08

CHAPTER EIGHT

TECHNICAL DEVELOPMENT

Introduction: Technical and Structural Intentions
Material Palette and Application
Sculpting the Landscape through the Constructed Water Channel
The Structural and Service Spine
The Internal and External Edge Conditions
Water as Service and Environmental System

8.1

Introduction: Technical and Structural Intentions

The technical development becomes an extension of the design process discussed in Chapter 8: Design Development, and aims to technically illustrate and synthesise the refinement process and most significant technical requirements towards a final resolution of the main conceptual intentions.

The technical development discussion is structured as an elaboration on the various components of the primary intentions toward a technological resolution of materials and methods as concluded in the final design diagrams. The chapter concludes with an investigation of the conceptual intentions through the environmental systems and services (see material palette and descriptions of material choices).

Sculpting the landscape through the constructed water channel:

The continuous sculpted landscape, water channel and boundary wall are constructed as a continuous stereotomic concrete platform, creating a continuous translation between the ground and lower boundary wall condition.

The Service and structural core:

The extended structural and service spine as filtration device , supporting the continuous lightweight roof structure, mediates between the stereotomic concrete landscape and the extended steel structure, and is expressed through the change in material application method and resolution of connections. The infrastructural nature and structural integrity of the continuous service spine is expressed though the robust nature and bracing of the structural components.

The internal and external edge conditions as serviced by the structural and service core:

The circulation and public street activities skin / façade is constructed as a tectonic steel frame to express the permeability and rigid organisation of the structure, responding to the public contextual and functional informants.

The internal activities are supported by circular steel members to express the lightness, transparency and permeability of the structure and translate its relationship to the constructed natural landscape through structures and spaces that are adaptable, organic and less restricted by contextual and functional conditions.

Water as Service and Environmental System:

The concept of water as providing opportunities for activities and spatial and structural arrangements is continued through an expression of water as service and environmental system.

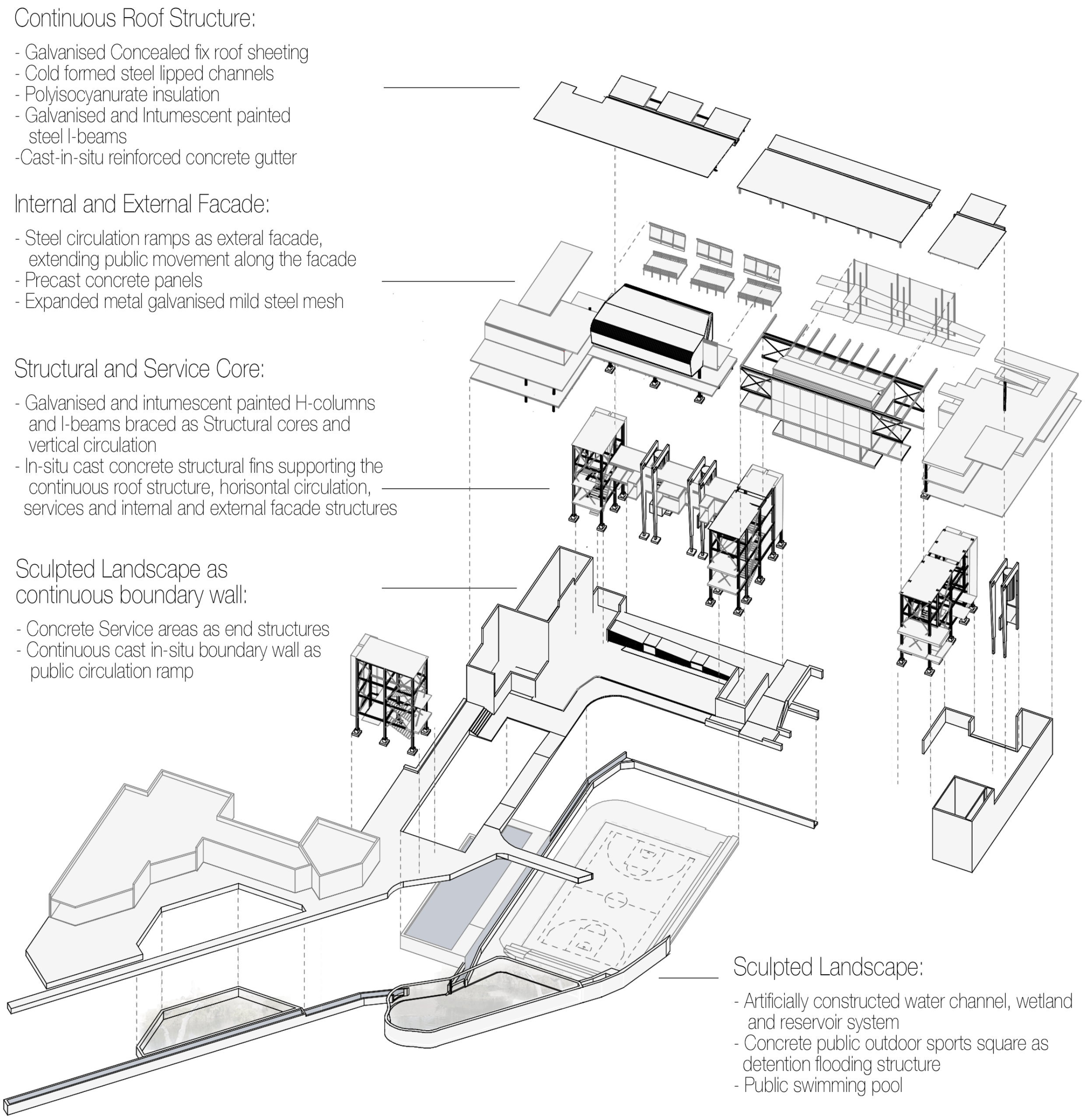


Figure 8.1: Exploded axonometric of the main components of the structure and site (Author 2015)

8.2

Material Palette and Application

Sculpted Landscape

Pervious (No fines) Concrete

Due to the extent of the reconstruction of the landscape as well as the significance of harvesting stormwater run-off on site, the existing asphalt parking terrain is replaces with concrete predominantly as conceptual and aesthetic continuous sculpted material that becomes the base platform to the steel structures. (The existing asphlt to be used for filling and excess to be recycled.)

Pervious concrete are selectively used to increase the sustainability of the site through alowing stormwater to replenish the groundwater table. Pervious concrete to be created with narow graded coarse aggregate, mixed with cement paste or mortar. Fines as used in conventional conrete to be eliminated.

Steel trowelledfinish to cast-insitu reinforced concrete slabs

The internal concrete floor areas are constructed of a cast in-situ reinforced concrete floor slabs with a monolithic topping. The topping to be mechanically floated and trowelled, using the delayed trowelling method to obtain a hard, smooth finish.

Permissible deviation to be Class 2: 10mm from datum level. Concrete to have a characteristic 28-day compressive strength of Class AR2. The coarse aggregate to be used for monolithic toppings should be of 6,7mm nominal size. The expansion joints as well as joints around the columns to correspond with th structural grid and be at maximum 3000mm x 4000mm spacing.

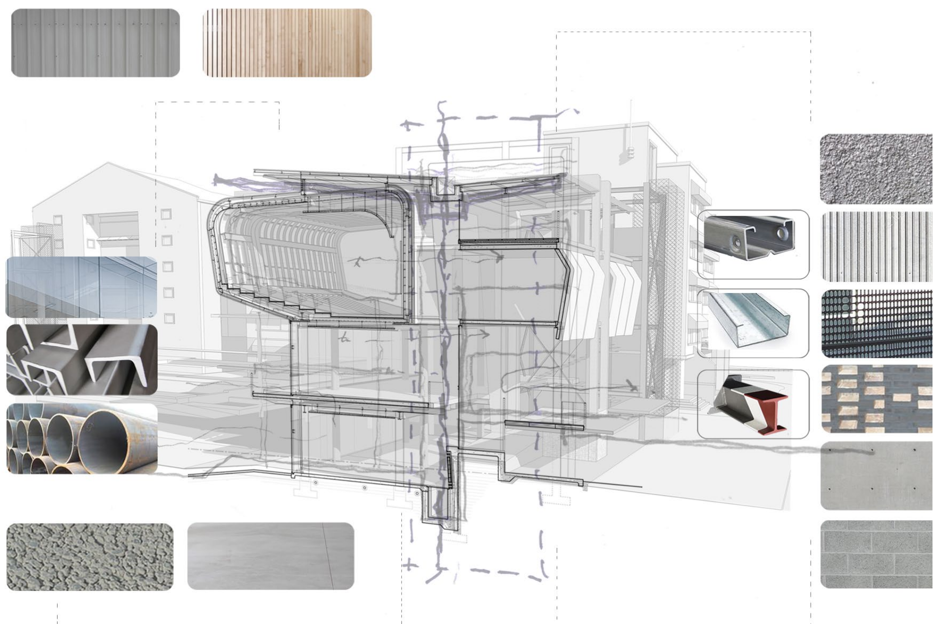
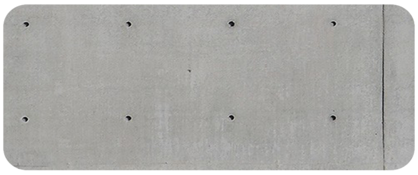


Figure 8.2: Conceptual illustration of materials used and construction methods as elaborated in the material palette (Author 2015)

Boundary wall and Structural fins

Precast Concrete bricks

Off-shutter in-situ concrete walls and precast panels



The boundary retaining wall acts as vetilating structure to the interior space and water channel and its internal skin is constructed of 140mm x 90mm precast concrete bricks, with the lowest two coarses laid on edge to provide an aesthetic edge to the wall as well as vetilation openings. The use of precast bricks alows for an ease of constructing the internal skin after the curing of the concrete sculpted floor,channel and ramp.

