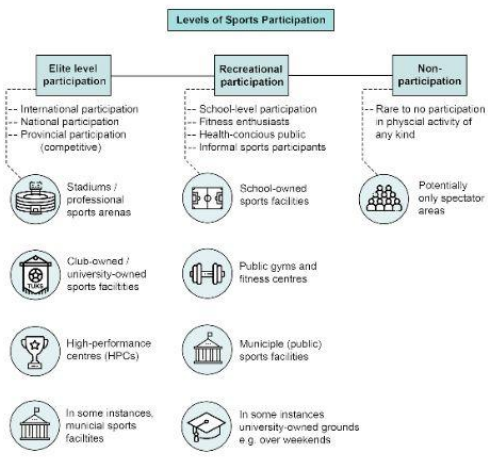
The **performance** speaks of the actual movements and actions of users in the space

RESEARCH QUESTIONS AND OBJECTIVES

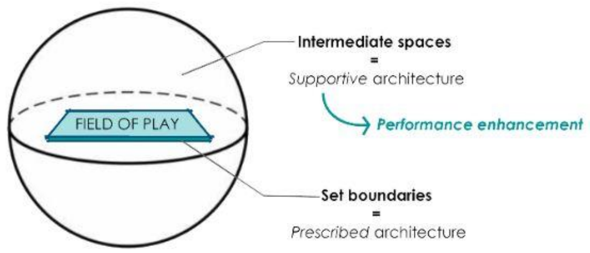
Through this research I aim to identify **spatial** and **functional** drivers that aid in physically and psychologically enhancing athletic performance by determining a prototype for professional-athlete-centred sports architecture in the **local** context, specifically related to competitive swimmers in TuksSport.

This poses the questions:
1. How is **current sports architecture**, for professional athletes specifically, failing the athletes who use it?
2. How can the design of sports architecture be improved to benefit and **enhance the performance** of the professional athletes it serves?

TuksAquatics Centre (Schlechter, 2021).



Sports architecture typologies are formed around well-defined 'boundaries'. These boundaries regulate how the sport is played (Cleary, 2017). Regulation authorities and sporting associations typically set standards and requirements for the design of facilities in each specific sporting code. This gives architects a relatively good reference when designing sports facilities. However, there are few building typologies or standards that regulate the optimum training or competition environments outside of the physical dimensions of the field of play; for example, the **intermediate spaces** that athletes interact with on the lead-up to their race or match, like the marshalling room where athletes report before their race.



Most sporting histories follow the general trend of the **transformation of informality and improvisation into standardisation** and specificity (Cleary, 2017). However, modern sport requires much more standardised settings (Figure 10). Most physical court or field dimensions became fully standardised in the 1920s (Cleary, 2017). Various sporting authorities emerged as a result of the need to govern this standardisation and fair practice in sport.

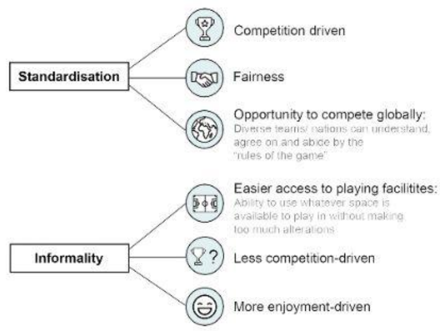


Figure :169: Theory (Author, 2021)

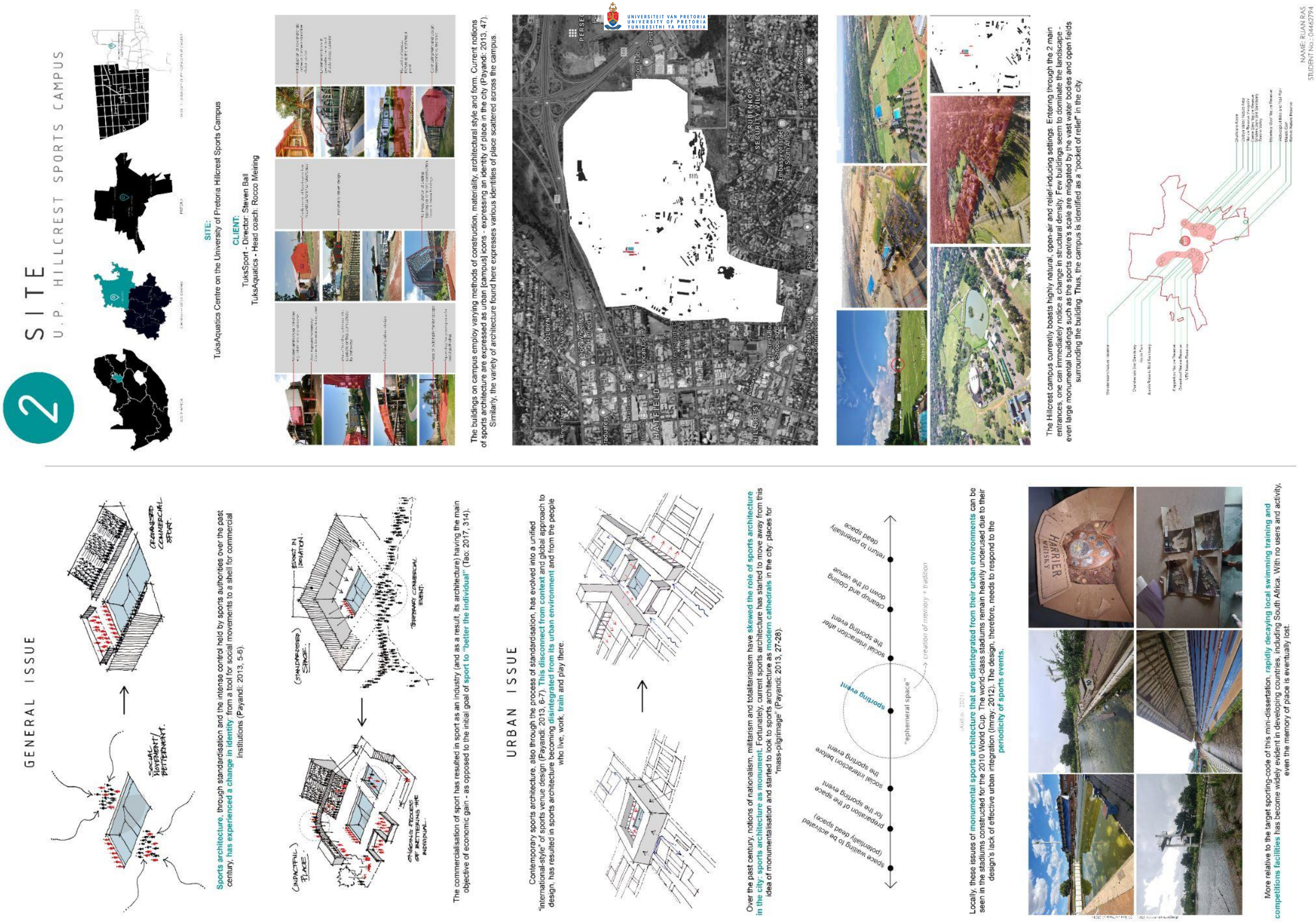
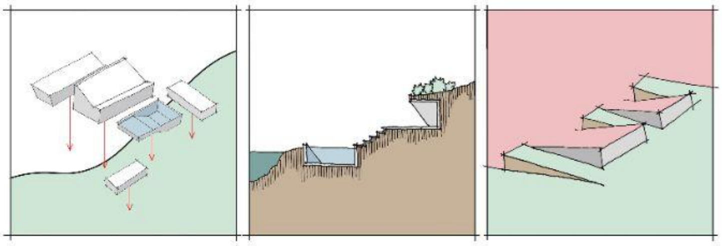


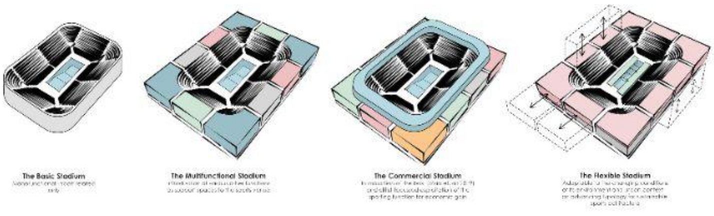
Figure 170: SIte information (Author, 2021)

RELATION TO THE LANDSCAPE



Buildings on campus do not seem to respond to the landscape - instead, they appear as large monuments 'placed' on top of the site. This contrasts the desired idea of a pilgrimage (Payandi: 2013, 27-28) - a journey, not a destination - experience, not only function. An appropriate design response will be to merge the ground plane of the site and building plane (integration through literal spatial weaving).

ISSUE OF FUNCTIONALITY OVER EXPERIENCE

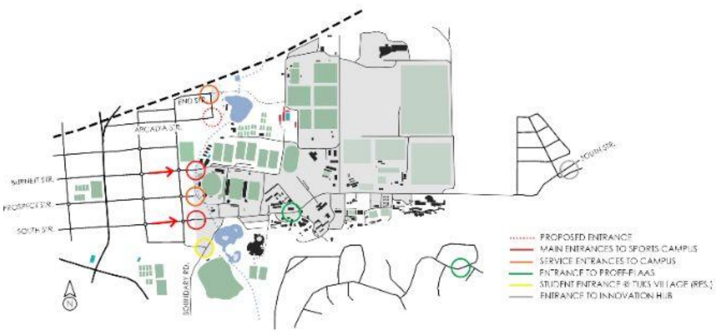


Existing buildings appear mainly expressive of function - ignoring the experiential quality of space. Architecture on the sports campus can be located as part of the continuum of sports architecture by comparing it to the evolution of the stadium (Payandi: 2013, 37-44) as the most iconic form of sports design.

To strengthen this observation, experiential mapping was done to identify sources of emotion, excitement, activity and experience on the campus - relating the design to the other end of the scale (functionality >>> experiential). The mapping shows that experiences on campus are mainly linked to temporary events (functions); As soon as function disappears, so do the users and their experiences / excitement / emotion and activity. Potential dead space starts to form.

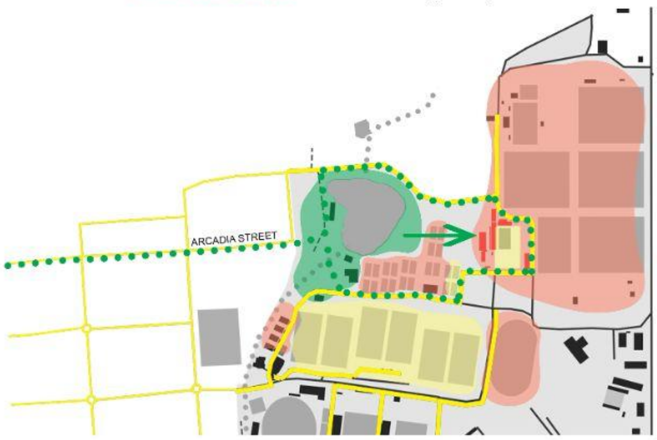
"The activation of a space through the movement of bodies." - Bernard Tschumi

IMPROVING ACCESS + ACTIVITY TO ENSURE THE CREATION OF CONTINUAL EXPERIENCES

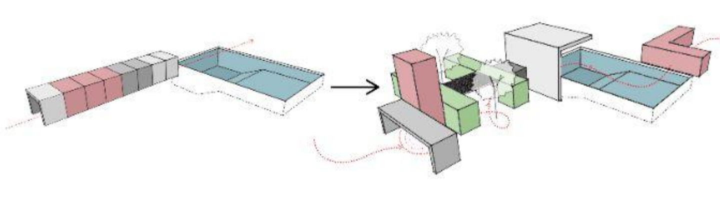


ACCESS TO CAMPUS: ENTRY AND EXIT POINTS

The existing condition of accessibility shows very limited fully-public access. Existing pedestrian routes can be effectively linked to a newly proposed semi-pedestrianised Arcadia Street. This activates the Uitspan node as a now fully-public social and recreational hub, strengthening the link between the new proposed entrance at Arcadia Street and the TuksSwimming pool complex.



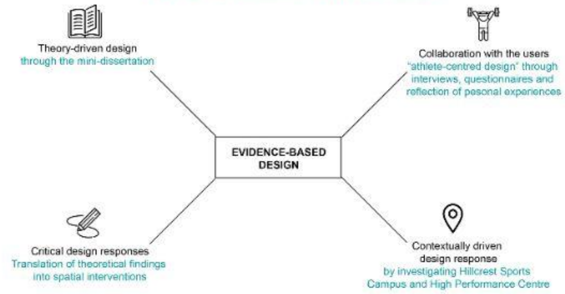
ARCHITECTURAL ISSUE



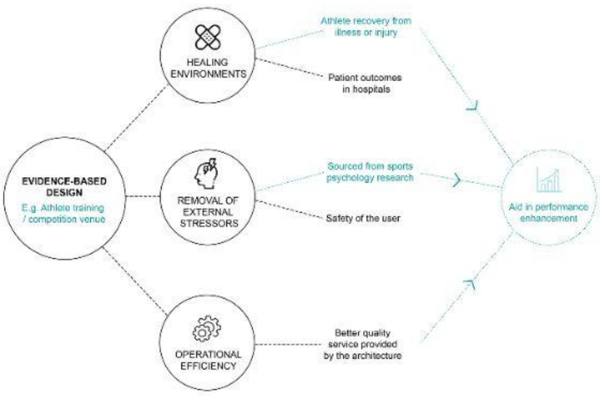
Due to the commercialisation of sport and through the process of standardisation in sports environments, functionality has become favoured in sports design. The experience of the user (athlete) is often ignored during the design process resulting in the architect only responding to some aspects of the professional athlete as their main user group. If the architecture carries any potential of "bettering the individual" (Tao: 2017, 314), through athletic performance enhancement specifically, the designer must spatially respond to the athlete as a whole - physically (function) as well as emotionally, mentally and spiritually (experiential) (Reynaldi et. al: 2019, 70).

METHODOLOGY

"Environmental psychology can affect one's mood and behaviour which, in turn, affects one's physiological condition." - IRWING WEINER



Key aspects for the effective use of evidence-based principles in architecture
(Adapted from Malkin: 2008)



DESIGN RESPONSES BASED ON SPORTS PSYCHOLOGY

	Evidence-Based Design	Additional Spatial Responses
Focus and Concentration	Focus – To prevent "result-oriented" mindsets	Restrict visual access – From external distractions
Doubt vs. Confidence		Break-away spaces – Protecion from doubt inducing external factors
Coping skills	Positive thoughts – Combat emotional toll of minor setbacks	Improved accessibility – Between athlete and support figures
Regulating adrenaline	Calmness; Energy-inducing	
Motive to perform		Athlete residence facilities; Complimentary facilities
Mental impact of injuries		Visual access to rehab spaces; Transparent design to familiarise athletes with the recovery process
Game plan		Accessible design of coach's office; Visible, centrally located game plan
Being in the zone	Improve concentration and remove distractions	Break-away spaces – Avoid external distractions
Athletes with disabilities		Universally accessibly spaces for mobility impaired athletes; Visual access for visually impaired athletes
		Social spaces for interaction between athletes; Spirituality-related design drivers for resilience
Spirituality in sport		Social spaces to encourage healthy habits; Removal of dead spaces
		Improved accessibility to training facilities; Performance spaces
Coach-athlete relationship		Locality of coach's office in relation to other stakeholders; Accessible design of coach's office and support facilities
	Promote creativity in coaching environments	Adaptable design of training venues to suit varied coaching methods
		Transparent design of coach's office and physio rooms
		Private space in athlete's living environments; Zoning between coach, athlete and secondary stakeholders

NAME: RUAN RAS
STUDENT No.: 04462794

Figure 171: Site information and Architectural issue (Author, 2021)