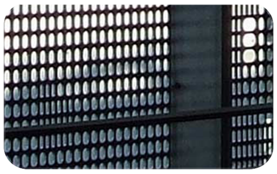
The structural fins that are expressed on facade as the structural and service core, containing environmental systems as well as providing the central structural support, becomes important elements to express its truest form of material finish without treatment or cladding. A smooth off-shutter concrete finish is specified and achieved through the use of steel formwork with a phenolic film on the surface. For areas with compaction difficulty due to restricted space, self-compacting concrete (SCC) should be considered.

Internal and External thresholds

Structural glazing

Precast concrete brick skin as

Galvanised mild steel expanded mesh screen



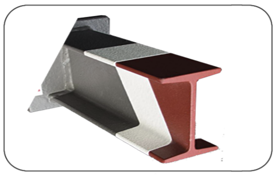
Structural glazing is used as internal and selectively external threshold, creating a transparent transition between internal and external evironments throughout the building as well as allowing significant sightlines around the sight to remain exposed.
A monolithic, anti-reflective, thermally tempered safety glass is to be used in a double glazed system that allows for the seamless aesthetic of silicone butt joint connections without frames as well as enhanced thermal resistance and a 2hour fire protection rating. Glass thickness availability up to 12mm and to be specified according to the structural requirements of the thresholds.

A precast concrete brick skin, with selected bricks laid on edge, is used as threshold to internal service space window openings to allow for the filtraton of natural light as well as ventilation by still maintaining the privacy of the internal activities.

The external circulation and structural towers as well as the screen enclosing the circulation ramps across the Apies River channel are cladded with a galvanised mild steel expanded mesh, fixed to a secondary supporting steel structure. The use of expanded mesh allows for a continuous surface throughout, without joints, interweaving or welds and has a high

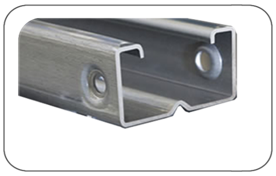
Primary and Secondary supporting structure

Hot-rolled galvanised steel sections



Cold-formed galvanised steel sections

Galvanised light-gauge steel frame sections



The primary steel components of the structural core are conceptually and aesthetically expressed through the use of exposed hot-rolled Galvanised and Intumescent painted H-columns and I-beams. The main infrastructural towers (columns) as external spaces, supporting the extent of the spanning structure expresses this structural integrity throught the exposure of its primary members and its galvanised steel angle bracing components that allow the towers to act as a collective column structure.. The exposure of the bolted connections between the steel members conributes to the infrastructural aesthetic of the structural core.

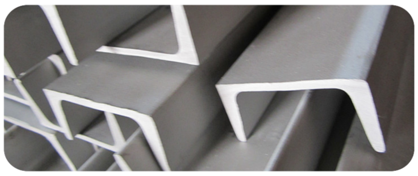
The secondary structural components supporting the continuous roof structure as well as the exterior and interior finishes are constructed of cold-formed galvanised steel sections as lightweight supporting structure, spaced according to the requirements of the finish specification. All steel connections to be bolted as opposed to welding to allow for the disassembly and reuse of components.

The secondary supporting structure of the auditorium space is constructed of galvanised light-gauge steel framing to support the internal and external cladding spacing requirements.

Auditorium Primary Structure

Seamlessly joined, galvanised and intumescent painted circular steel columns

Continuous, custom profile galvanised and intumescent painted steel channels



The auditorium space as placed within the landscape, seperated from the structural core is vertically supported by six 406mm Ø x 8mm seamlessly joined, galvanised and intumescent painted circular steel columns.

The extent of the floor and roof structures adjacent to the structural core is supported by smaller 300mm Ø x 6mm eamlessly joined, galvanised and intumescent painted circular steel columns. The use of circular creates a clear aesthetic and structural distinction between the primary infrastructural core and the extended adjacent floor spaces as wel as allows for an elegant, transparent reading of the sructure due the rounded edges softening and reducing the visibility of the profile size.

The primary auditorium structure consits of three continuous, custom galvanised steel channels, welded from mild steel plate. The central continuous circular beam is constructed from two channels placed back to back to allow for a central structural member, the acoustic separation of the structure as well as internal support to the secondary structure. The secondary structure to be bolted to the primary channels and all steel sections to be intumescent painted.

Internal and External cladding of the Auditorium Space

Saligna wall planks and acoustic ceiling panels

Saligna wall planks and suspended acoustic ceiling panels are used throughout the building in selected spaces according to absorption and refraction acoustic requirements as well as the spatial and aesthetic contribution of the organic characteristic contrasting and softening the robust and sterile characteristic contributed by the steel and concrete finishes. This aesthetic contrast expresses the integration of a "natural" aesthetic within the building and artificially constructed landscape. The wall planks are fixed to a light-gauge steel framework with acoustic seperatng spacers and underlay membrane.

Concealed fix galvanised metal roof sheeting

The external cladding of the auditorium structure consists of a continuous concealed fix metal roof sheet, cranced and bullnose according to the structural and spatial reuirements of the auditorium. The external cladding is supported by the light-gauge steel framework as secondary structure. Adaptabilty is made possible through the ability to dismantle and re-use the sheets as there are no fixing holes created i the construction process.

Continuous Roof Structure

Concealed fix galvanised metal roof sheeting

The conceptual intention of the continuous roof structure as an elegant, lightweight slender profile is aesthetically expressed as floating entity elevated above the rest of the structure, is achieved through the use of 0.58mm galvanised concealed fix metal roof sheeting. Apart from the aesthetic considerations, the concealed fixing method offers various pragmatic advantages over the S-Rib or IBR profile sheeting, such as longer spans between purlins due to the structural integrity of the profile as well as the prevention of water penetration though seamless connections.

Cast in-situ off shutter conrete

The extension of the structural and service core at roof level is expressed through the central cast in-situ concrete gutter collecting and conveying rainwater along the roof level to storage areas. The use of concrete as structural beam allows for the reduction in depth of the steel roof's supporting beams' profiles. The internal surface area of the gutter to be lined with a waterproofing membrane and all connections between the sheet metal and concrete to have sheet metal flashings and counterflashings.

8.3
Sculpting the Landscape through the Constructed Water Channel

The constructed water channel, as discussed in Chapter 8: Design Development, is constructed as a primary unifying concrete component of the design, embedded in the artificial landscape. The water channel facilitates a process of harvesting stormwater runoff and treated greywater from service areas into a linear system for treatment and reuse in various activities of the site. The processes and components of the ground-floor water system are discussed under the environmental system and services section of the technical development chapter. The activities around the site, activated or influenced by the continuous water channel, are discussed in their respective parts below. (See Figure 8.3)

8.3.1
Horticulture workshop and greenhouses

The horticulture workshop and greenhouse structure become the furthest activation point of the channel that extends through the greenhouse structures as edge to the main circulation route through the site, leading to the central constructed wetland area. The edges of the exposed channel between the greenhouse structures are raised as a boundary wall to the constructed wetland areas, and vegetated as bioswales for the untreated stormwater runoff as well as an aesthetic edge to the circulation route. (See Figure 8.3)

8.3.2
Public swimming pool and outdoor sports court

The circulation route continuing between the outdoor sports court and the public swimming pool is created by the continuation of the water channel from the building to the central constructed wetland (See Figure 8.3) The edges of the water channel are extended to become a supporting boundary structure between the seating area of the outdoor court and the raised swimming pool seating platform, and are partially exposed through the platform as points of reference on the circulation route, with exposure to the water processes of the site (See Figure 8.3).