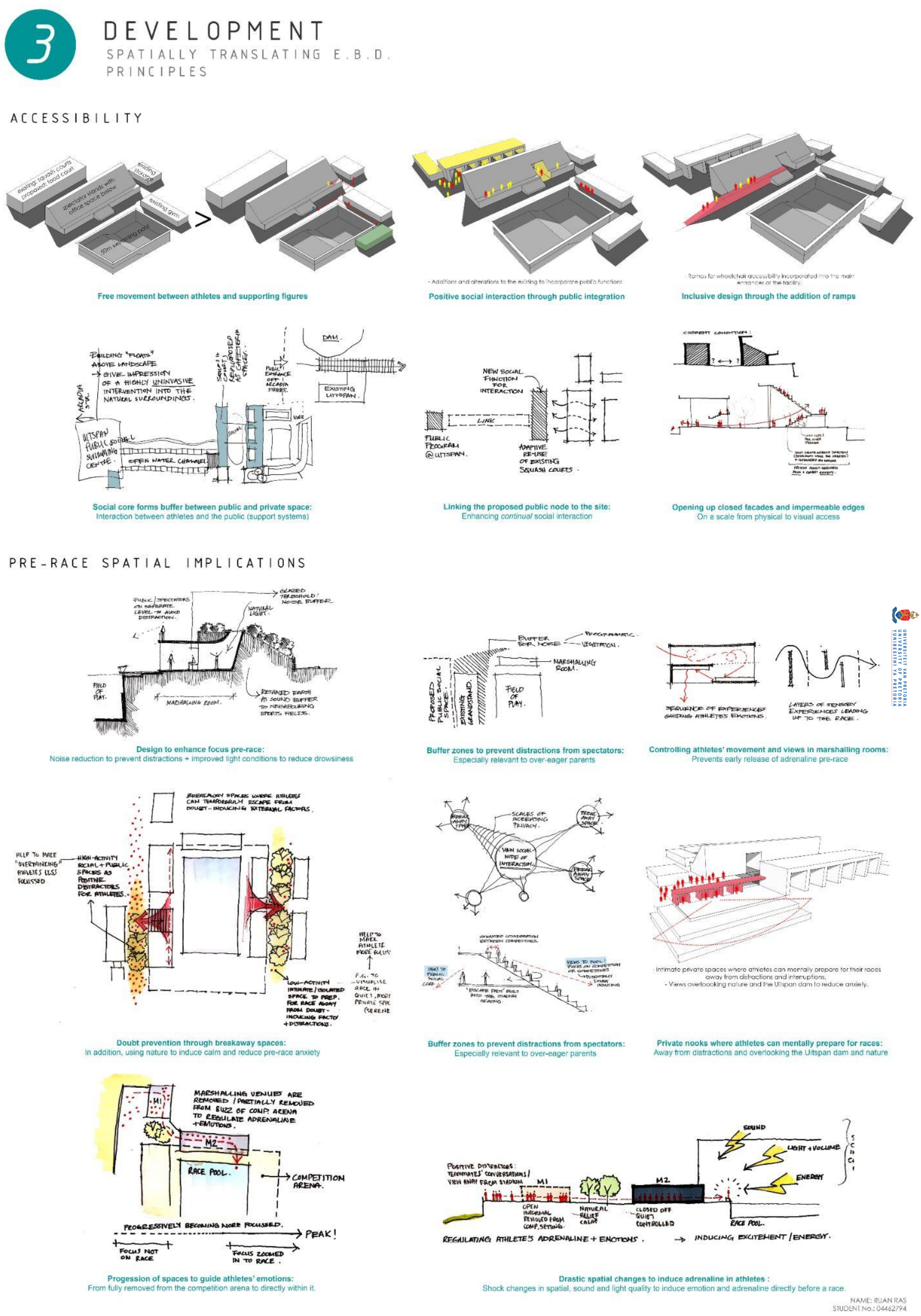
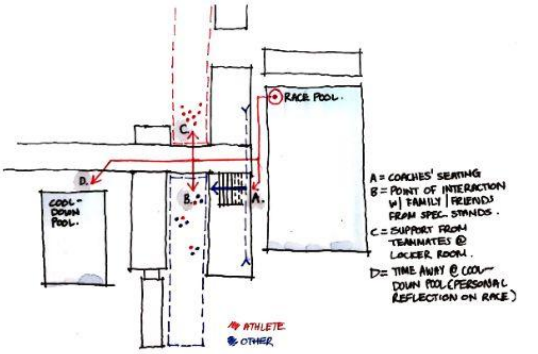
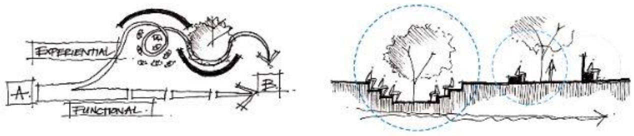


Figure 172: Design development (Author, 2021)

POST-RACE SPATIAL IMPLICATIONS

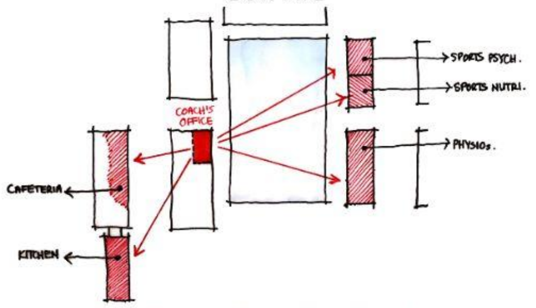


Guiding athlete's interactions post-race



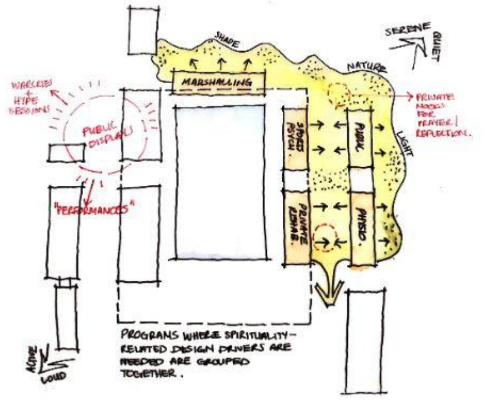
Giving users control over their environments:
On scales from experiential to functional and social to private

ZONING

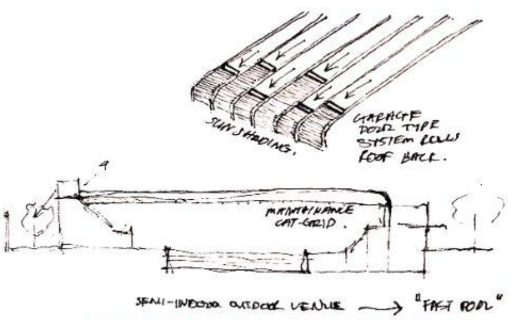


Zoning of the coach's office in relation to other stakeholders

SPIRITUALITY-RELATED DESIGN DRIVERS

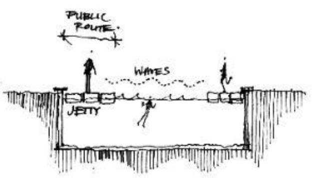


REDUCING IMPACT OF ENVIRONMENTAL STRESSORS



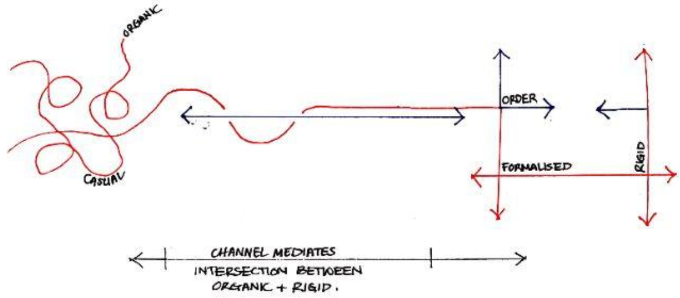
Retractable roof to mitigate the impact of unfavourable weather

RACE SIMULATIVE ENVIRONMENTS

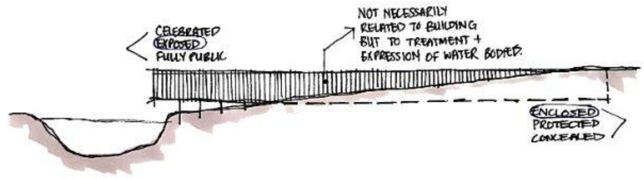


People jog over the jetty-structured running route creating waves in the open water channel simulating the racing conditions experienced by open-water swimmers

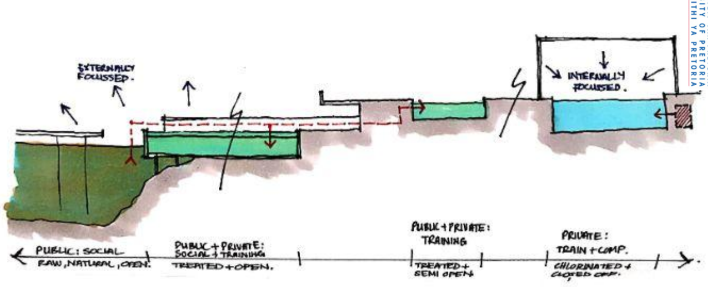
GENERAL SITE ARRANGEMENT



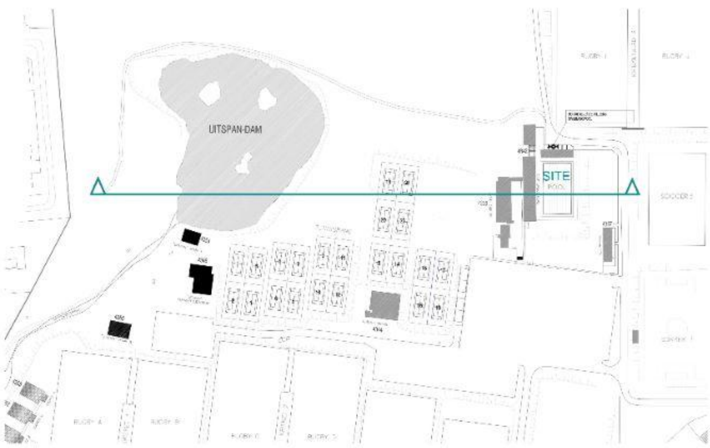
Scale of organic + informal to rigid + formal:
Circulation, activity, interactions and spatial layouts change across the site from more casual, informal spaces with social interactions, to more formalised and rigid spatial layouts that house organised activities.



Scale of public (exposed) to private (enclosed):
The slope of the existing topography is used to distinguish between exposed and enclosed spaces. This is further used to arrange the public (exposed) spaces and the private (enclosed) and protected spaces across the site.



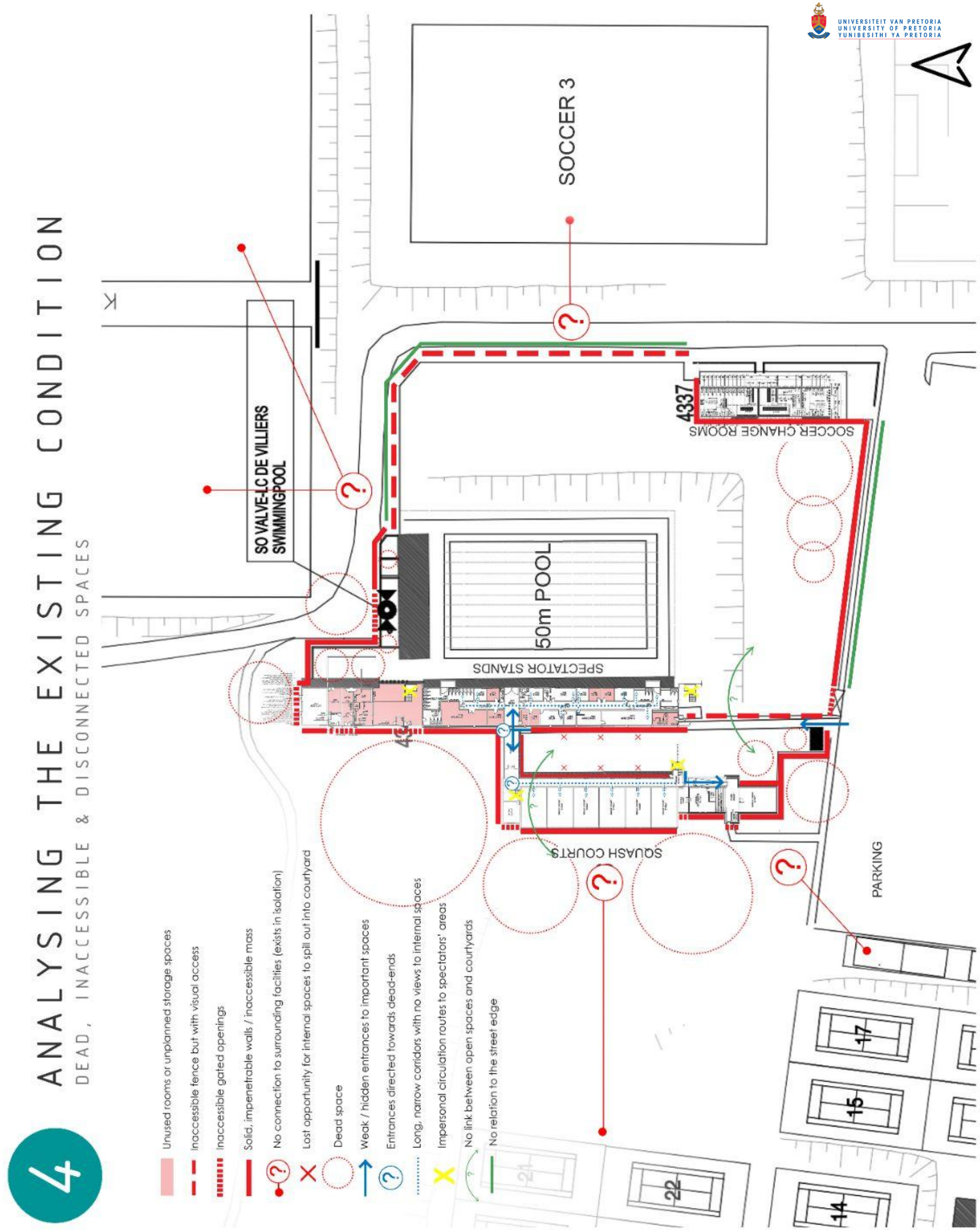
Treatment of water bodies:
The above translates further to the treatment of water bodies across the site. The Uitspan Dam exists as natural, raw, organic and fully open. This translates through to the open water swimming channel and the natural water filtration channels that take on a more rigid and formalised form, but that exist to house more organic, part-social-part-training functions. This channel mediates between the dam and the 50m competition pool. The 50m pool exists as more enclosed and internally focussed environment serving more private functions in a much more standardised, rigid and formalised setting.



NOTE: The above sections are drawn through the site as indicated above.
(Base plan adapted from Verbeek, 2017; Dinolofatsi, 2009; Dinolofatsi, 2020, Dinolofatsi, n.d.)

NAME: RUAN RAS
STUDENT No.: 04462794

Figure 173: Design development (Author, 2021)



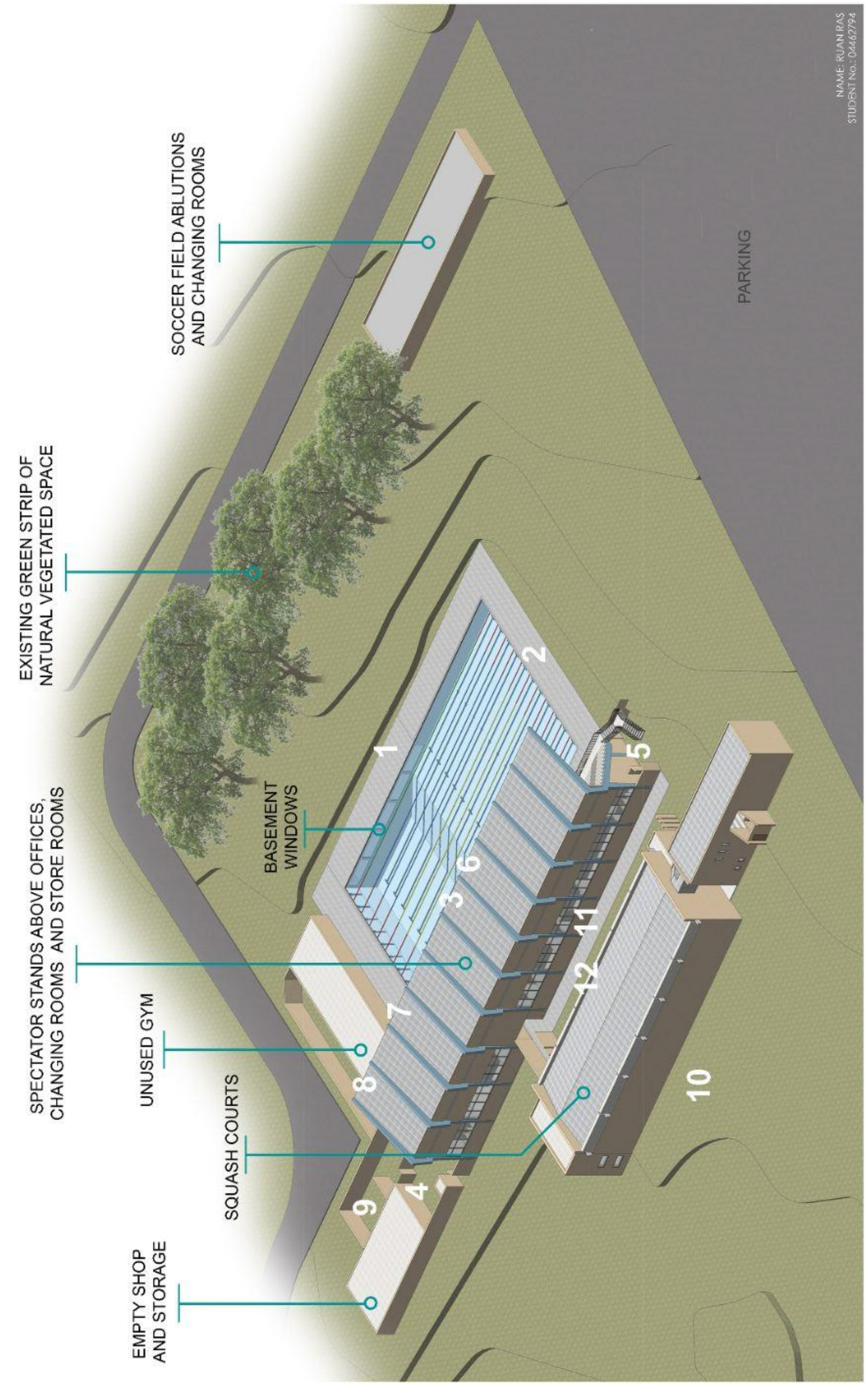


Figure 174: Analysis of the existing (Author, 2021)

5

ANALYSING THE EXISTING

PHOTOS ON SITE SHOWING MATERIALITY & SPATIAL QUALITY

POOLDECK - MONUMENTAL SPECTATOR STANDS AND SURROUNDING GREEN SPACES:

1

2

3


FAILED TUKS-SHOP & MERCHANDISE STORE, UNUSED BRAAI AREA & INACCESSIBLE COACH'S OFFICE:

4

5

6


INFORMAL KIT-BAG STORAGE AND EQUIPMENT STORAGE & DEAD SPACES USED AS DUMPING SITES:

7

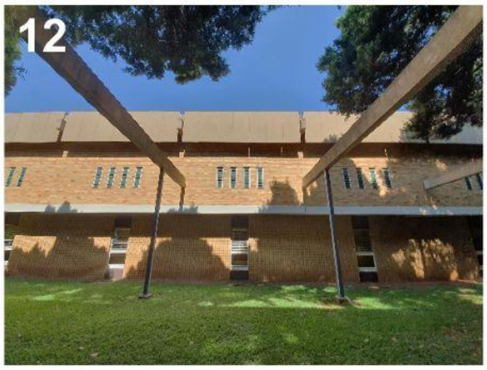
8

9


INACCESSIBLE WALLS, UNUSED OPEN LAND AND LACK OF VISIBILITY TO THE FIELDS OF PLAY:

10

11

12


NAME: RUAN RAS
STUDENT No.: 04462794

Figure 175: Analysing the existing (Author, 2021)

6 PRECEDENTS

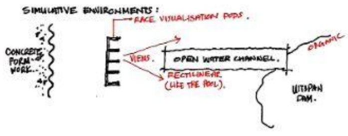
DESIGN PRECEDENTS:

Leça Swimming Pools by Álvaro Siza

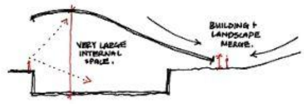
The man-made structure of the pools lie sensitively between and against the natural rock formations, merging the building with its context.

The view from the street edge is retained as passers by look over the new building.

The ramp immerses users into a space with no views, heightening their auditory experience of the ocean.



The building elements mimic those of nature (Author, 2021)

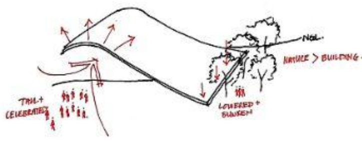


The change in level distinguishes the swimming pool complex from the surrounding urban infrastructure, acting as a more natural element in the landscape as opposed to built structure (Author, 2021)

Function is not forgotten amidst all the sensory experiences: seen in the practically designed wet-to-dry transition of the changing rooms.

Sharp changes in direction create climax moments where views to the ocean are exposed.

The building, experienced in full height upon exiting the change rooms.



Calm private moments where nature dominates structure and climax public spaces where structure stands tall and celebrated (Author, 2021)

Linking the man-made and the natural water bodies vacross the site (Author, 2021)

Duna Arena by NAPUR Architects

The steel structure attempts to reflect the movement and undulating light quality of the adjacent river.

Layered facades step down towards the street edge, bringing the large mass to a more human scale.

The facade facing the river edge, how ever, stands tall and proud - acting as a landmark for boats passing by.

Continuity of internal spaces is created linking water elements to one another.

Social spaces for user interaction edges the perimeter of the field of play.

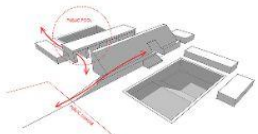
Transparency at ground level attempts to reduce the structural density of the arena and allows visual access to the internal activities.

Category	Room name
Swimming training	50m swimming pool
	Open water channel
	Ablutions (wet and dry)
	Changing rooms
	Locker rooms
	Wetbag storage
	Pre session stretching
	Team talks
	Coach's office 1
	Shared coach's office 2 + 3
	Administrator's office
	Gym receptionist's office
	First-aid room
	Security house
	Parking lot
	Emergency pickup point
	Recovery quarters
	Physiotherapy consultation
	Nutritionist consultation
	Sports psych. consultation
	Support facility's reception
	Support facility's waiting area
	Gym
	Athletes' social space
	Athletes' living quarters
	Athletes' cafeteria + kitchen
	Maintenance + equip. storage
	Electrical control room
	On-deck showers
	Staff breakroom
	Auditorium
	Pool covers storage

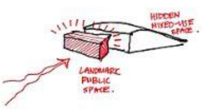
Category	Room name
Swimming competition	Spectator seating
	Temporary food stands
	Permanent cafe' / snack shop
	Temporary product stands
	Tickets booth
	Additional / separate ablutions
	25m cool down pool
	Podium / performance platform
	Doping control room
	Dryland warmup space
	Media room
	Post-race interview space
	Race-suits changing rooms
	Marshalling venue 1
	Marshalling venue 2
	Officials meeting room
	Coaches' seating
	Starter's platform
	Timekeeper's seating
	Technical officials clear route
	Commentator's room
	Administrator's office
	Storage for comp. equipment
	Results wall

Category	Room name
Public spaces	Food court
	Kitchen
	Service and delivery
	Outdoor braai area
	Indoor braai area
	Events space
	Temporary market space
	Informal play space
	Recreational training pool
	Recreational social pool
	Changing + locker rooms
	Ablutions (wet and dry)
	Lifesaver's bench
	Public jogging / cycling route

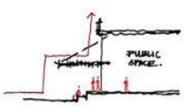
Accommodation list for the new TuksAquatics Complex based on precedents of FINA-approved sports facilities as well as personal experiences.



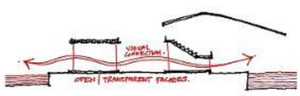
Continued use through public integration (Author, 2021)



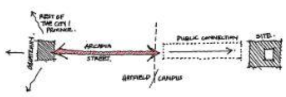
Stepped facades mitigate the building's scale (Author, 2021)



A landmark on the campus vs. a hidden facility (Author, 2021)



Water bodies are linked to one another (Author, 2021)

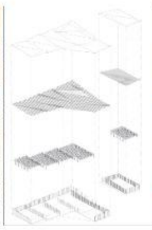


Linking the Gautrain, Arcadia Street and the site to enhance access to the facility and encourage continued use (Author, 2021)

TECHNOLOGICAL PRECEDENTS:

Work by Kengo Kuma

Exhibition Center of Strasbourg, Kuma and Associates, 2018 (arquitecturaviva, 2021)

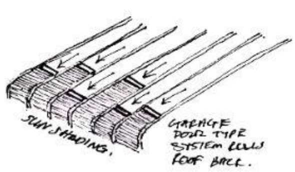


Japan National Olympic Stadium, Kuma, 2016-2019 (Lynch, 2016)

Due to the desired use of timber as a construction material for the roof ("the roof as an extension of the ground plane"), issues of span and material efficiency arose. Kengo Kuma does a lot of work using timber construction, however, for larger buildings, he resorts to hybrid structural systems where timer and steel are used in conjunction with one another. This creates an efficient solution where steel as the primary structure allows for the desired large spans, and timber as the secondary structure improves the general energy efficiency as well as the aesthetic of the roof.

Wimbledon Centre Court by Populous Architects

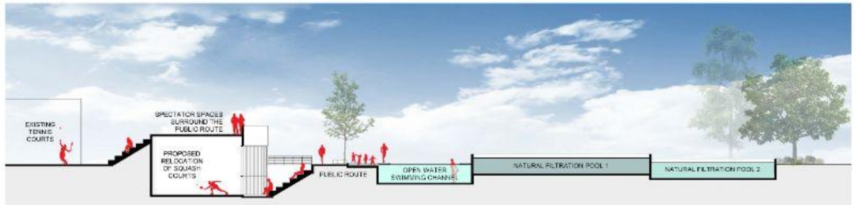
Retractable roofs have become common features in architecture. However, at larger spans like those needed to house sporting facilities, they become more challenging. The Wimbledon centre court employs a retractable roof that operates similar to a stacking door or concertina. The roofing material (translucent Tenara fabric), held by large steel trusses, stacks away to open up the space above the tennis court. However, in order to reduce the amount of structure that is needed to achieve this, the retractable roof in my scheme is broken into segments; each segment running on its own set of tracks, which is fixed to the steel trusses that run across the swimming pool. This breaks up the heavy weight of the retractable members, requiring less structure and creating a better aesthetic.



NAME: RUAN RAS
STUDENT No.: 04462794

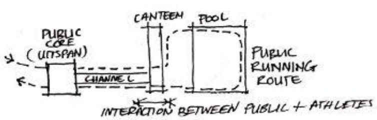
Figure 176: Precedents (Author, 2021)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



SECTION D-D: Proposed relocation of the squash courts

Due to the low structural density and high natural quality of the Hillcrest Campus, it is identified as a 'pocket of relief' in the city. To become a public 'pocket of relief' in the city, the design's accessibility becomes vital. However, the existing condition of accessibility shows very limited fully-public access. Therefore, a new public pedestrian entrance is proposed to link the newly semi-pedestrianised Arcadia Street to the campus. This helps to activate the existing Uitspan node as a now fully-public social and recreational hub. Using Arcadia Street as a semi-pedestrian linkage also connects the Gautrain Station to the new TuksAquatics Centre; promoting use by out-of-city athletes living in Johannesburg, improving safety and passive surveillance in Arcadia Street, connecting the many Bed-and-Breakfasts to the wider out-of-city public and spectators as well as enhancing athlete-public interaction. Arcadia Street is connected to the site itself through a public jogging and cycling route. Parallel to the route, a 200m linear open water swimming channel further connects the water bodies on site, mediating between the now fully public social core of Uitspan and the semi-private training and competitions venues used by the athletes. Furthermore, the channel is supported by an adjacent natural filtration system that naturally filters the dam water making it safe to train in.



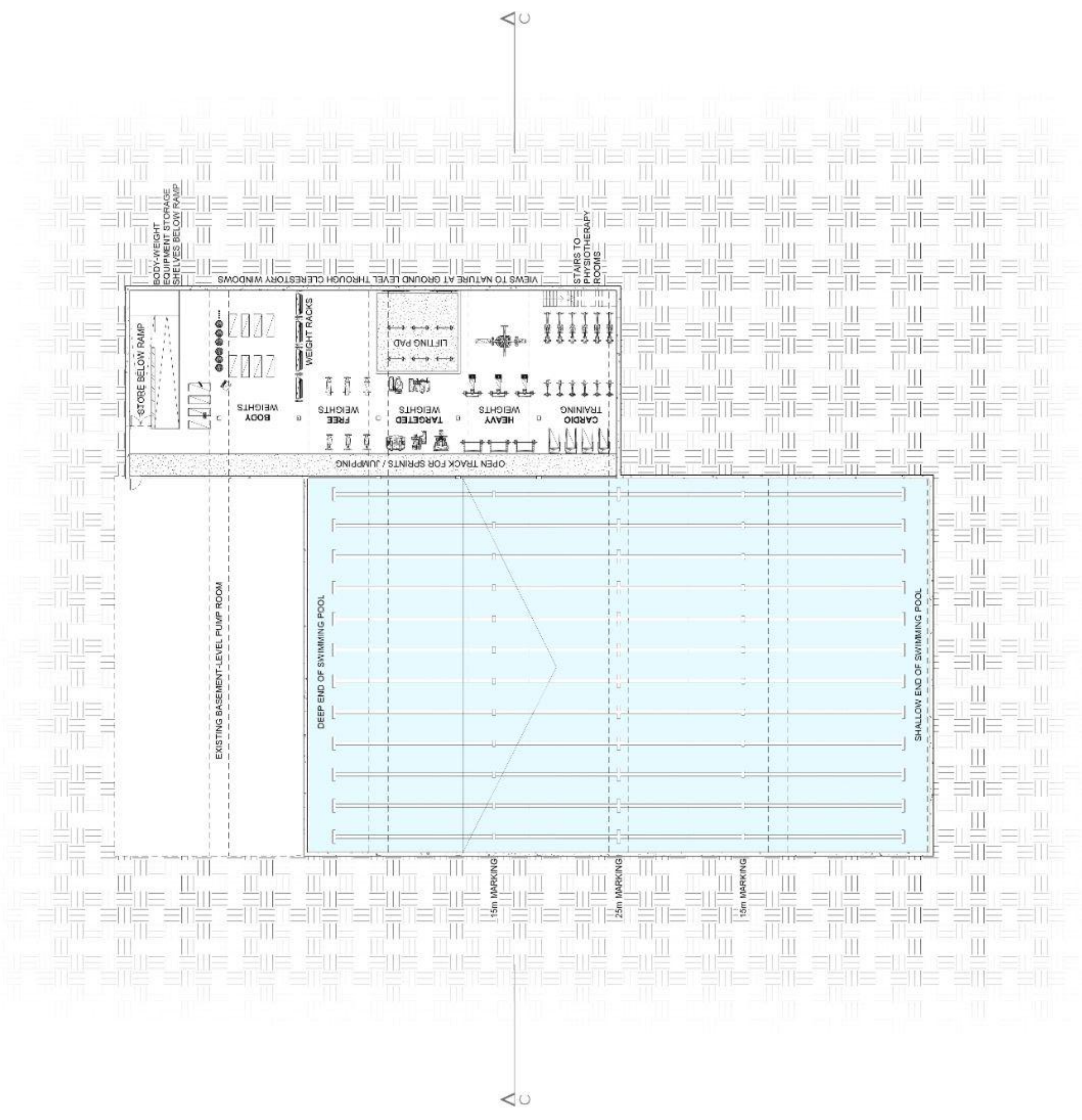
NAME: KUAN RAS
STUDENT No.: 04462/94

Figure 177: Site plan (Author, 2021)

BASEMENT FLOOR PLAN

SCALE 1:200

8



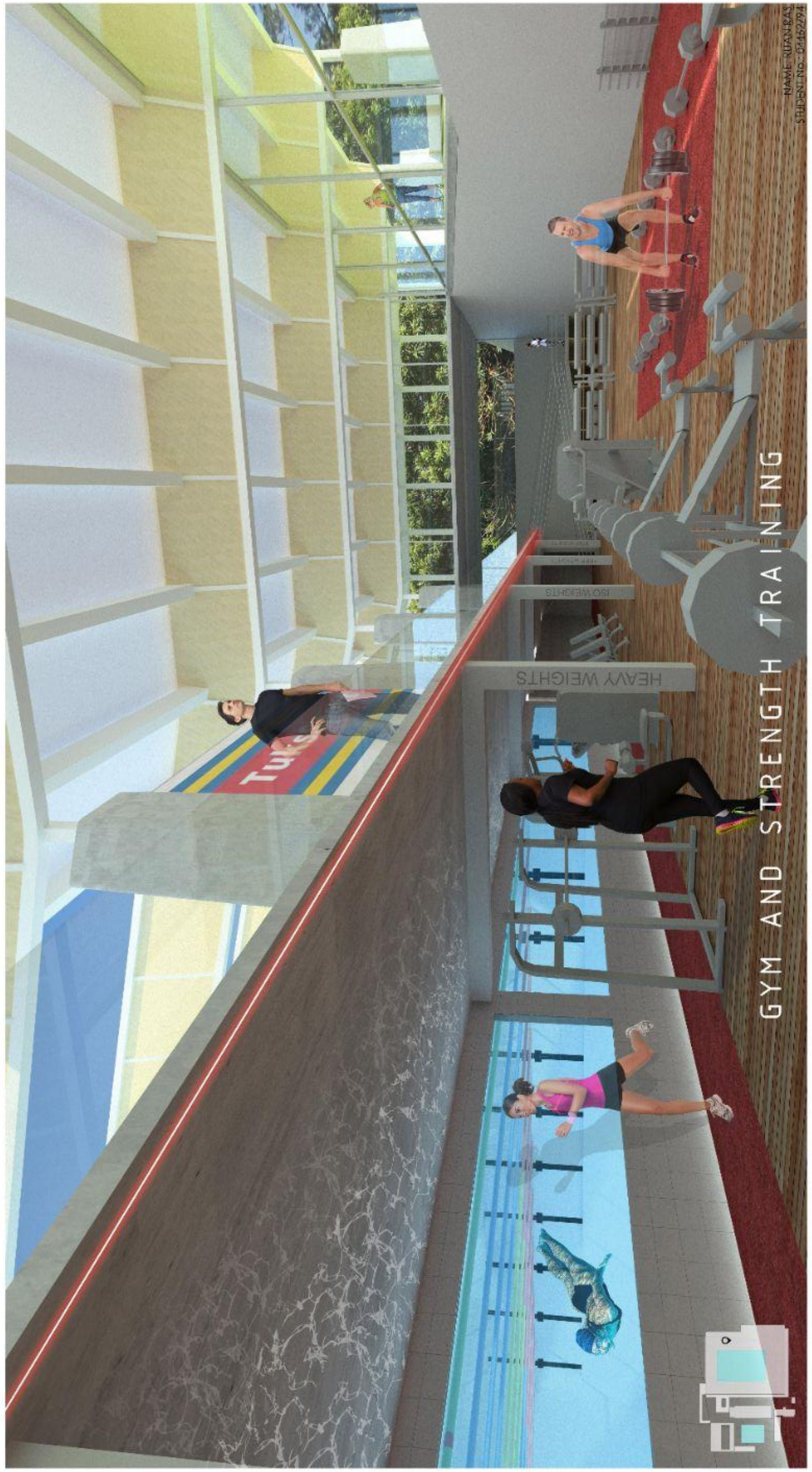


Figure 178: Basement floor plan (Author, 2021)