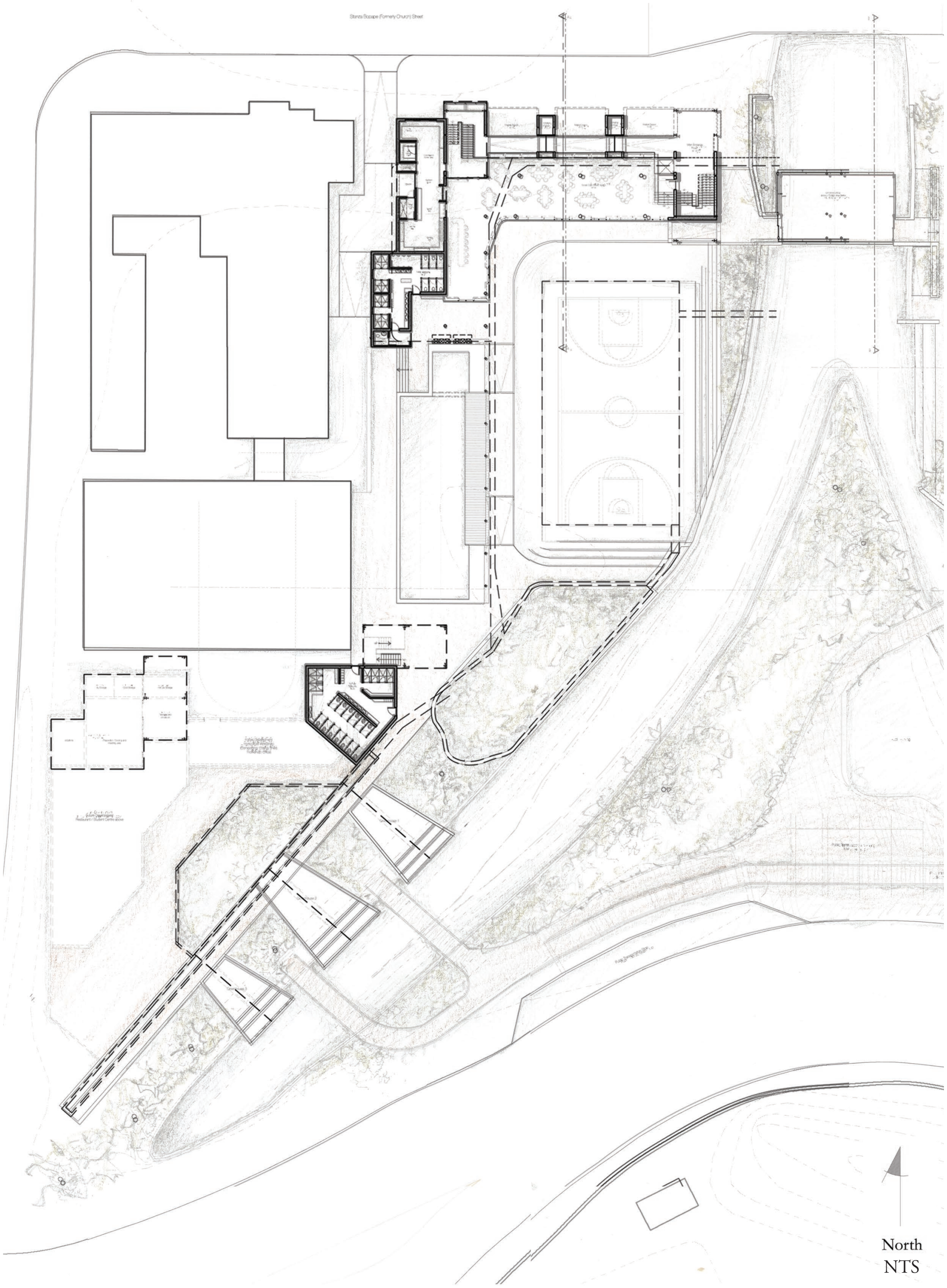


Figure 8.3: The circulation route and activities around the site, activated or influenced by the continuous water channel (Author 2015)

9.3.3

Water channel as structural and service spine to building

The water channel extends from the sculpted landscape and circulation route into the recreational social club and event space, becoming the structural and service spine at ground floor level that continues through the building with an overflow into the Apies River at the entrance lobby suspended above the Apies River channel (See Figure 8.1).

The concrete surface bed of the recreational social club is continuously moulded from the external landscape into the internal edge of the concrete channel, extending into the channel and external boundary edge to the recessed internal ground-floor space. The external edge of the channel as boundary wall becomes the concrete circulation ramp at street level, supporting the extended concrete structural fins that contain all environmental systems and services. The sculpted ground is finally extended into a continuation of the external raised surface bed to the market spaces at street level (See Figure 8.4 and Figure 8.5).

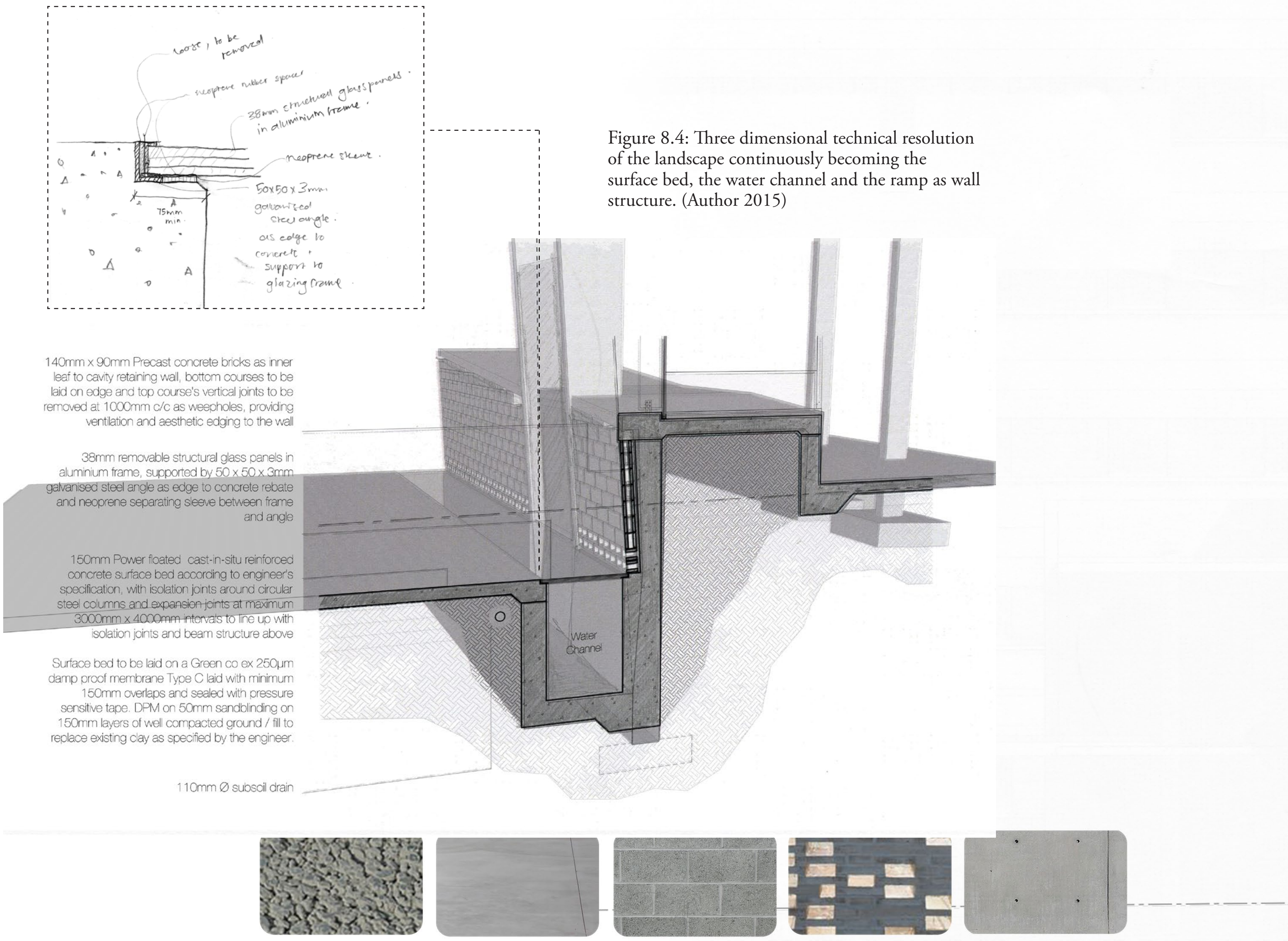


Figure 8.4: Three dimensional technical resolution of the landscape continuously becoming the surface bed, the water channel and the ramp as wall structure. (Author 2015)

Figure 8.4 [Section A-A (1)] andFigure 8.5 [Section A-A (2)] illustrates an iterative development of the ground floor condition and technical resoulution, through the continuous landscape from the internal public square to the external street activities, becoming the boundary structure to the site and support the the structural and service core.

The construction of the water channel and boundary retaining wall is approached as a ventilating structure, as opposed to a tanked construction, allowing water to drain through the wall cavity into the continuous channel that obviates the necessity for a sump.

In the case of extreme flooding occurring at the confluence of the Apies River and Walker Spruit, the channel would act as additional drainage outlet to the internal ground-floor spaces, and this fact has an influence on the finishing of the surface bed.

Figure 8.6 illustrates a three-dimensional technical resolution of the constructed water channel within the ground floor space. The boundary, ventilating cavity wall consist of an external continuous concrete structure with an internal skin constructed from 140mm x 90mm precast concrete bricks with the bottom two courses laid on edge and the top vertical joints as weepholes at every 1000mm c/c, to provide ventilation openings as well as an aesthetic texture surface to the boundary ramp.