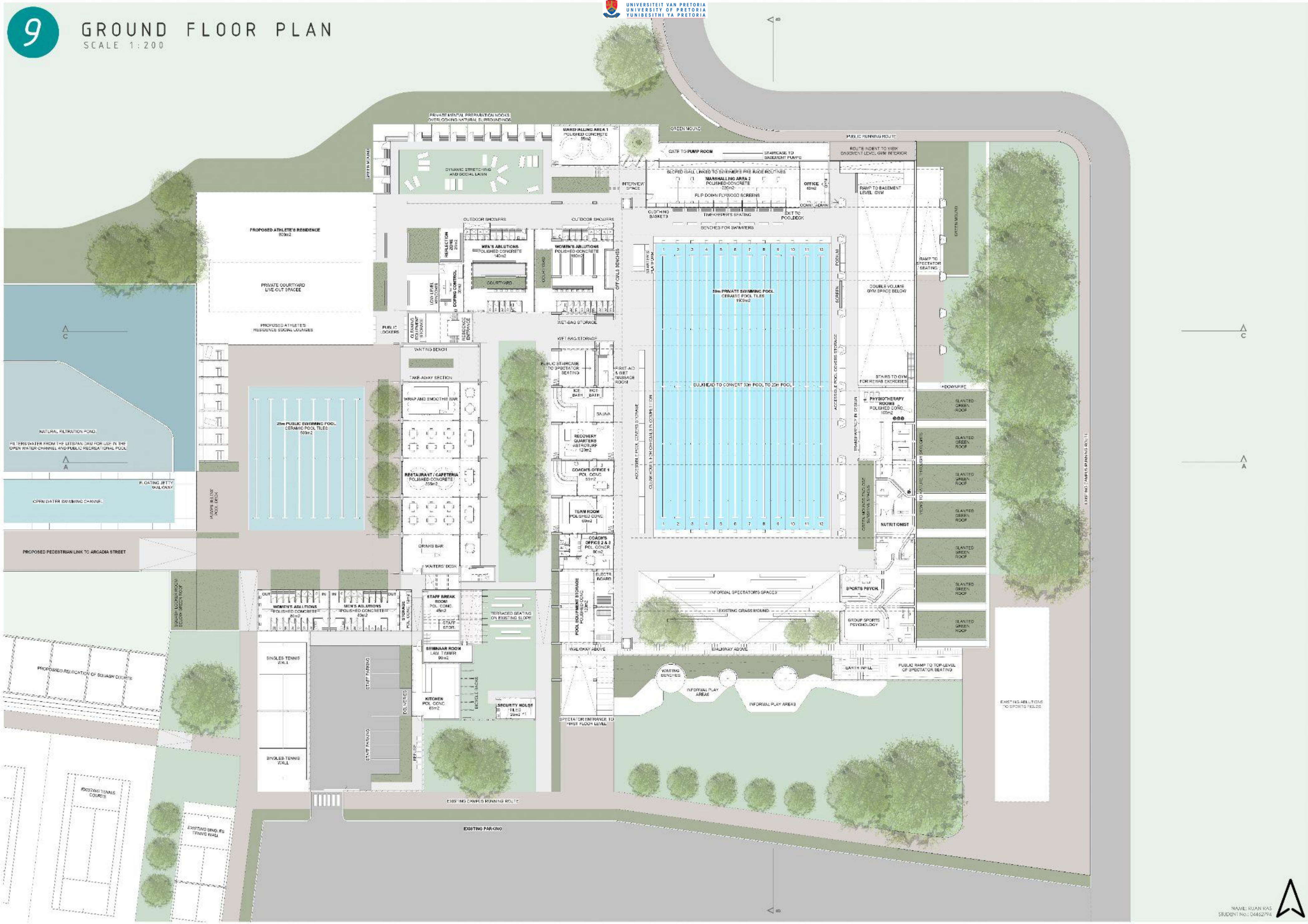


Figure 179: Ground floor plan (Author, 2021)

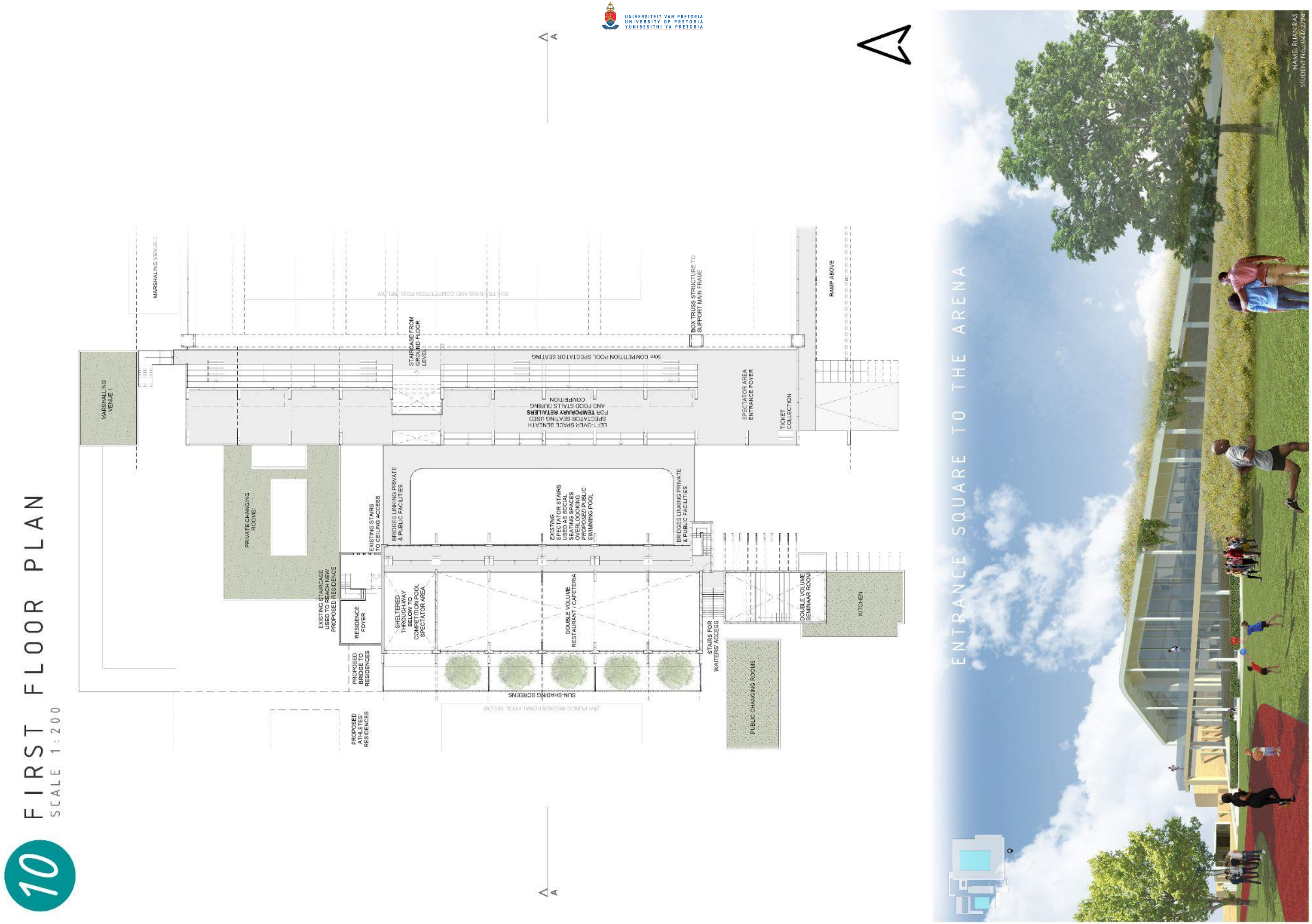


Figure 180: First floor plan (Author, 2021)

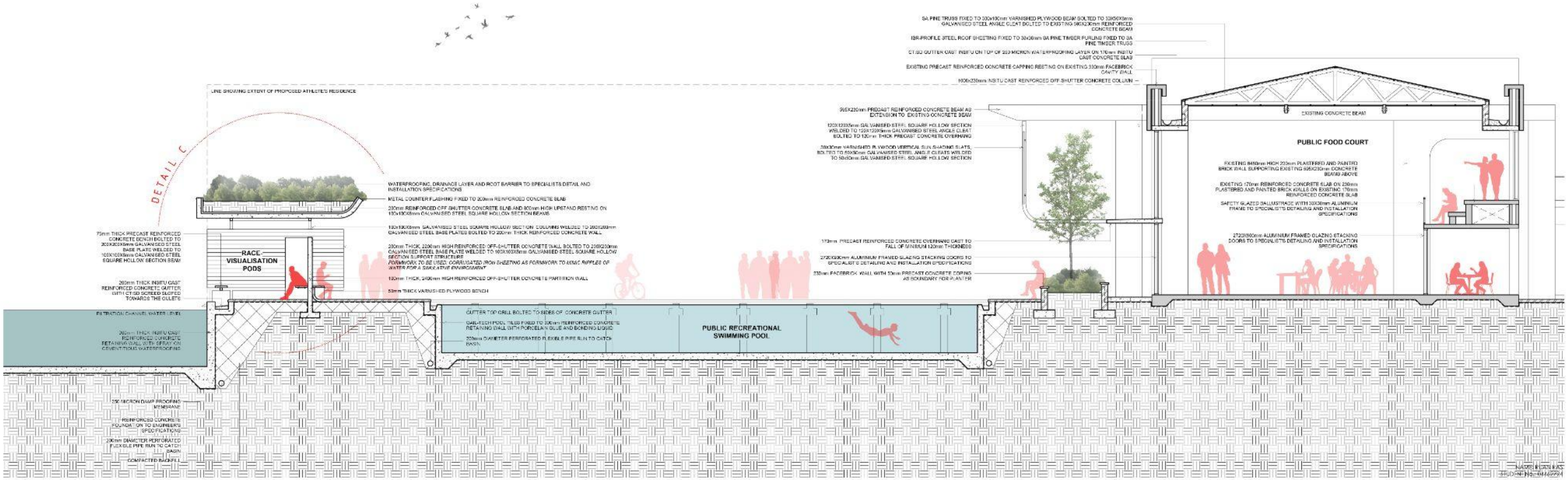


Figure 181: Section A-A (Author, 2021)

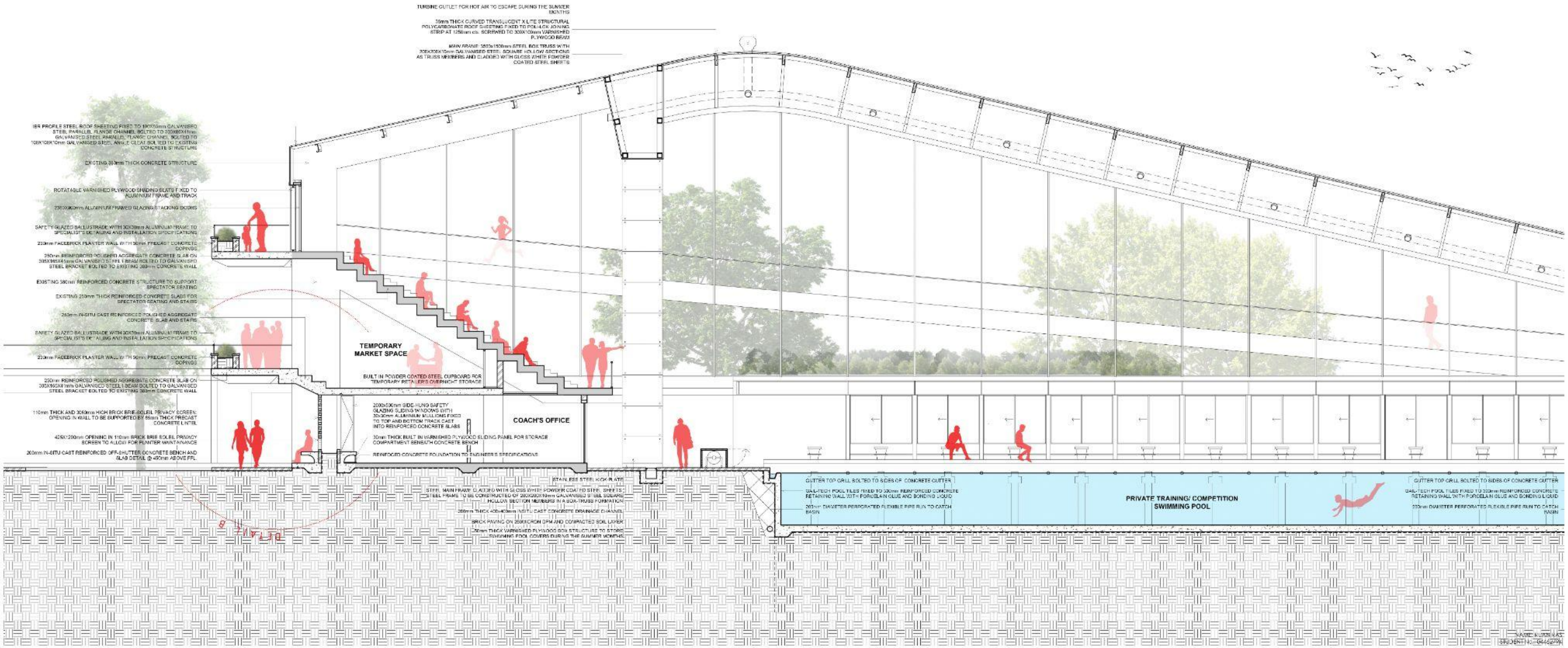


Figure 182: Section A-A continued (Author, 2021)

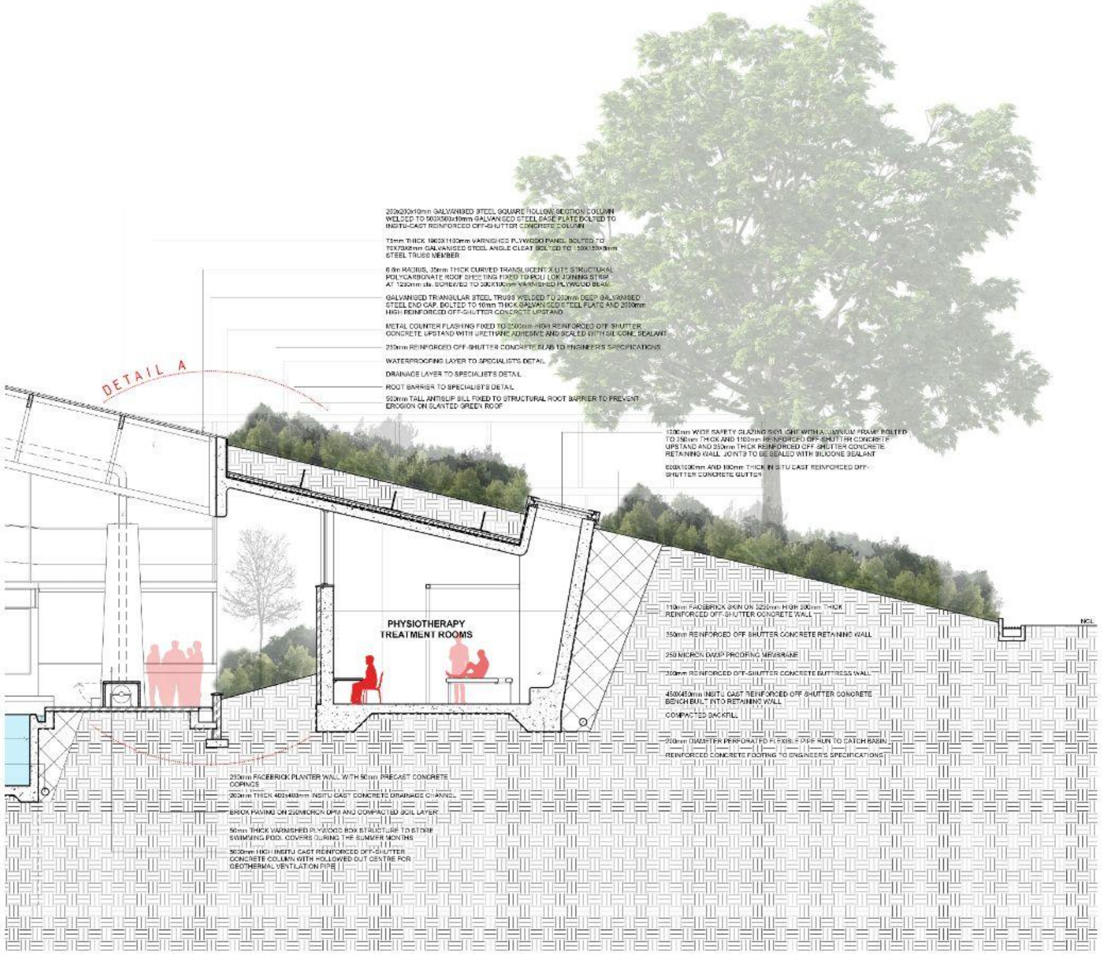


Figure 183: Section A-A continued (Author, 2021)