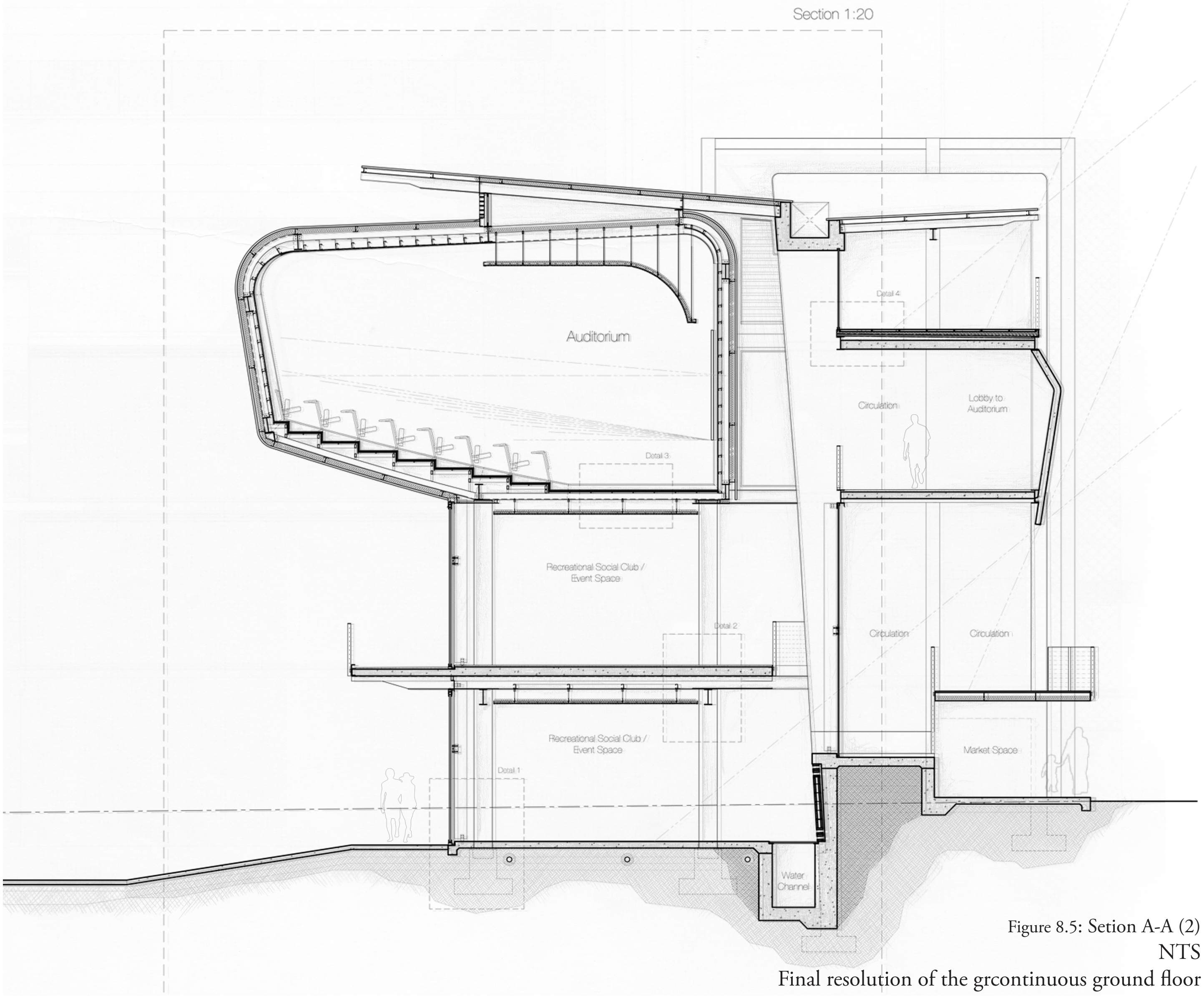


Figure 8.5: Setion A-A (2)
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Final resolution of the grcontinuous ground floor
(Author 2015)

8.4

The Structural and Service Spine

The service and structural core as an extension of the sculpted landscape consists of:

1. The boundary wall structure
2. The three primary structural cores
3. Environmental systems and services contained within the spine
4. The continuous roof structure

and is discussed according to its various components as illustrated in the conceptual diagrams (See Figure 8.7, Figure 8.8 and Figure 8.9).

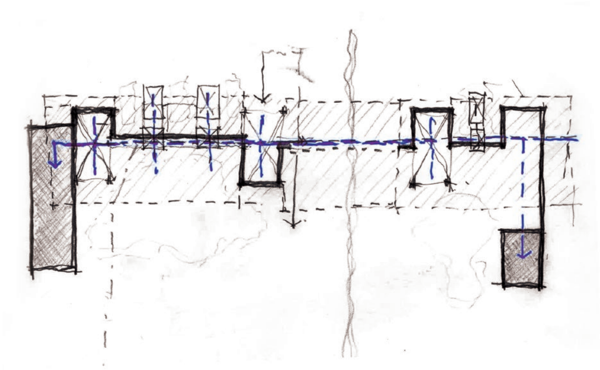


Figure 8.6: Plan diagramme illustrating the conceptual intentions of the structural and service core. (Author 2015)

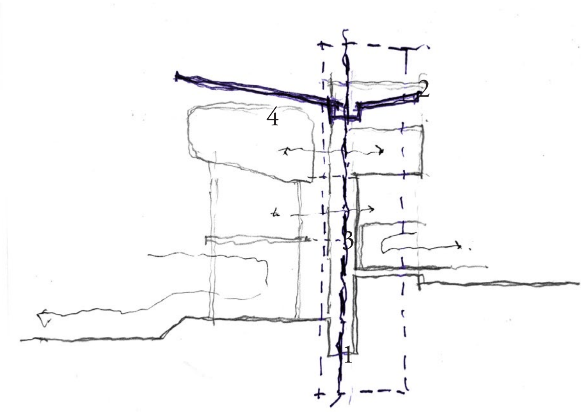


Figure 8.7: Section diagramme illustrating the conceptual intentions of the structural and service core. (Author 2015)

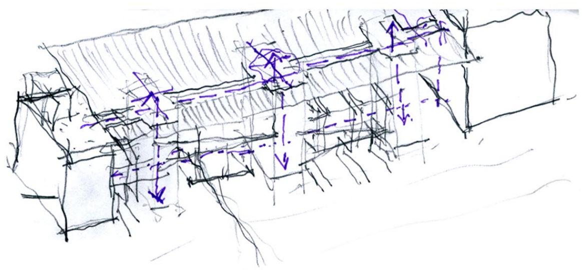


Figure 8.8: Perspective diagramme illustrating the conceptual intentions of the structural and service core. (Author 2015)

8.4.1
The boundary wall structure

The boundary wall structure adapts and transforms to facilitate the various functional conditions throughout the building, but reads as a unifying entity of the structural core on ground level through its continuity and materiality. The depth of the central section of the boundary wall containing the market spaces creates the circulation ramp into the first-floor spaces, and the extent of the wall terminates in the eastern and western full-height service structures as stereotomic edges to the building (SeeFigure 8.11).

The western and eastern service end structures contain the public ablution and kitchen facilities on all floor levels as decentralised service cores to the site. The structure of the service areas consists of 280 mm thick, 250Mpa cast in-situ off-shutter concrete walls with plywood shuttering to create a smooth external finish. Joints are to be lined up with the top edges of window openings on each floor.

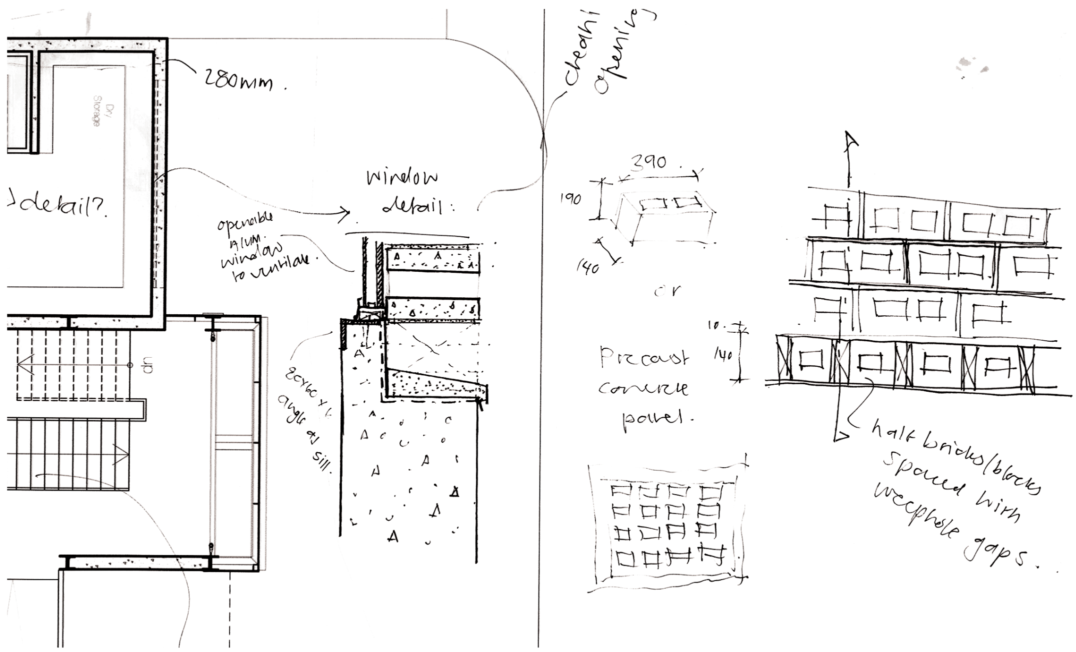
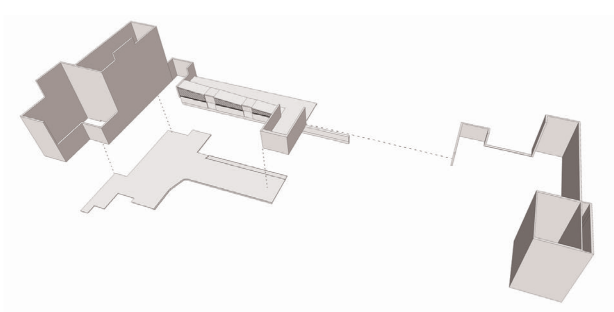


Figure 8.9: Detail development of the window details (Author 2015)



In these service areas, the window openings with their bottom sills at a height of 1500 mm are constructed with an external concrete brick on edge skin within the concrete walls, with sliding glass panels behind, providing filtered light without reducing the privacy of these areas on the street façade (See Figure 8.10).

Figure 8.10: Axonometric of the continuous concrete boundary wall and service structures . (Author 2015)

8.4.2

The three primary structural towers as infrastructural cores

The three primary structural cores facilitate an aesthetic and structural mediation between the stereotomic substructure and the ground floor condition, and extend from the concrete boundary wall as tectonic steel-framed structures. The collective structure of the cores consists of 305 mm x 305 mm x 97 mm hot-rolled, galvanised steel H-columns and 254 mm x 146 mm x 31 mm hot rolled, galvanised steel I-beams, and are braced at the indicated edges with compression rods, (See Figure 8.12 – development of the towers), to provide lateral support and ensure the structure acts as a single column.

The concrete wall sections as well as the floor landings between the columns supplement the lateral bracing of the collective columns. The structural integrity and infrastructural nature of these towers as core supporting entities are expressed through their materiality contrasting with the lightweight extended structures adjacent to the towers as well as the exposure of its structural components and connections.

The bracing of the columns as collective structural entity, specifically the two structures adjacent to the Apies River channel, supports the 29 m span of the exhibition spaces suspended across the channel. The second-floor wall structures are braced as lightweight structural beams, supporting the suspended first-floor and ground-floor platforms. Figure 8.12 , Figure 9.16, Figure 8.16, Figure 8.17 and Figure 8.18 illustrate the technical development of the spanning structure to express the conceptual intentions of lightness and materiality, and its relationship to the historic Lion Bridge.

Beyond a structural purpose, the towers provide central vertical circulation and fire-escape cores along the building, and contain additional tanks for storage of harvested rainwater as well as water pumped from the reservoirs to supply water closets in the adjacent service areas.

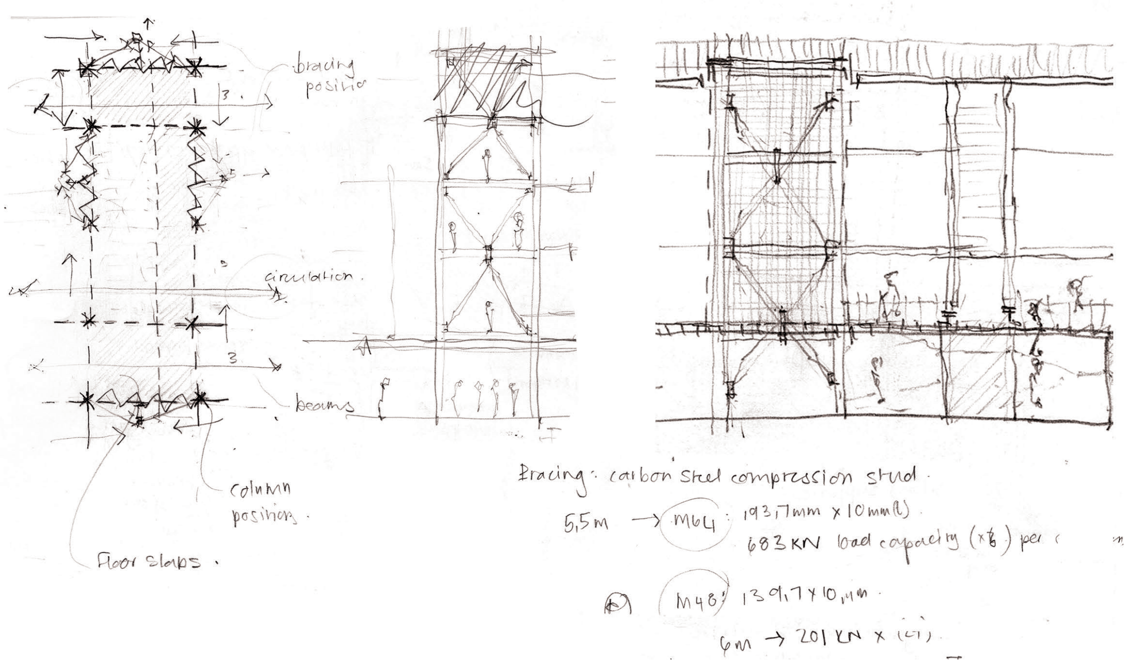


Figure 8.11: Development and perspective illustration of the structural towers and bracing connections as well as development of the spanning structure across the Apies River channel. (Author 2015)

8.4.3

Environmental systems and services contained within the structural core

The structural concrete fins are built of 280 mm thick, 250Mpa cast in situ off-shutter concrete with plywood shuttering to create a smooth external finish. They support the first-floor lightweight steel circulation area, the second-floor waiting area floor and roof structure, and the northern glazed and precast concrete panel façade that spans between the steel towers and concrete fins.

Storage tanks for rainwater harvested from the continuous roof are supported between the exterior sections of the concrete fins to supply the indirect evaporative cooling towers contained within the interior sections of the concrete fins. The system, structure, finishes and technical requirements of the cooling towers are discussed in the environmental systems and services section of this chapter.

Alternating between the enclosed indirect evaporative cooling towers, the concrete fins frame continuous vertical ventilation spaces throughout the section of the building, and have ventilation openings at the top.

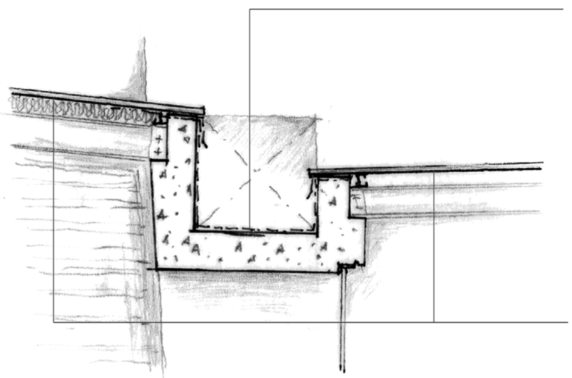
8.4.4

The continuous roof structure

The continuous roof structure becomes the unifying element of the structural and service spine. Supported between the structural core towers and concrete fins, the continuous roof structure consists of 0.58 mm thick galvanised roof sheets, fixed to 100 mm x 50 mm x 2.5 mm galvanised cold-formed steel-lipped channels at a maximum spacing of 1500mm c/c by means of a concealed fastening bracket, directly over 100 mm thick polyisocyanurate insulation installed between purlins according to supplier specifications. A 254 mm x 146 mm x 31 mm galvanised steel I-beam, painted with intumescent paint, and at a maximum spacing of 4000mm c/c according to the structural grid, supports the roof structure and is fixed to the concrete gutter as structural beam.

The roof section extending across the spanning exhibition structure is changed from a concrete gutter beam to a concealed lightweight steel gutter, as informed by the structural and aesthetic requirements of the exhibition spaces. Its internal form and surface is influenced by southern daylight considerations.

Figure 8.14 and Figure 8.19 illustrates of the roof structure in consideration of the significant influential factors identified as water harvesting, protection of solar angles, and internal spatial and service area implications. The aesthetic lightness and slender profiles of the roof's supporting structure is achieved through the utilisation of the continuous gutter as supporting concrete beam



850mm x 400mm x 300mm deep cast-in-situ reinforced concrete gutter to engineer's specification, with a water-proofing lining and roof flashing and counter flashing at edges, suspended between concrete structural fins.

0.58mm thick Galvanised Concealed fix roof sheet profile, to be fixed to 100mm x 50mm x 2.5mm Galvanised cold formed steel lipped channels at maximum 1500mm c/c spacing by means of a concealed fastening bracket, directly over 100mm thick Poly-isocyanurate insulation installed between purlins according to supplier specifications.

Brackets shall be manufactured from Galvanised steel and shall be fixed to steel purlins with one 25-50 mm long full thread self–drilling screw

Figure 8.12:Detail of the concrete gutter and roof sheeting connections. (Author 2015)

8.5

The Internal and External Edge Conditions

8.5.1

External activities as facade

The external spatial conditions and threshold to the public street activities are contextually informed, and the assembly of its structure aims to express that significance. Rigidly organised and contained by the components of the structural and service spine, the external façade activities create an aesthetic rhythm across the façade of the building.

The western edge of the site is activated on ground-floor level by the adaptable market spaces that are enclosed at ceiling level by the lightweight steel ramp leading to the first-floor spaces (See Figure 8.14).

The second-floor façade is enclosed by precast concrete panels with recessed, vertical, fixed glazed openings between the panels, allowing northern light to penetrate the internal spaces without permitting direct solar gain.

The external skin of the exhibition spaces spanning across the channel becomes a continuance of the circulation ramps that animate the façade. Figure 8.15 to Figure 8.18 illustrates the structural intention to create a transparent spanning structure at ground level through the recessed suspension of the ground-floor platform as well as the perforated stainless-steel screen diffusing the first- and second-floor circulation activities while simultaneously facilitating a filtered northern daylight condition in the exhibition spaces.