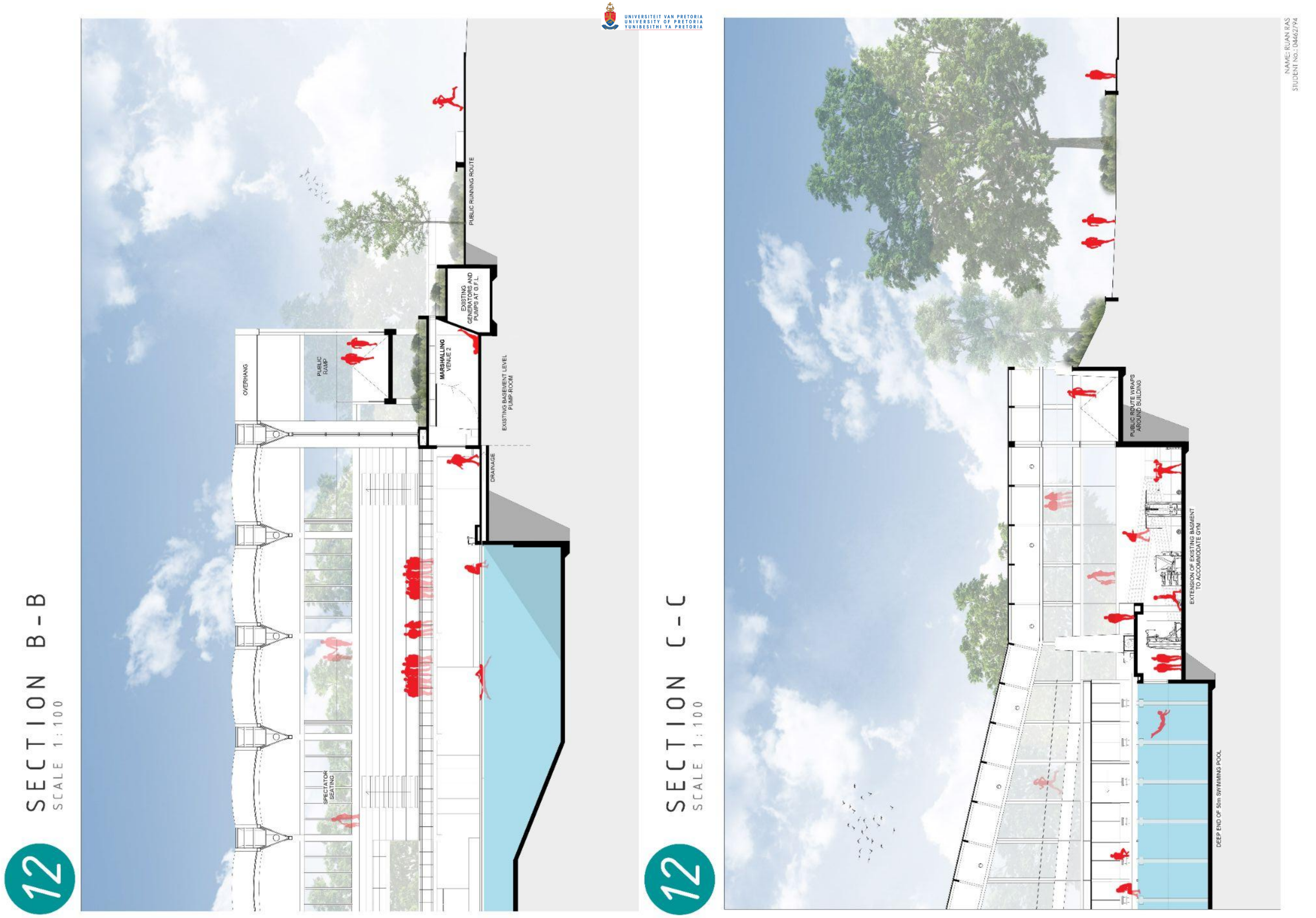


Figure 184: Section B-B and C-C (Author, 2021)

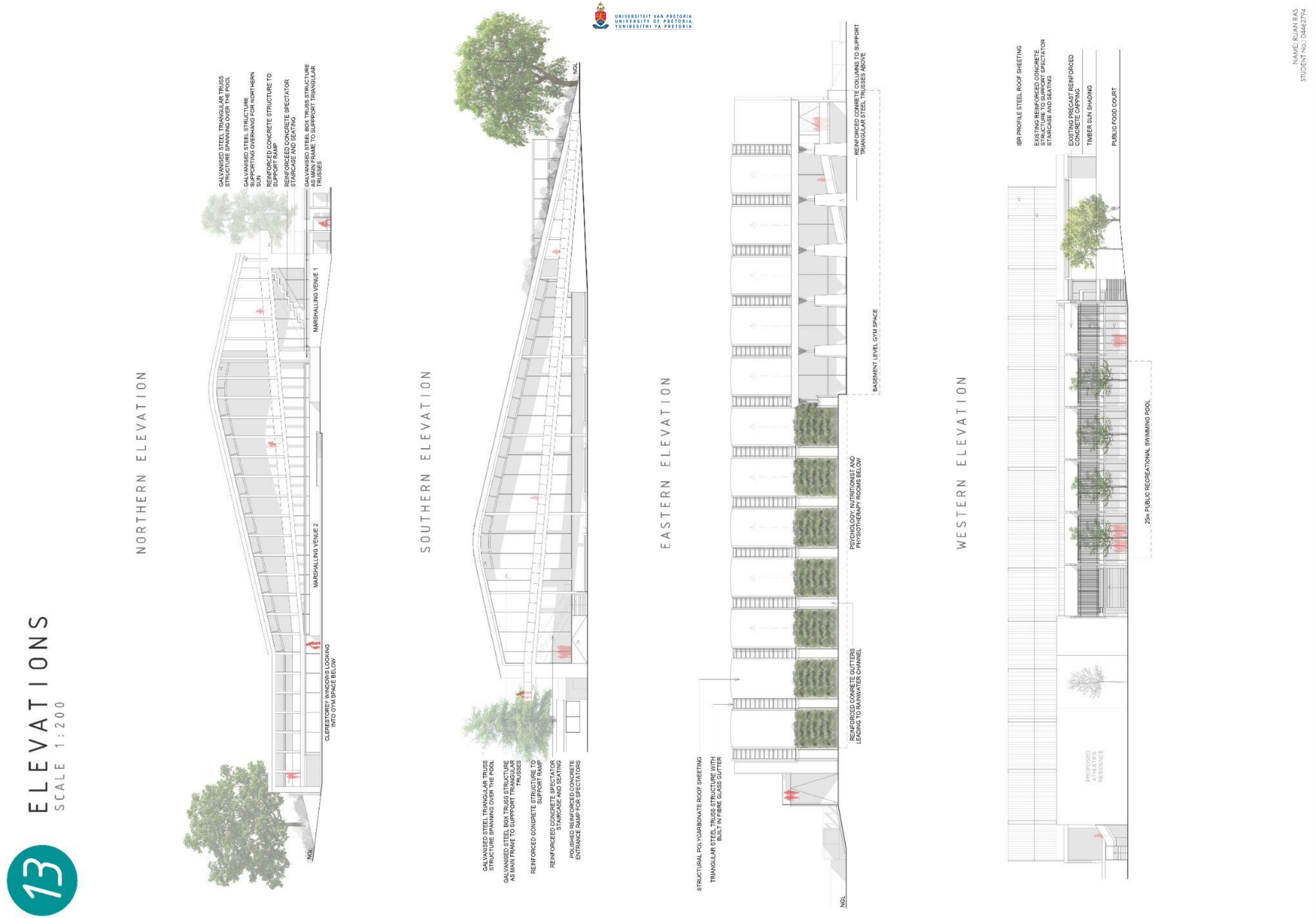


Figure 185: Elevations (Author, 2021)

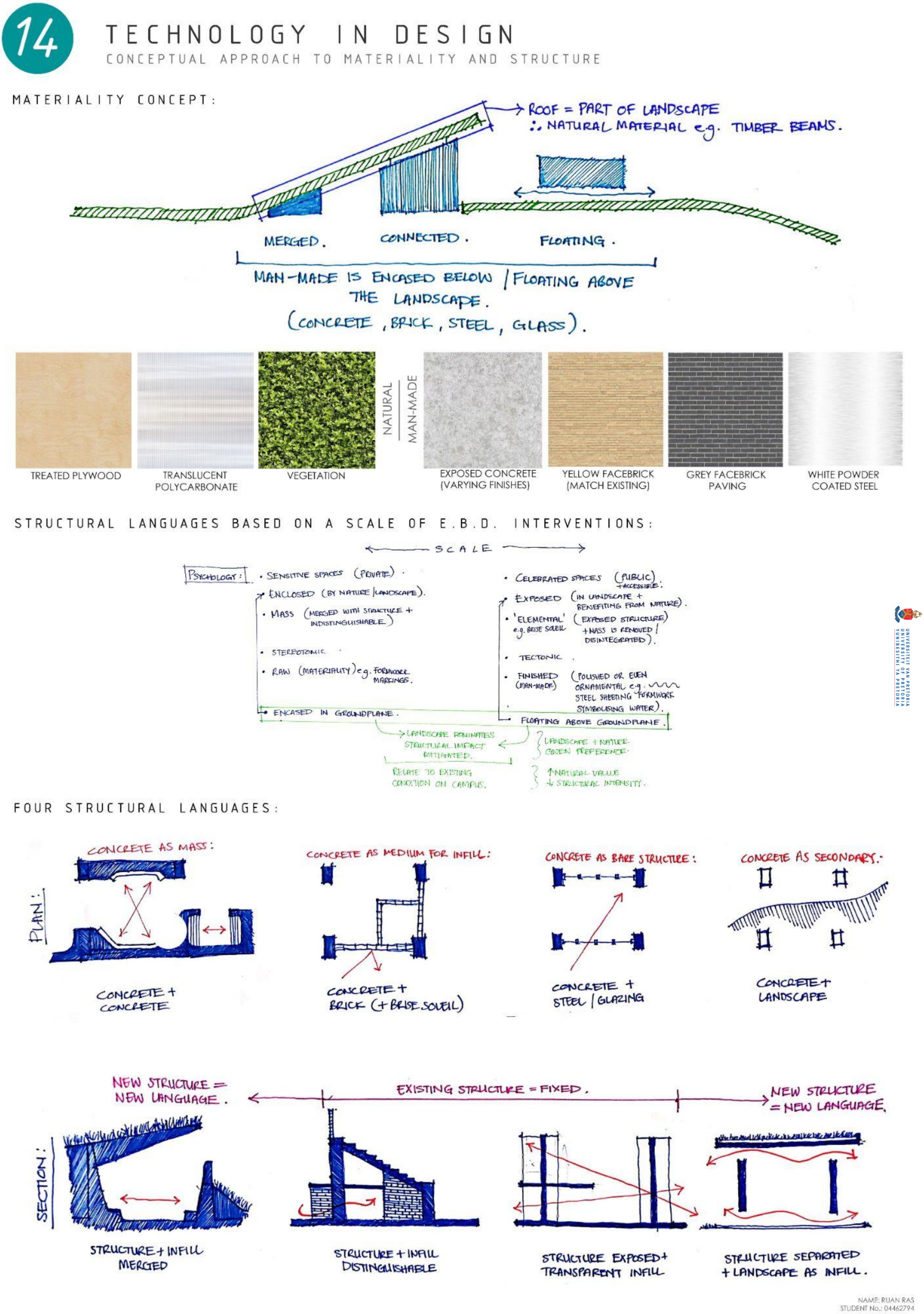
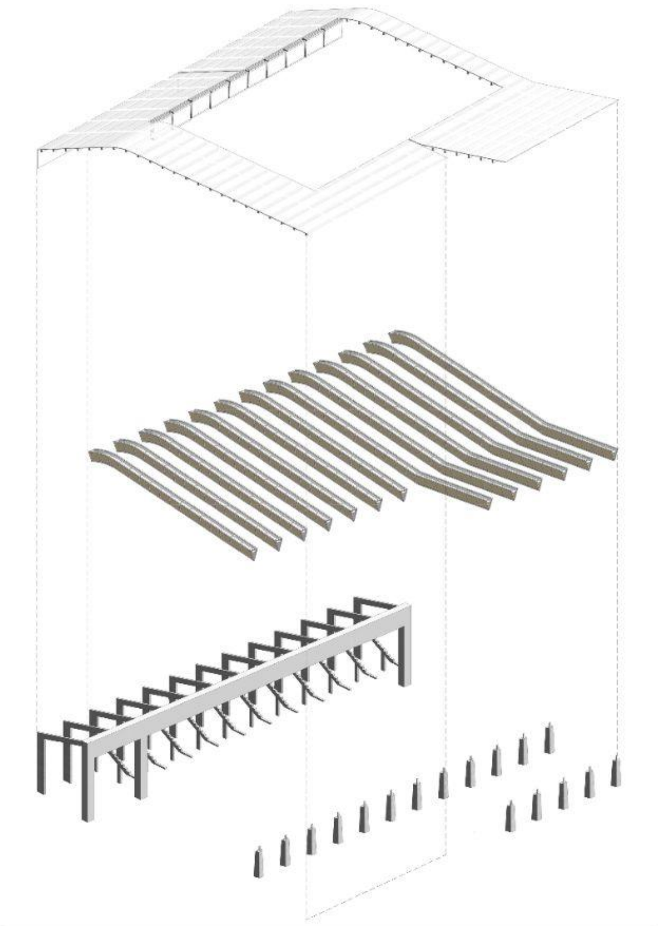


Figure 186: Technology in design (Author, 2021)

15 TECHNOLOGY IN DESIGN

STRUCTURE AND GREENSTAR RATING

BREAKDOWN OF STRUCTURE:

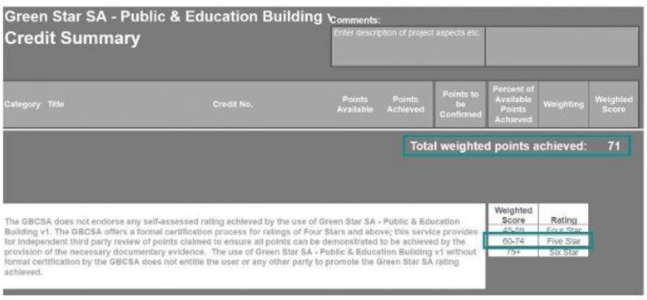


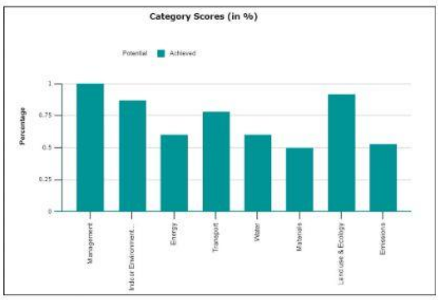
TERTIARY STRUCTURE:
POLYCARBONATE ROOF SHEETING
ON 50x50mm PLYWOOD PURLINS
ON 300x100mm PLYWOOD BEAMS

SECONDARY STRUCTURE:
2000mm DEEP WHITE POWDER COATED GALVANISED STEEL TRIANGULAR TRUSS WITH 50mm PLYWOOD INFILL PANELS AS LATERAL BRACING

PRIMARY STRUCTURE:
- EXISTING CONCRETE STRUCTURE
- NEW STEEL MAIN FRAME: 3500x1500mm RECTANGULAR TRUSS ON SIMILAR STEEL FRAMED SUPPORTS CLADDED WITH GLOSS WHITE POWDER COATED ALUMINIUM SHEETS
- NEW CONCRETE COLUMNS

GREENSTAR RATING:





GreenStar rating achieved: 71 points (5 stars)

Sustainable design measures have been taken in the form of improved natural daylighting in internal environments. This has been achieved without resulting in too much heat gain on the interiors through the use of various shading devices and large roof overhangs that also help to reduce glare. Openings in smaller spaces like the food hall allow natural ventilation, while larger spaces such as the competition venue employ mechanical ventilation strategies that work to minimise energy consumption. This is done through a geothermal heating and cooling strategy that works to keep internal environments thermally comfortable. This ventilation also prevents unwanted humidification of the indoor spaces that house the swimming pool, further helping to prevent mould and other health hazards from occurring.

In terms of water usage, stormwater is retained in large natural water filtration channels that filter rainwater, stormwater and water from the Hartbeesspruit. This water is reused for the public ablutions, showers in the changing rooms as well as to fill the 25m public recreational swimming pool. These channels, along with the vast natural open space surrounding the site has also allowed many visual connections to be created between internal spaces and natural external spaces.

Building materials are also chosen with sustainability in mind where materials are chosen based on their low embodied energies, local availability as well as, where relevant, their insulative properties. Furthermore, materials that are left over after the demolishing of parts of the existing building; for example: the facebrick left over after opening up the facades of the old squash courts, is reused to fill gabion structures that can be used to terrace the landscape.

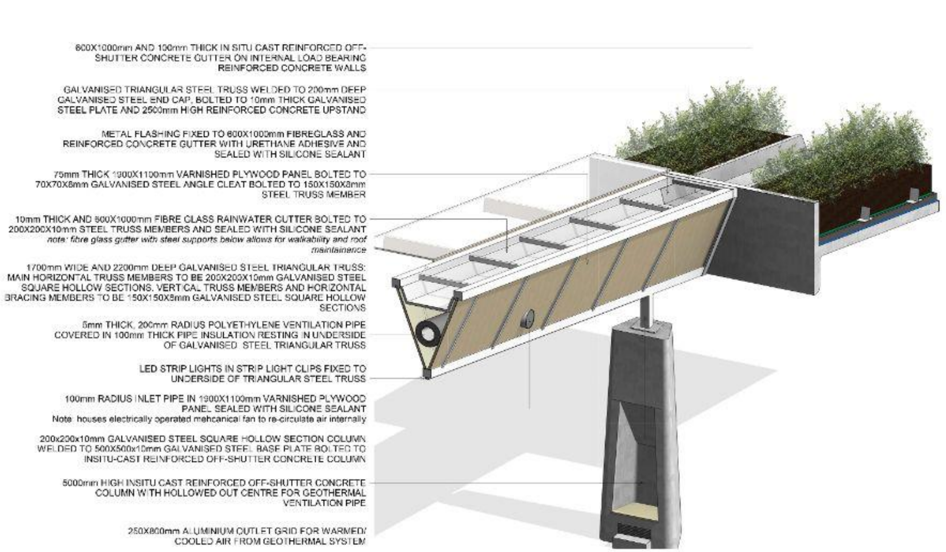
Lastly, public and community are brought into the scheme through the site's connection with the Gautrain station, the proposed semi-pedestrianised Arcadia Street, the braai areas at the Uitspan dam and the public running and cycling route that stretches across the campus. This encourages continued use of the site, healthy habits of running and cycling for the users of the site as well as minimising fossil-fuel emissions by encouraging the use of public transport. Furthermore, community members are able to use the public 25m recreational swimming pool, which adds value to the site's context.

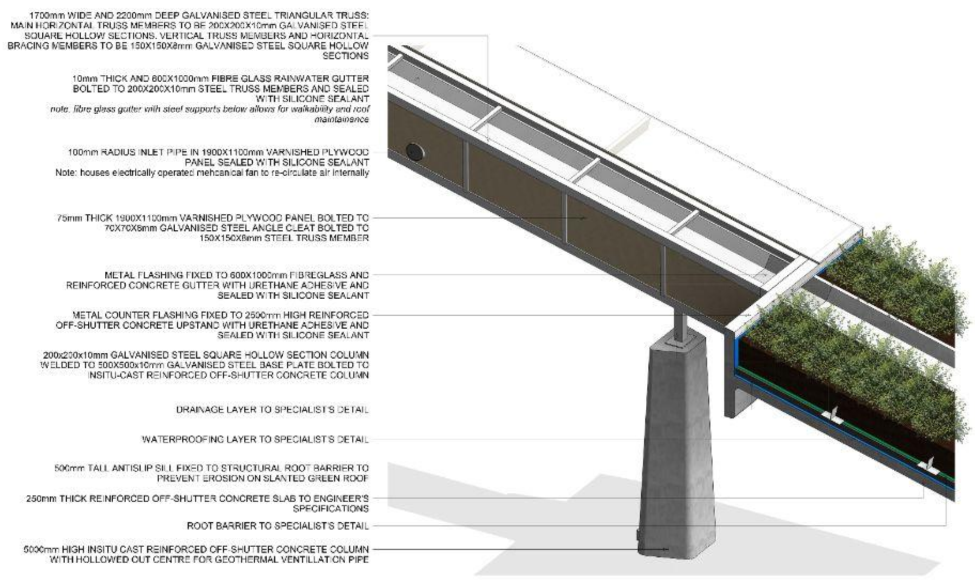
NAME: RUAN RAS
STUDENT No.: 04462794

Figure 187: Structure and Greenstar rating (Author, 2021)

16 DETAIL A

SCALE 1:40





PROCESS WORK:

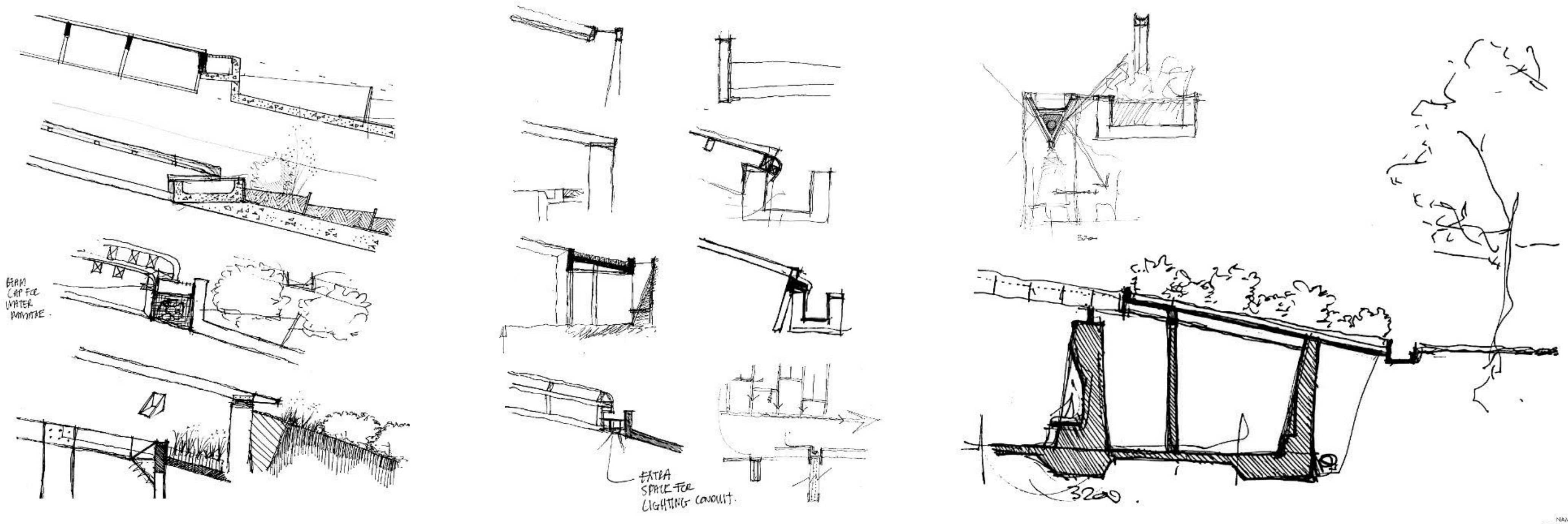


Figure 188: Detail A (Author, 2021)

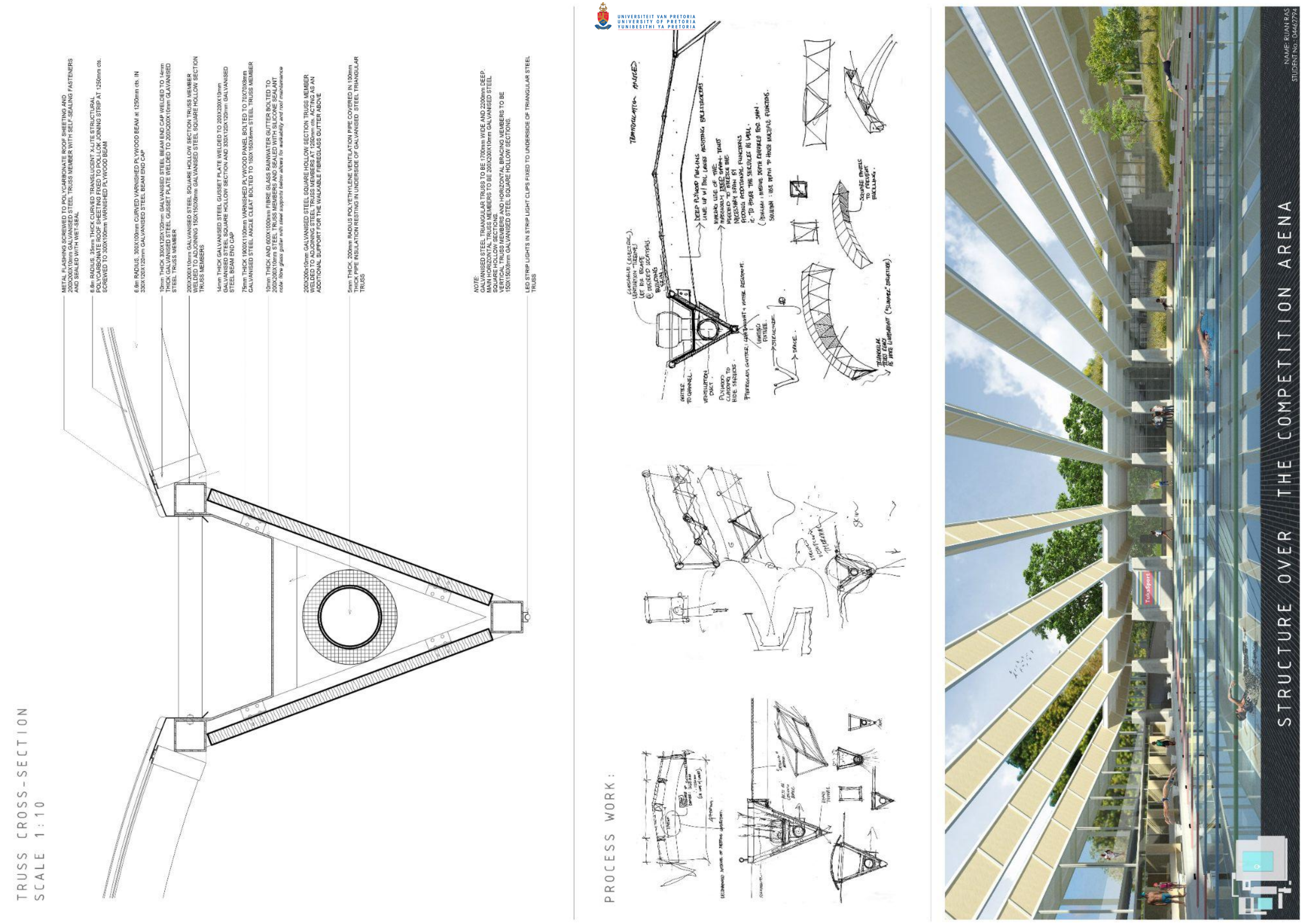
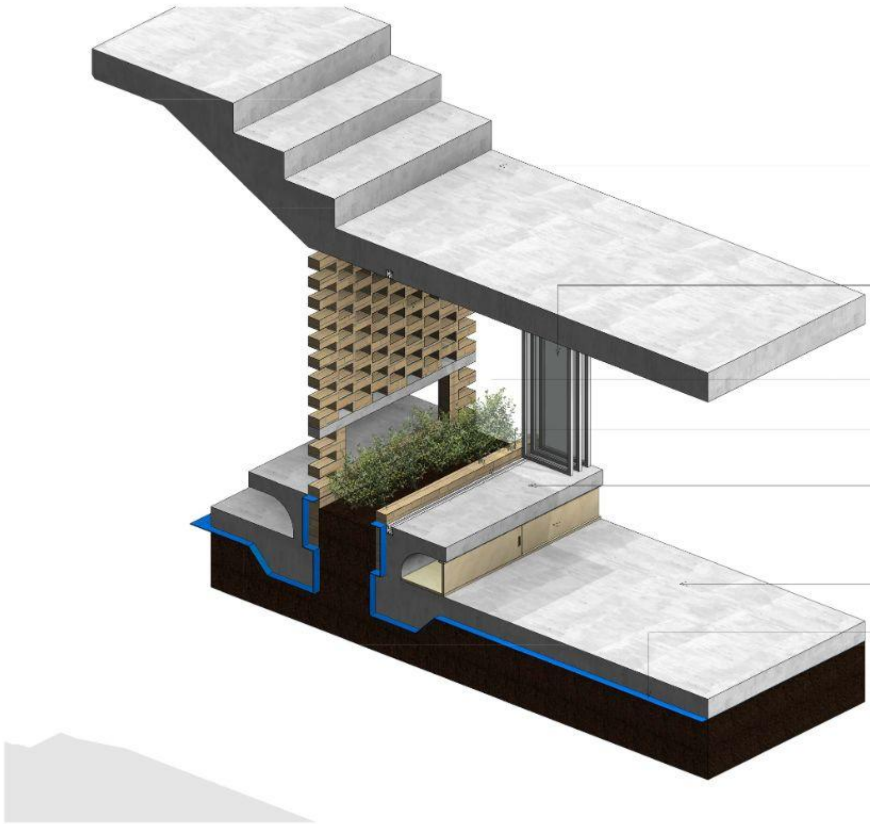
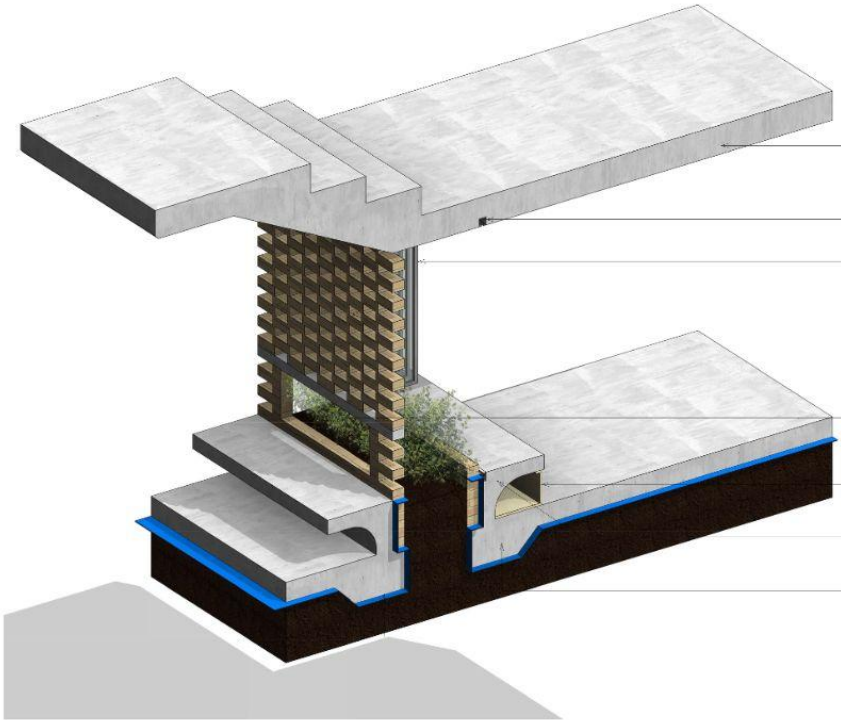


Figure 189: Detail A continued (Author, 2021)

17 DETAIL B

SCALE 1:20





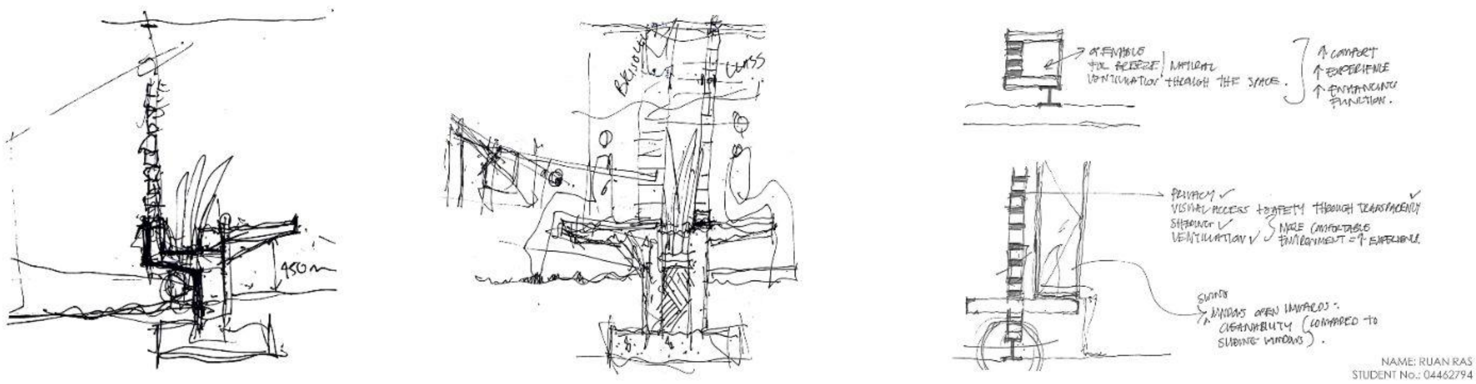


Figure 190: Detail B (Author, 2021)