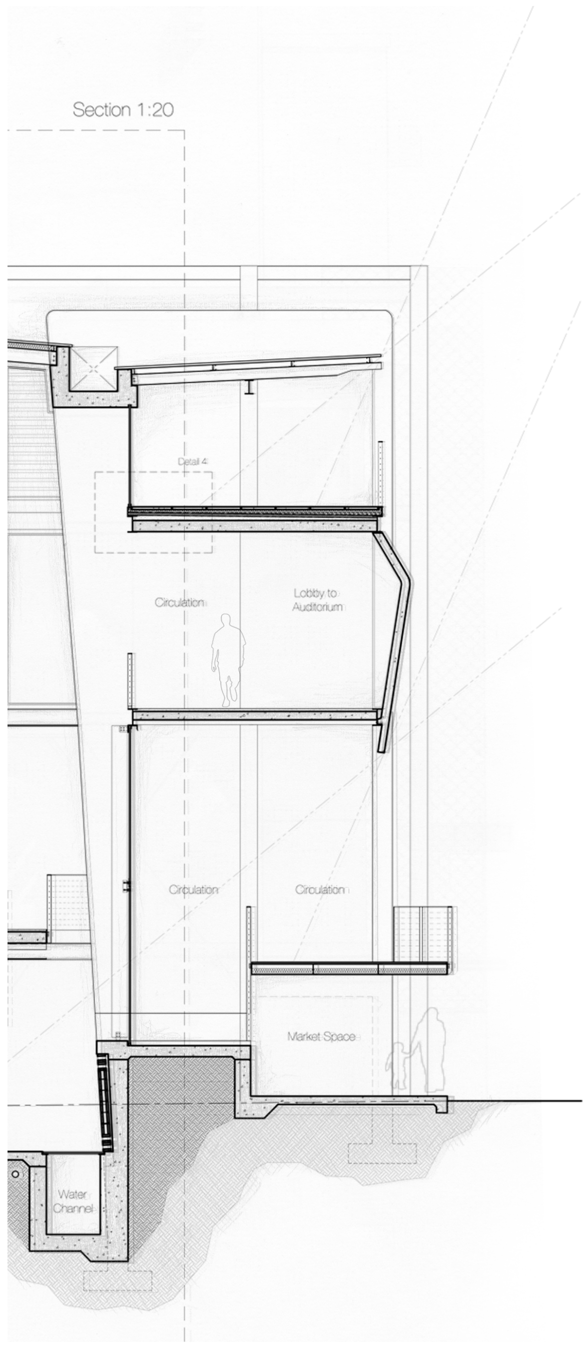


Figure 8.13: Section of the external facade on Stanza Bopape Street illustrating the circulation as facade activity from ground floor extending throughout the building (Author 2015)

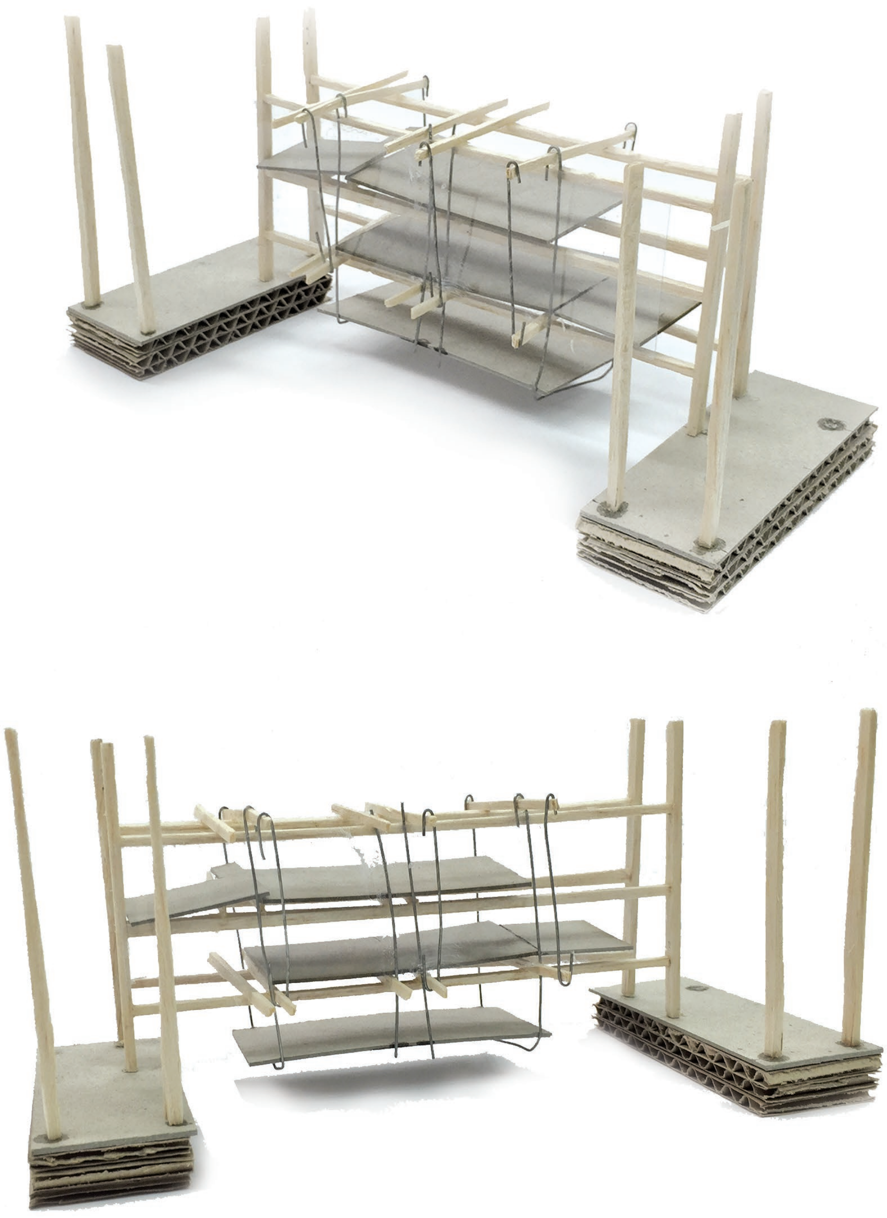


Figure 8.14: Photographs of the structural development of the exhibition structure spanning the Apies River channel through model exploration. ((Author 2015)

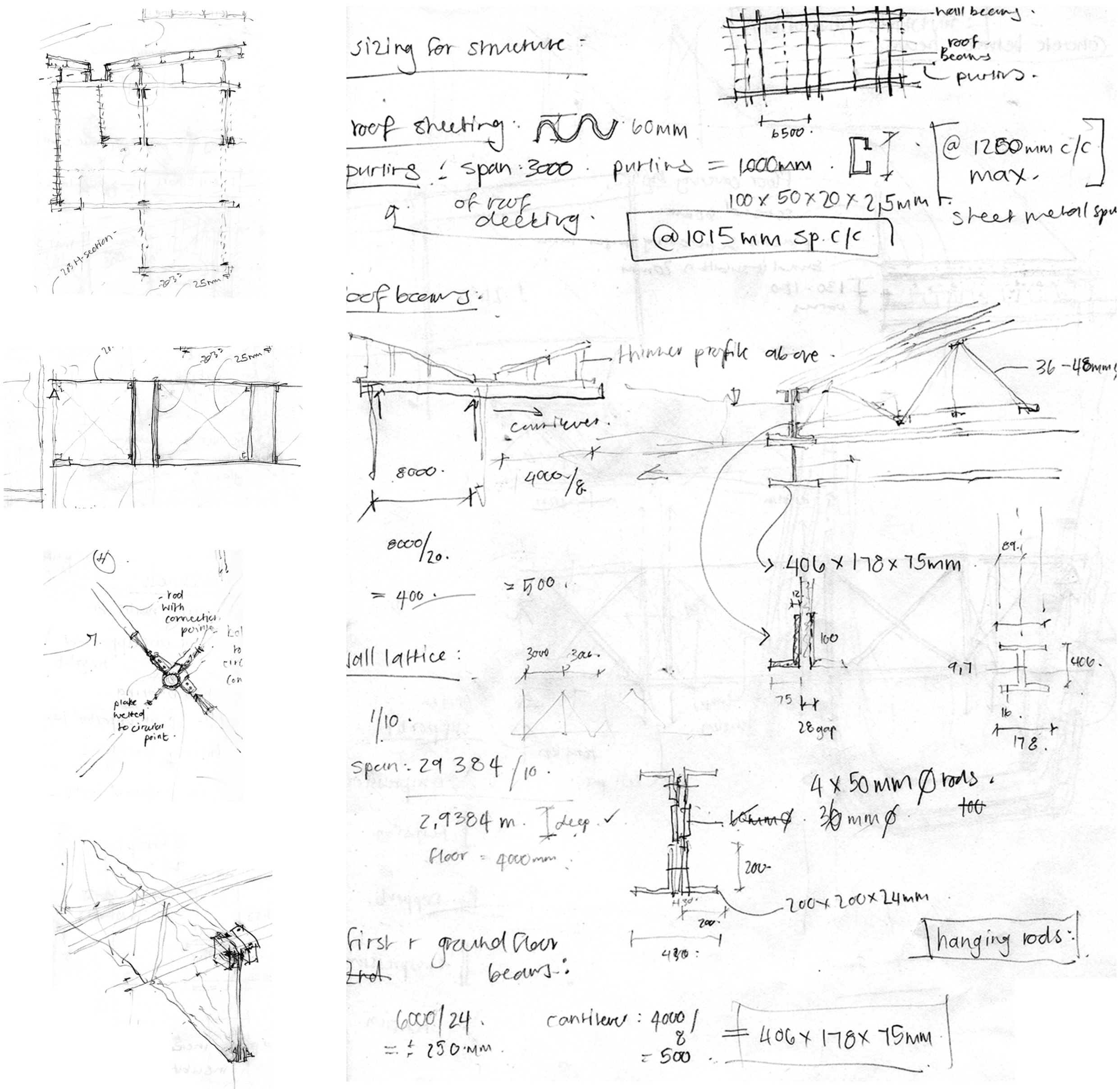


Figure 8.15: Structural investigation towards developing an appropriate resolution for the conceptual, aesthetic, functional and spatial requirements. (Author 2015)