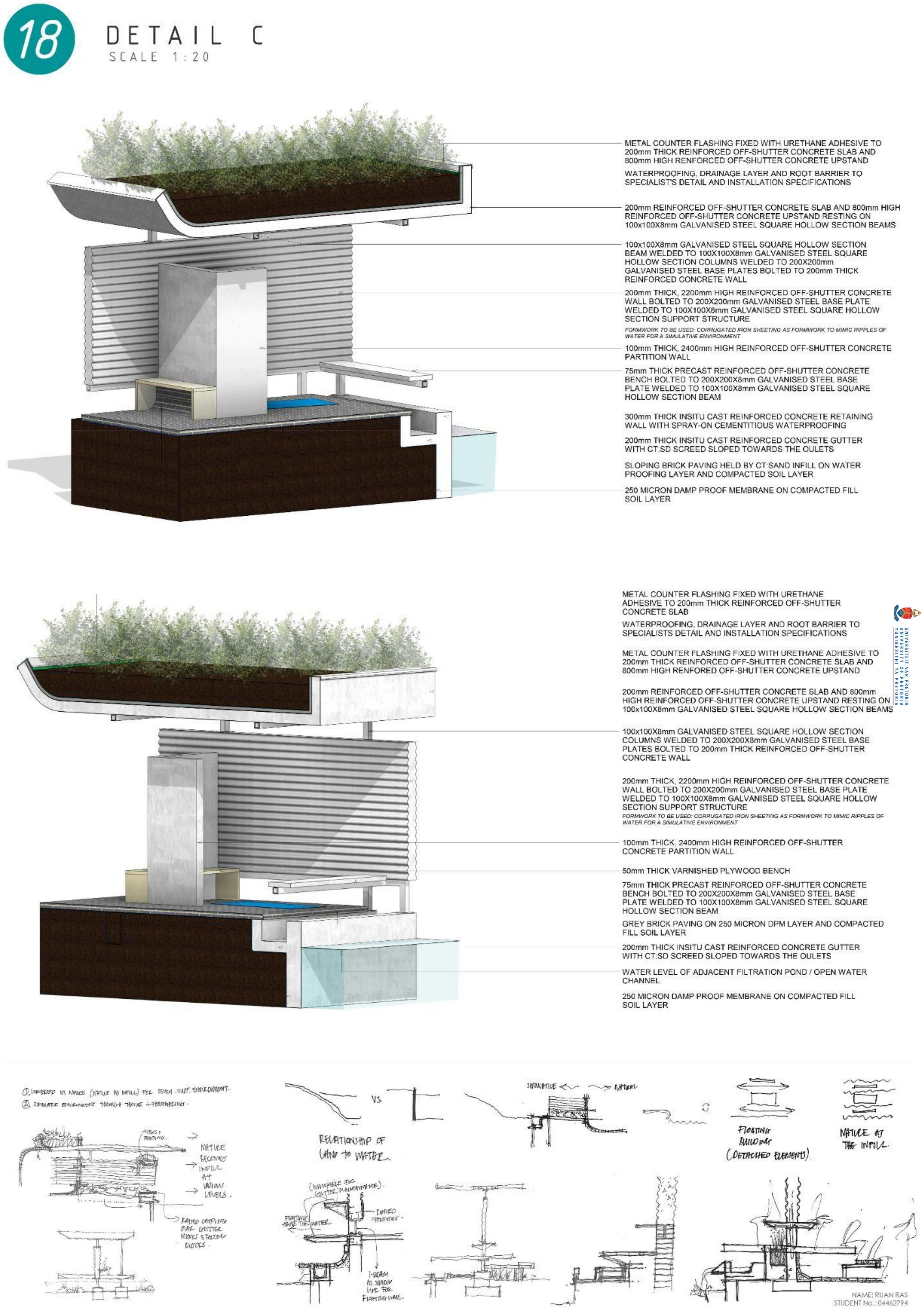
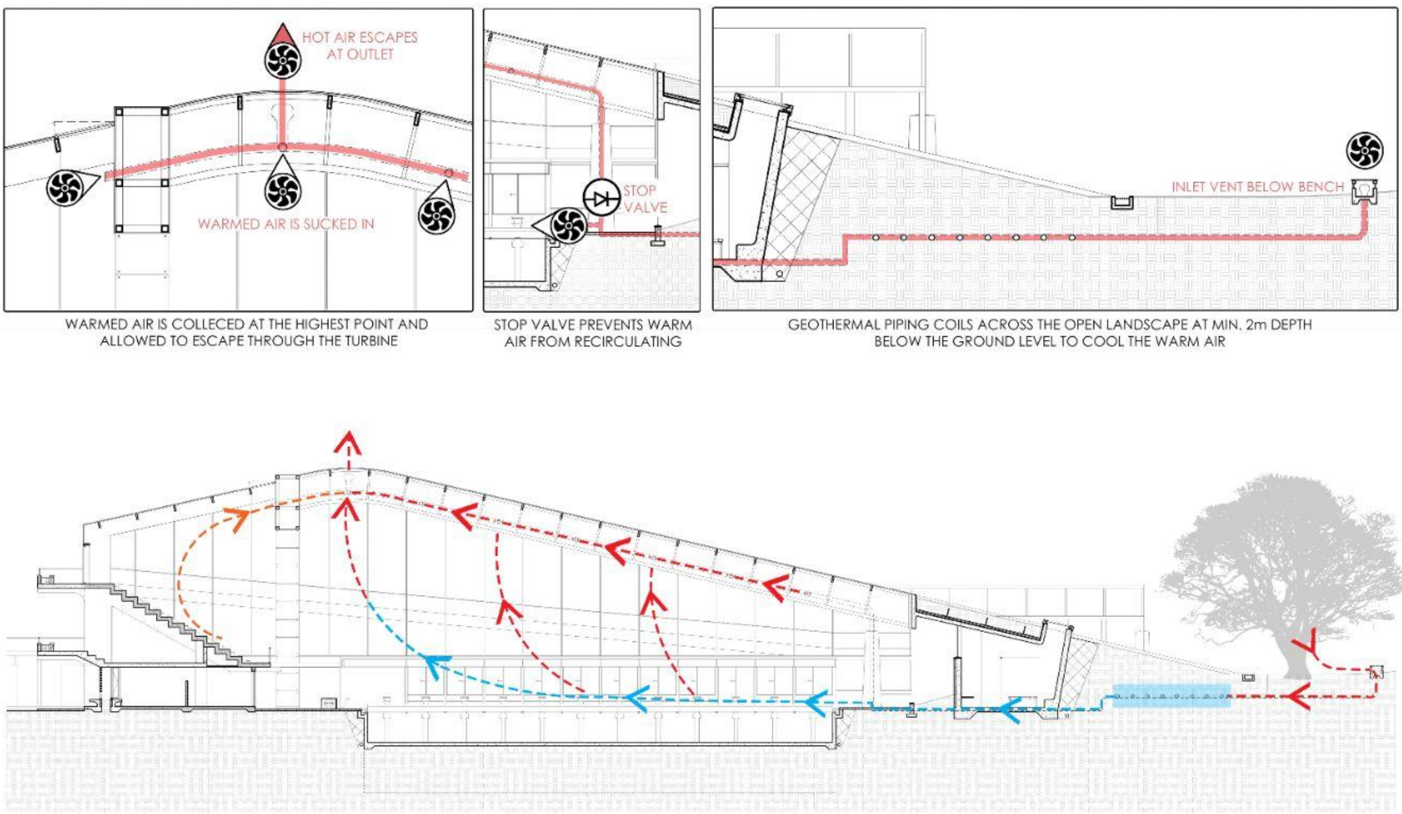


Figure 191: Detail C (Author, 2021)

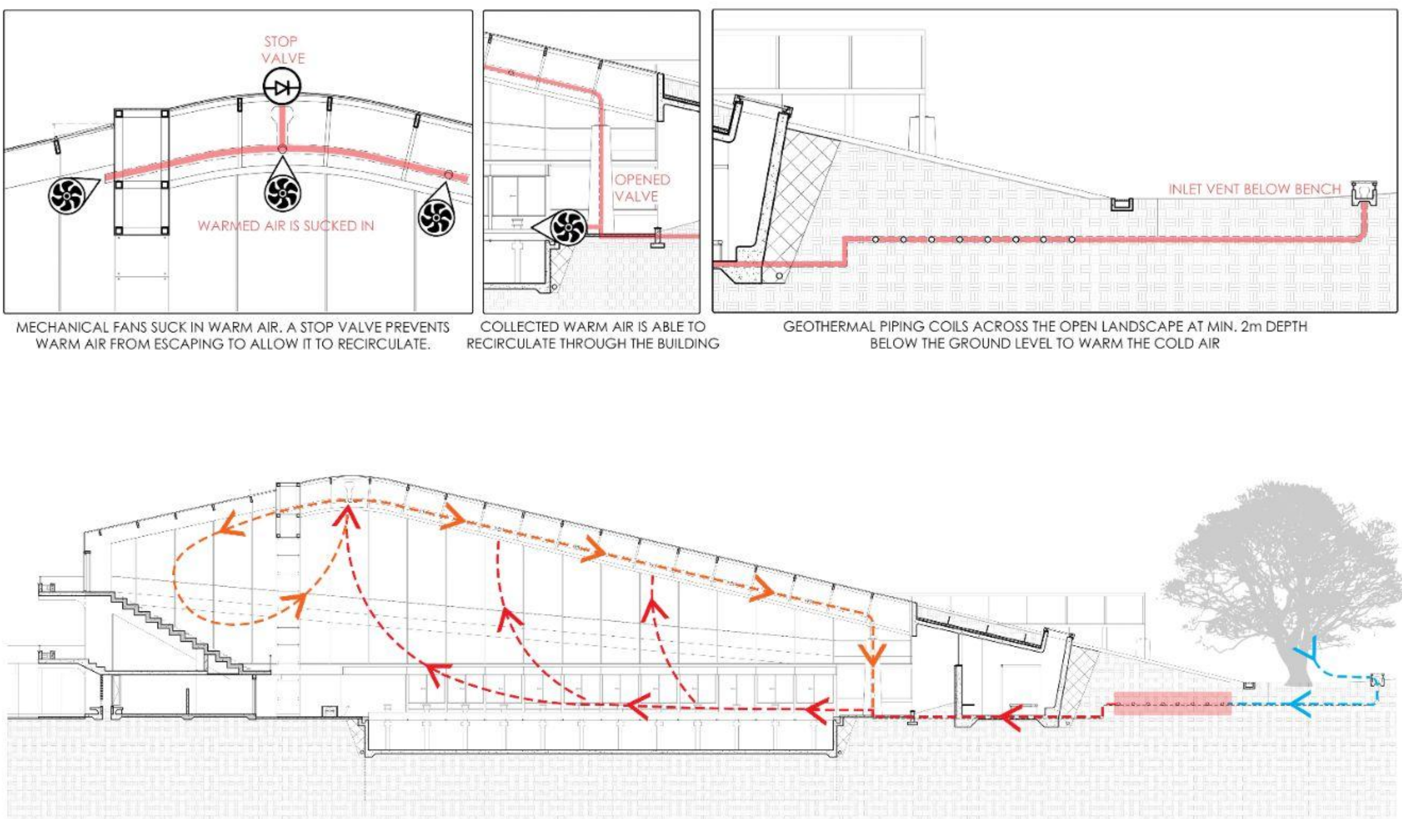
SYSTEM: GEOTHERMAL HEATING AND COOLING

SUSTAINABILITY IN SPORTS ARCHITECTURE

COOLING STRATEGY DURING THE SUMMER MONTHS:



HEATING STRATEGY DURING THE WINTER MONTHS:



NAME: RUAN RAS
STUDENT No.: 04462794

Figure 192: Geothermal heating and cooling systems (Author, 2021)

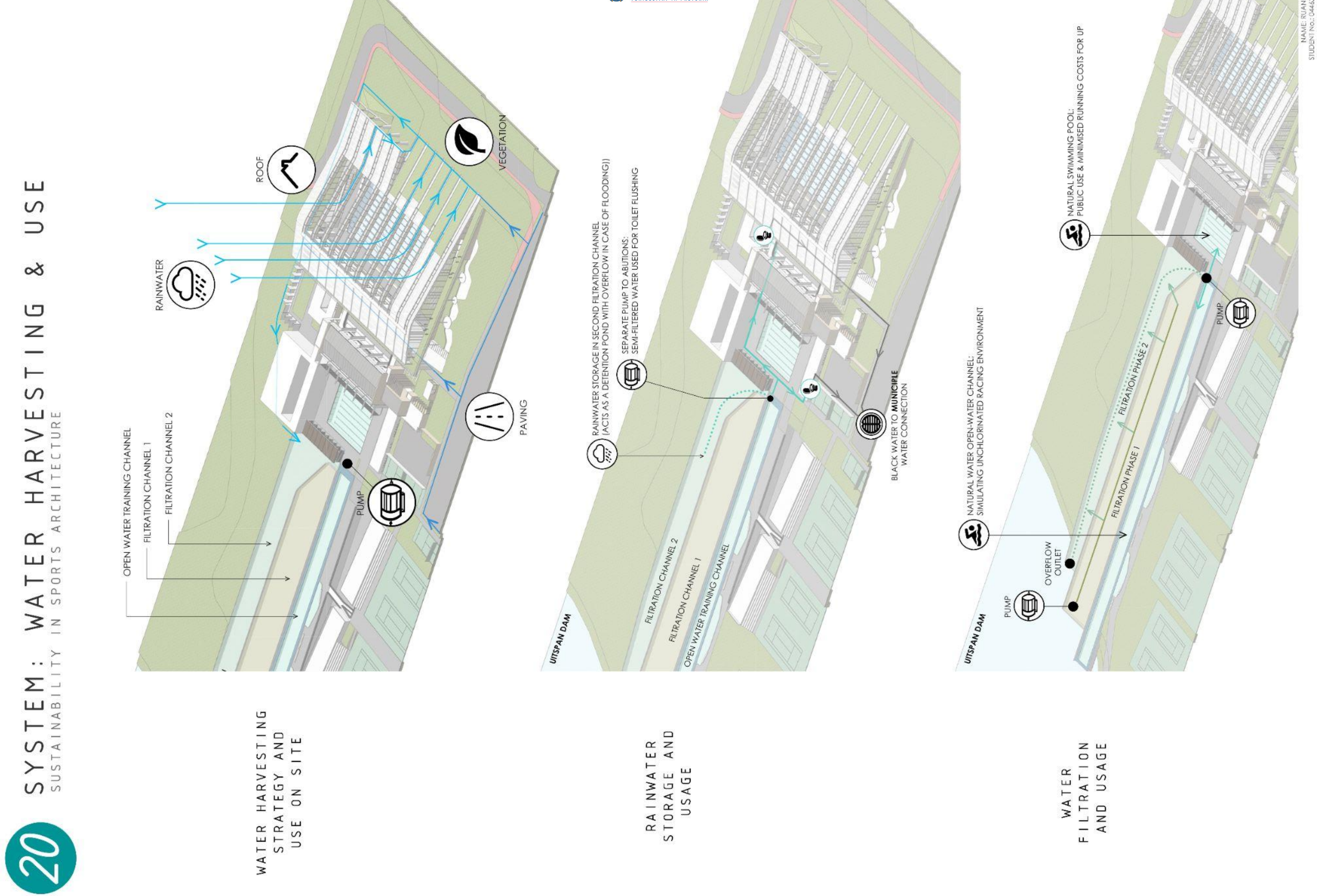


Figure 193: Water harvesting systems (Author, 2021)

CALCULATING RAINWATER YIELD

AREA CALCULATIONS

Catchment	Area, A (m²)	Runoff Coefficient,	
Lawn, sandy	3400	0.08	0.01
Roof	6100	0.9	0.30
Paving	7000	0.8	0.30
Veld Grass	0	0.3	0.00
Gravel	0	0.5	0.00
Slope lawn, 25%	1200	0.2	0.01
Cultivated vegetition	740	0.5	0.02
TOTAL	18440	3.28	0.65

RAINWATER YIELD CALCULATION

Month	Ave. rainfall, P (m)	Yield (m³) (Yield = PxAxC)
January	0.154	1843.688
February	0.075	897.9
March	0.082	981.704
April	0.051	610.572
May	0.013	155.636
June	0.007	83.804
July	0.003	35.916
August	0.006	71.832
September	0.022	263.384
October	0.071	850.012
November	0.098	1173.256
December	0.15	1795.8
ANNUAL AVE.	0.674	8763.504

TOTAL YIELD

Month	Total Yield (m³/month)
January	1843.688
February	897.9
March	981.704
April	610.572
May	155.636
June	83.804
July	35.916
August	71.832
September	263.384
October	850.012
November	1173.256
December	1795.8
ANNUAL TOTAL	8763.504

CALCULATING WATER DEMAND

IRRIGATION DEMAND

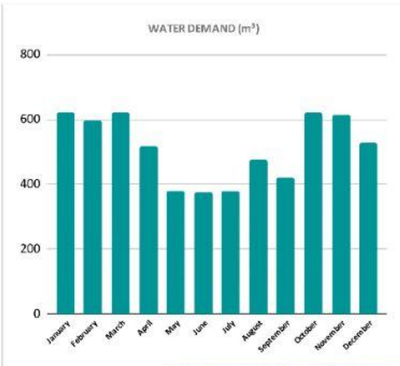
Month	Planting area (m²)	Irr. depth / week (m)	Irr. depth / month (m)	Irrigation demand (m³/month)
January	1940	0.05	0.2	388
February	1940	0.05	0.2	388
March	1940	0.05	0.2	388
April	1940	0.04	0.15	291
May	1940	0.03	0.1	194
June	1940	0.03	0.1	194
July	1940	0.03	0.1	194
August	1940	0.03	0.15	291
September	1940	0.03	0.1	194
October	1940	0.05	0.2	388
November	1940	0.05	0.2	388
December	1940	0.05	0.2	388
			ANNUAL TOTAL	3686

ALT DEMAND

Month	Entity (Persons ?)	Entity demand / day (l)	Alt demand (m³/month)
January	500	15	232.5
February	500	15	210
March	500	15	232.5
April	500	15	225
May	400	15	186
June	400	15	180
July	400	15	186
August	400	15	186
September	500	15	225
October	500	15	232.5
November	500	15	225
December	300	15	139.5
		ANNUAL TOTAL	2460

TOTAL DEMAND

Month	Total demand (m³/month)
January	620.5
February	598.0
March	620.5
April	516.0
May	380.0
June	374.0
July	380.0
August	477.0
September	419.0
October	620.5
November	613.0
December	527.5
ANNUAL TOTAL	6146.0



CALCULATING THE WATER BUDGET

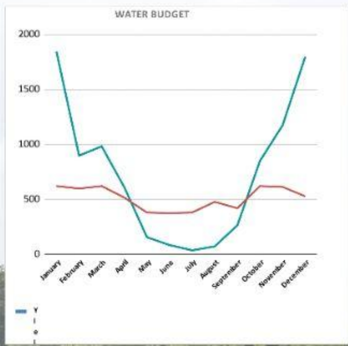
WATER BUDGET

Month	Yield (m³)	Demand (m³)	Monthly balance
January	1,843.7	620.5	1,223.2
February	897.9	598.0	299.9
March	981.7	620.5	361.2
April	610.6	516.0	94.6
May	155.6	380.0	-224.4
June	83.8	374.0	-290.2
July	35.9	380.0	-344.1
August	71.8	477.0	-405.2
September	263.4	419.0	-155.6
October	850.0	620.5	229.5
November	1,173.3	613.0	560.3
December	1,795.8	527.5	1,268.3
ANNUAL AVE.	8,763.5	6,146.0	2,617.5

WATER BUDGET (ACCUMALATIVE)

Month	Yield (m³)	Demand (m³)	Monthly balance	Vol. added water in reservoir (m³)
January	1,843.7	620.5	1,223.2	3,051.70
February	897.9	598.0	299.9	3,351.60
March	981.7	620.5	361.2	3,712.80
April	610.6	516.0	94.6	3,807.40
May	155.6	380.0	-224.4	3,583.10
June	83.8	374.0	-290.2	3,292.90
July	35.9	380.0	-344.1	2,948.80
August	71.8	477.0	-405.2	2,543.60
September	263.4	419.0	-155.6	2,388
October	850.0	620.5	229.5	2,617.50
November	1,173.3	613.0	560.3	560.3
December	1,795.8	527.5	1,268.3	1,828.60
ANNUAL AVE.	8,763.5	6,146.0	2,617.5	

	AREA (m2)	REQUIRED AREA FOR FILTRATION POND (m2)
25m SWIMMING POOL	500	1000
OPEN WATER TRAINING CHANNEL	2300	4600
	TOTAL	5600
REMAINING BALANCE OF HARVESTED RAINWATER		3800
TOTAL SURFACE AREA OF FILTRATION CHANNEL NEEDED		9400



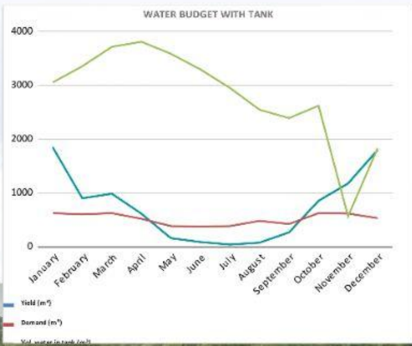


Figure 194: Water calculations (Author, 2021)

AERIAL VIEWS & 3D VISUALISATION

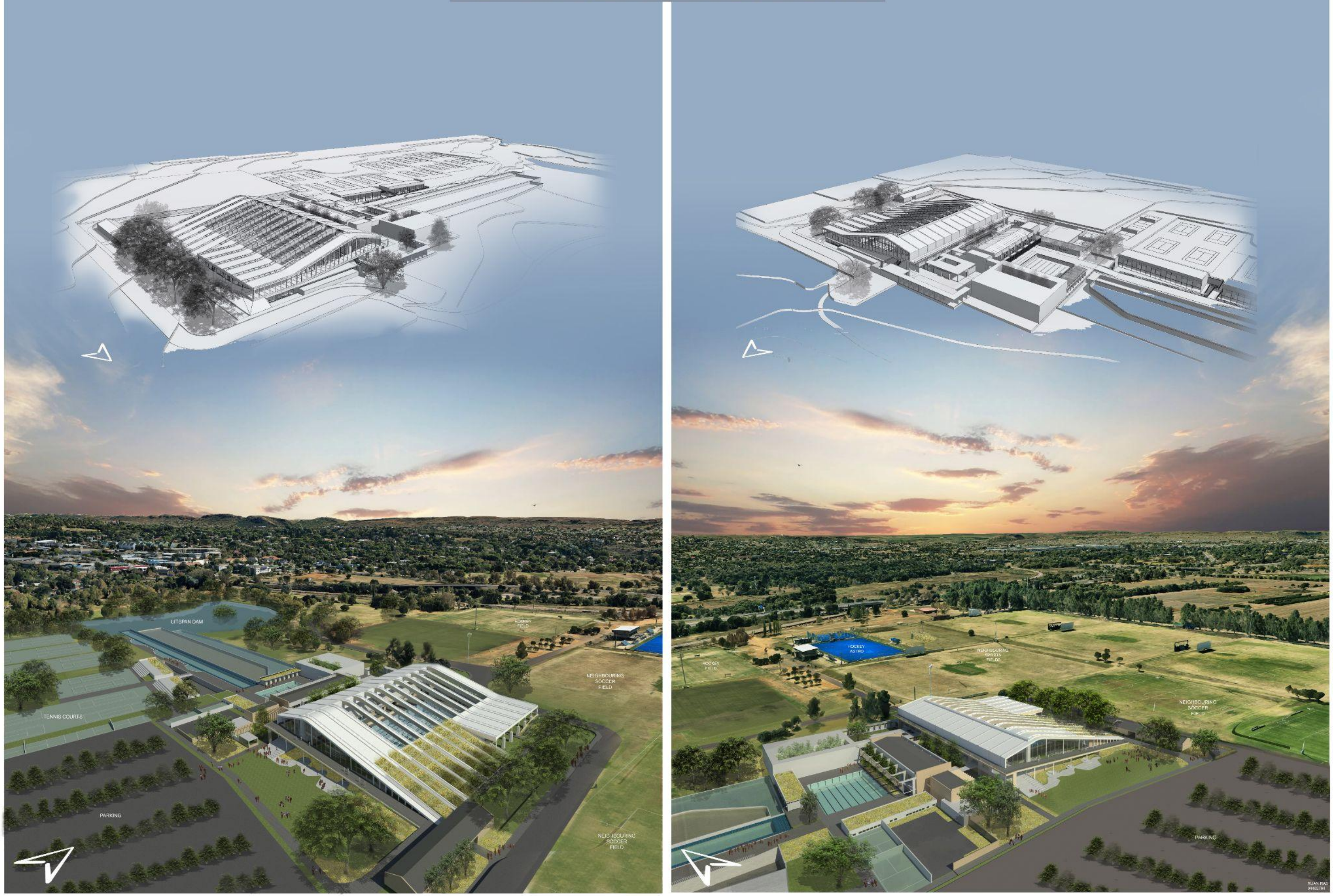


Figure 195: Aerial views and 3D visualisation (Author, 2021)

Part 4: Critical reflection

Introduction

This chapter summarises the finalised dissertation outcomes in terms of research, design and technology. I critically reflect back on the finalised design, the process that was followed and the decisions that were made. Through reflection, I am able to determine what impact this mini-dissertation has for my future career in the architectural industry.

The frame of most fields of play in sport has been clearly defined and standardised by regulatory sporting bodies. However, supporting spaces surrounding the field of play have become somewhat generic spatial solutions that are largely based on maximising a sports venue's profitability. However, with the focus on economy, attention is taken away from the athlete's needs when designing sports architecture. Little thought has been given to the athletic performance enhancing potential of architecture. On site, specifically, the UP Hillcrest Sports Campus accommodates sports venues that clearly favour *functionality* over *experience*. The architectural intention for this mini-dissertation was to retain the efficient functionality of typical local sports architecture, but to enhance this functionality through improved experiential design principles that could contribute to improved perceptions of a space, in turn, contributing to athletic performance enhancement for athletes.

Dissertation outcomes

The TuksAquatics Centre is transformed into a multi-programmatic complex of celebrated public spaces, protected private spaces and a variety of experiences that shape the intermediate spaces between those two ends of the spectrum. Operating on the campus, the vibrant, social and high-energy nature of the site has been used to enhance the functionality of the spaces by creating accessible public spaces that are correctly integrated into their surroundings. This has been achieved by linking the site to the newly proposed semi-pedestrianised Arcadia Street and the Gautrain station. This integrates athletes' support structures into the scheme and adds to the sustainability of the design by ensuring continued future use.

On site, spatial characteristics are warped and transformed as one moves through the facility, each time addressing a certain need, desire or stressor experienced by the athlete. These intentions are reinforced by the technological detailing of those spaces where design and technology are merged to create psychologically-supportive, competition-simulative and physically-beneficial environments for the athletes.

Figure 196: A swimmer in action (Serrao, 2013)

Critical reflection

In the research proposal of this mini-dissertation, it was hypothesised that an internationalised standard sports design prototype would not suffice when designing athletic performance enhancing sports architecture. Rather, a holistic approach to athlete-centred design is needed that spatially responds to the athlete's psyche, emotions and physical condition in sustainable ways to promote the further development of the sporting industry and its athletes. In line with my normative position, a contextually responsive, sustainable and user-centred design that employs both functional and experiential design principles could be a potential solution. This was proven true through research done on evidence based design.

Where research on evidence based design has been highly focussed on medical architecture, this dissertation expands its scope to other programs such as sports design (figure 178). Ultimately, evidence based design aims to remove stressors on the user. These stressors take the form of psychological stressors, for example, pre-race anxiety in athletes, as well as physical stressors, for example, poorly maintained spaces that cause hazards to an athlete's health.

A shallow understanding of evidence based design principles, however, could run the risk of re-generalising sports architecture in a merely newer format. To ensure that unique design solutions are created in response to sports architecture, specifically, and not a mere re-representation of existing design solutions borrowed from medical architecture, *sports psychology* principles are looked at to identify user-specific stressors. These athlete-specific stressors enabled me to translate the evidence based design principles into sports-focussed, athlete-relevant interventions based on athlete's psyche, competition routines, challenges and unique desires.

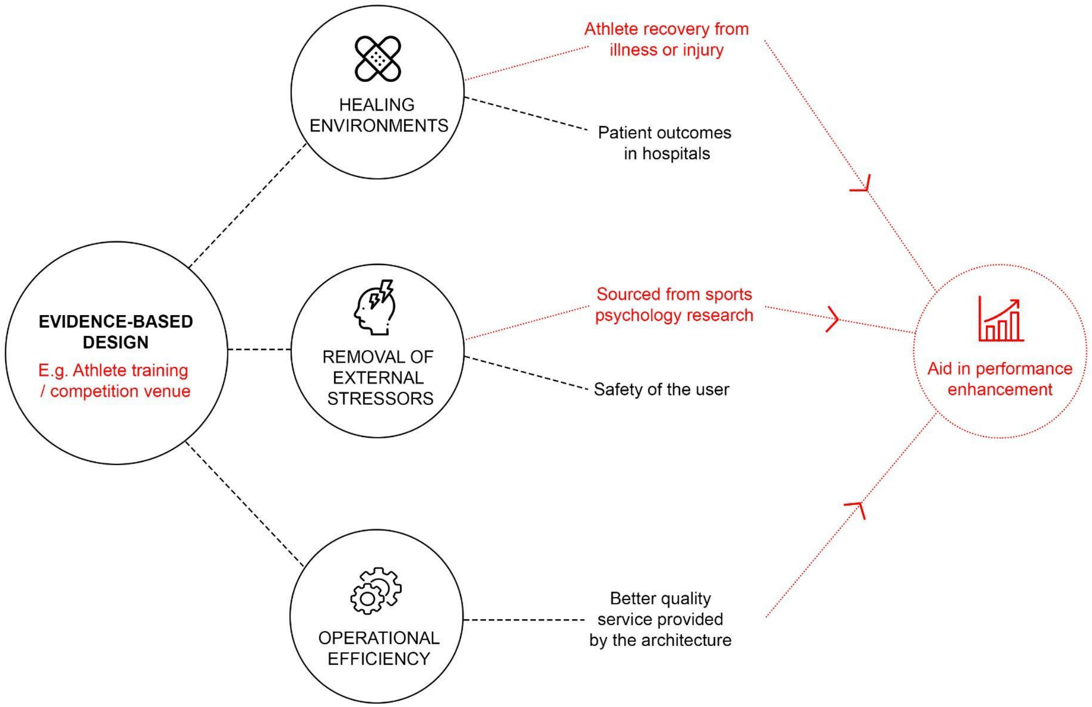


Figure 197: EBD and athletic performance enhancement (Author, 2021)

This all has to be designed in sustainable ways to align with the standards of international sporting bodies, as well as to solve the local crisis of non-functioning sporting venues. Research into sustainable design has proved contextually-relevant design to be a vital factor for a building's long-term success. The design and technological solutions for this mini-dissertation became very site-specific. This reiterated the hypothesised solution that a standardised prototype could not be followed; instead, that the site would dictate which spatial solutions of sport-specific evidence based design could be employed, based on the assets available on site. For example, geothermal strategies that are based on the large amount of open space surrounding a site, or the prioritisation of nature as an element for psychologically supportive environments based on its existing wide availability on the campus.

Moving beyond the limitations of a mini-dissertation, the extent to which evidenced based design can be applied can be explored even further. In more advanced research studies, physical testing on athletes physiological conditions in standardized versus those in psychologically supportive spaces can be done. In addition data of athletes' performances over various competition seasons can be analysed to determine where and why athletes performed better in some venues compared to others. Additional research in this regard could pave the way for even more sport-specific evidence based design solutions. This merely emphasises the performance enhancing potential that architecture has - my mini-dissertation forming a good foundation for future study.

Meaning for future career in architecture

Through the research done on evidence based design and in the attempt made to create a prototype that proved much more individualised than standardised, it becomes clear that the research does not have to be merely limited to sports architecture.

Findings can be used beyond the field of sports architecture and in a variety of spatial designs from designing comfortable large public spaces to creating intimate and supportive private environments. This knowledge that has been gained in my master's year, sets a solid foundation for understanding the large scope of impact of architecture from the functional to the experiential, all at a variety of scales of interventions.

In terms of my design process, I have learnt to advance beyond typically functionality-driven design decisions towards a deeper understanding of the experiential qualities of space. Through my involvement in sport, I was able to use personal experiences in the spaces under investigation to gain a better understanding of theoretical design informants, further helping me to confirm the impact that these design drivers can have on a user.

Overall, the design strategies that were explored in this mini-dissertation can be used in a variety of disciplines in architecture to create *frames* where the built environment, people and place merge into one collective, supportive whole (Sfinteş, 2012). Each scenario may differ slightly based on each scheme's unique contextual response, however, the core driver of the architecture remains the same.

Conclusion

The outcomes of this mini-dissertation could help to further drive architects' progression away from globalised, single solution architecture and could help to reverse the deprioritization of experience in design. Sport architecture has evolved and is constantly improving from a mono-functional, economy driven structure, to a multifunctional, flexible urban asset. This dissertation, however, has taken the impact of sports architecture beyond the multifunctional typology and has further injected *user-experience* as a means to benefit, uplift, protect and celebrate the athlete. A complex, context-specific and user-centred intervention becomes the mould for future sports architecture.

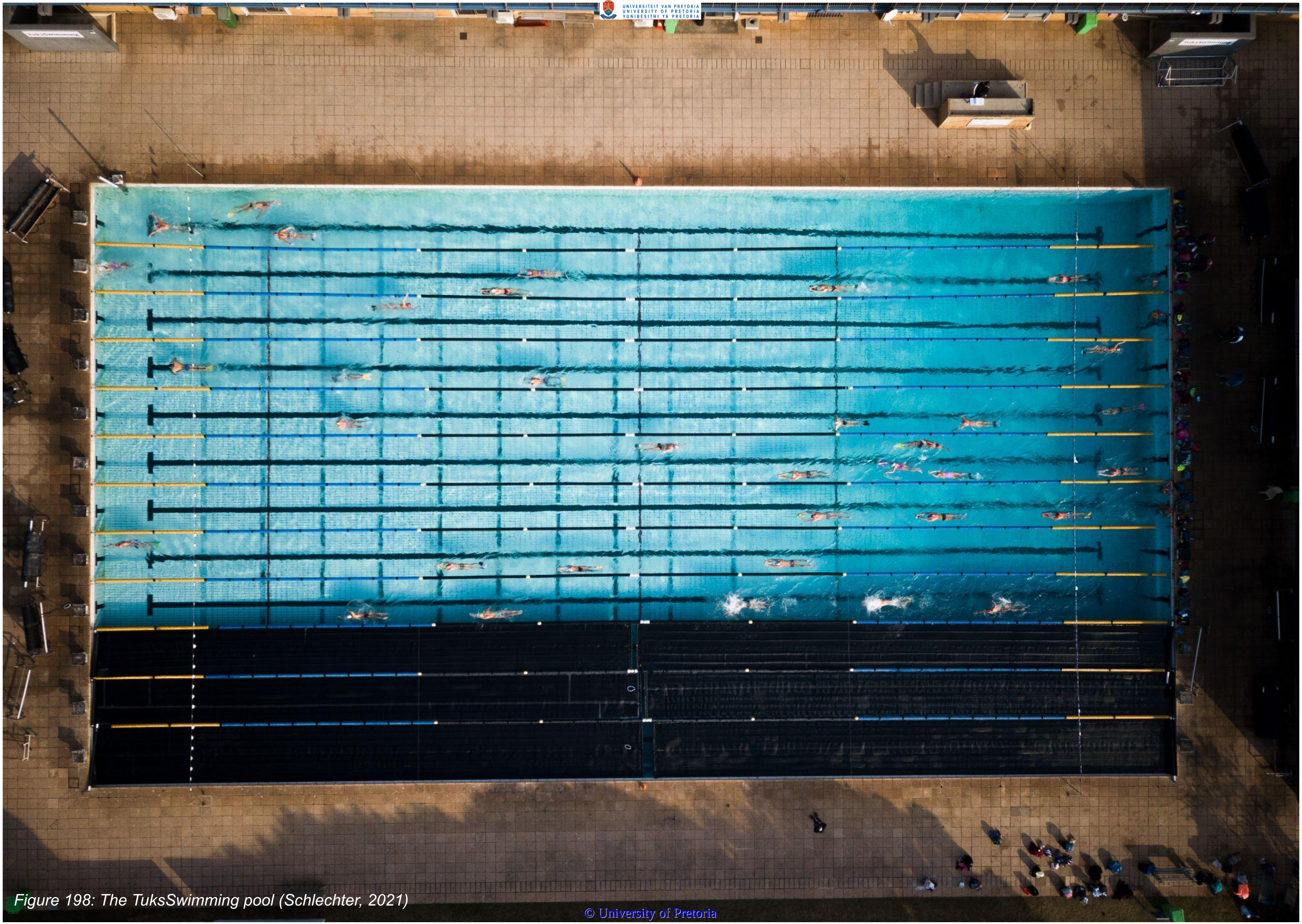


Figure 198: The TuksSwimming pool (Schlechter, 2021)

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APPENDIX A: *Ethics Approval*

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

9 June 2021

Reference number: EBIT/86/2021

Mr R Ras
Department: Architecture
University of Pretoria
Pretoria
0083

Dear Mr R Ras

FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Approval is granted for the application with reference number that appears above.

1. This means that the research project entitled "Architecture as a driver for the athletic performance enhancement of professional athletes" has been approved as submitted. It is important to note what approval implies. This is expanded on in the points that follow.
2. This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Research Ethics Committee.
3. If action is taken beyond the approved application, approval is withdrawn automatically.
4. According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.
5. The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Prof K.-Y. Chan
Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

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