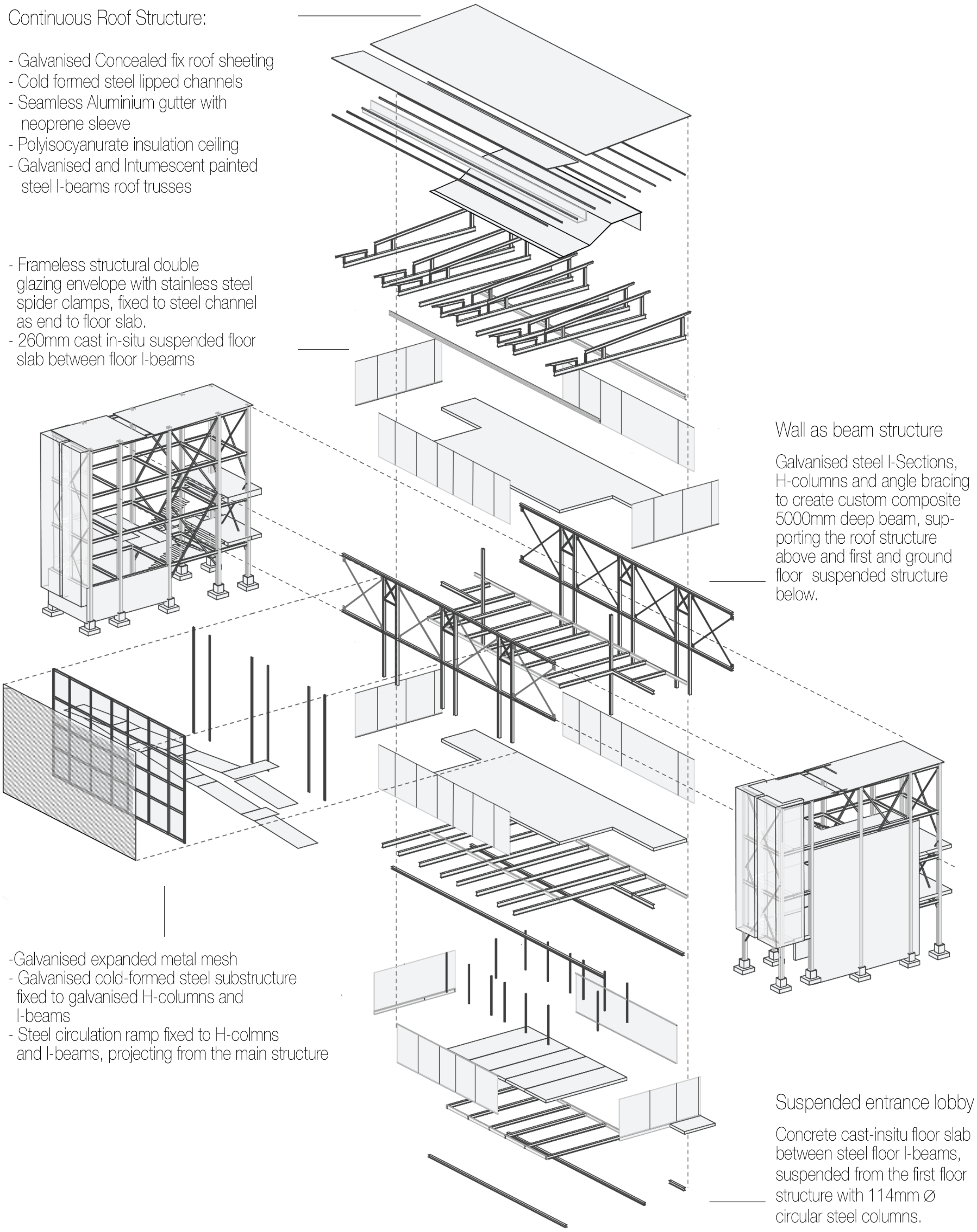


Figure 8.16: Exploded axonometric of the exhibition structure spanning the Apies River channel. (Author 2015)

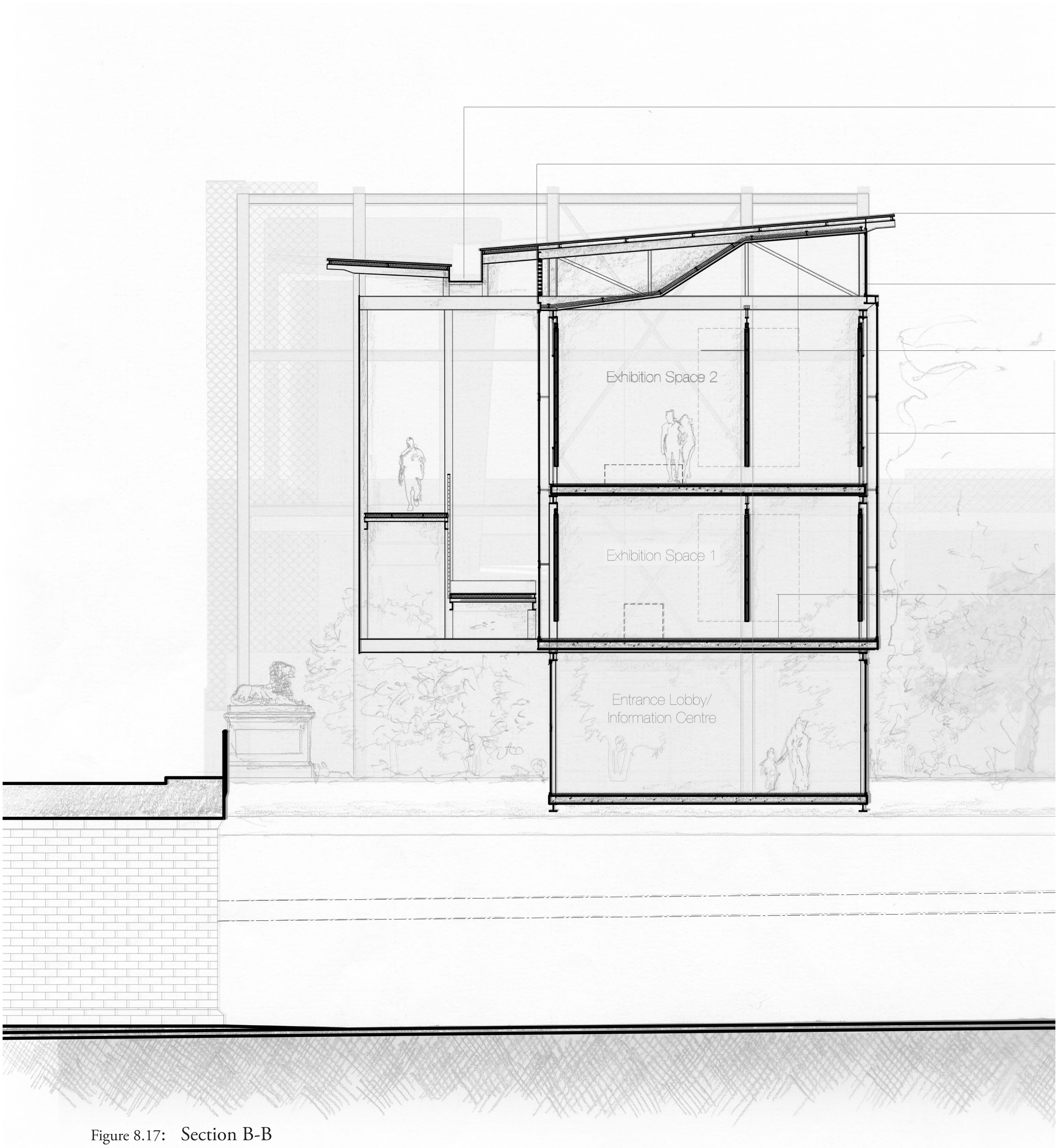


Figure 8.17: Section B-B
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(Author 2015)


850mm x 400mm Purpose made seamless aluminium box gutter, supported by gutter brackets fixed to the galvanised steel trusses with a neoprene separating sleeve. Gutter and roof sheeting to be flashed and cunter flashed
Fixed aluminium louvre
0.58mm thick Galvanised concealed fix roof sheet profile, to be fixed to 100mm x 50mm x 2.5mm galvanised cold formed steel lipped channels at maximum 1500mm c/c spacing on a reflective foil insulation layer
Openable Glass louvre with aluminium frame, fixed to steel trusses with neoprene sleeve
White painted gypsum ceiling board fixed to 100mm x 50mm x 2.5mm galvanised cold formed steel lipped channels, bolted between IPE 100 galvanised hot rolled steel I-sections bolted between the steel roof trusses
4000mm Composite beam structure consisting of 305mm x 102mm x 25 galvanised and intumescent painted H-sections as horisontal beams and vertical columns. 25mm Ø Compression rods to be used as diagonal bracing between frame. The horisontal structural members to be bolted to the end towers by means of a suspended bracket to allow for minimal movement across the extent of the span. The collective structural integrity of the beam supports the suspended first and ground floor structures
30mm power trowelled monolithic concrete topping on a 200mm reinforced cast-in-situ reinforced concrete slab to engineer's specification, supported between 356mm x 171mm x 45 galvanised and intumescent painted steel I-beams

8.5.2
Internal activities placed within the landscape

The internal activities placed within the landscape are explored through an iteration of refining the conceptual intentions through the development of the structure. At first-floor level, the reinforced, cast in situ floor slab is supported on galvanised and intumescent steel I-beams steel I-beams painted with Intumescent paint that translate the structural grid of the external façade into the internal freestanding circular columns

The threshold to the landscape consists of a frameless double-glazed façade with structural supporting fins corresponding with the structural grid.

The development of the auditorium structure was significantly influenced by both the conceptual intentions and specific acoustic requirements. The primary structure consists of three continuous circular steel channels, manufactured from hot-formed galvanised steel plates welded to the required form and depth, and supported by the six circular steel columns. The secondary structure, a light gauge steel framework, supports the internal and external envelope of the auditorium structure. It consists of an exterior galvanised roof with concealed fixings with saligna interior cladding to acoustic requirements.

The use of channels instead of I-beams allows the central continuous beams to be separated by neoprene components for acoustic considerations. See Figure 8.21for a detailed section through the steel channels. The sound lobby links, connecting the circulation within the structural and service core as well as waiting spaces to the auditorium entrance is constructed of soundproof and fire resistant glazing and emphasises the loose placement of the auditorium structure as well as the vertical spatial relationship throughout the core through its complete transparent appearance.

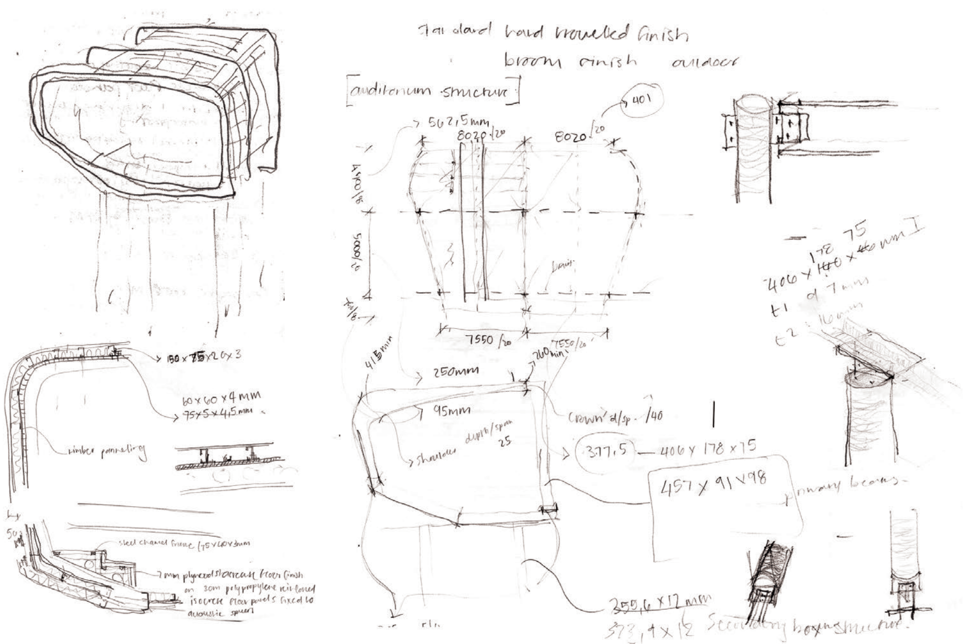
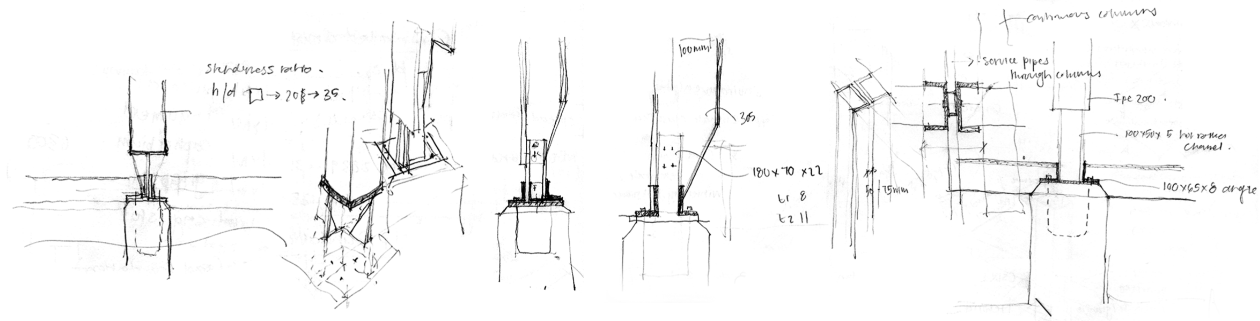
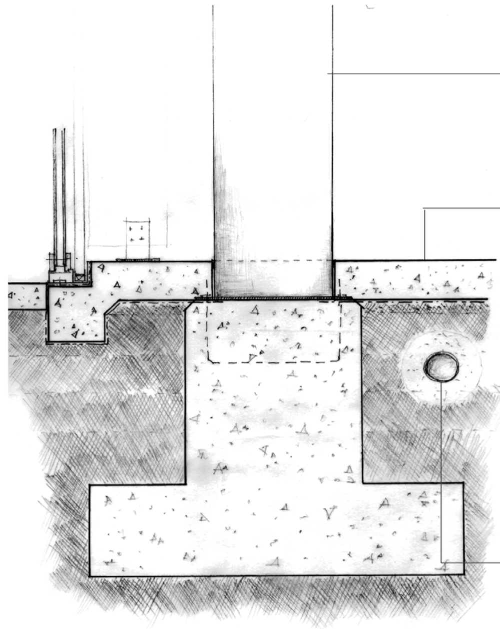


Figure 8.18: Development of the auditorium structure (Author 2015)





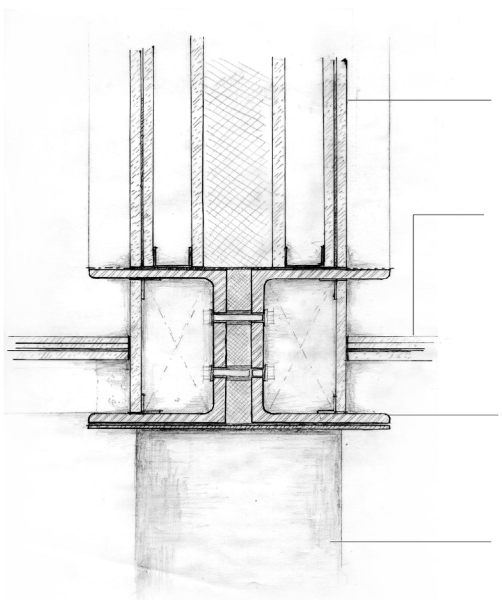
406mm x 8mm Galvanised and intumescent painted circular steel columns at 5000mm x 8000mm c/c spacing, welded to a 6mm base plate, bolted to the concrete footing with a hot-rolled steel U-bolt

150mm Power floated cast-in-situ reinforced concrete surface bed according to engineer's specification, with silicone sealed v-joint as isolation joints around circular steel columns and expansion joints at maximum 3000mm x 4000mm intervals to line up with isolation joints and beam structure above

Surface bed to be laid on a Green co ex 250µm damp proof membrane Type C laid with minimum 150mm overlaps and sealed with pressure sensitive tape. DPM on 50mm sandblinding on 150mm layers of well compacted ground / fill to replace existing clay as specified by the engineer.

110mm Ø subsoil drain

Figure 8.19: Deatil of the concrete footing, surface bed and circular steel column connection
(Author 2015)



100mm x 22mm Saligna wall planks, fixed to a 9mm Magnesium Oxide board with rubber acoustic separating layer, bolted to 78mm x 50mm galvanised cold formed channel framework as wall studs, with an internal fibre cement board for added fire resistance, with a 150mm thick Polyisocyanurate insulation

21mm Sealed plywood floor on a 9mm Magnesium Oxide board on a rubber acoustic separating layer, on a 21mm plywood, separated from the galvanised cold formed light steel floor structure with 25mm x 25mm timber acoustic spacers on a rubber sleeve

Continuous custom Galvanised steel channel as primary structure,between 356mm and 750mm deep, with 300mm flanges, at 8000mm c/c spacing maximum, bolted to the base plate with a neoprene separating sleeve for acoustic purposes

Steel channels to be bolted back to back with a neoprene gasket and 50mm thick Polyisocyanurate insulation for acoustic purposes

406mm x 8mm Galvanised and intumescent painted circular steel columns at 5000mm x 8000mm c/c spacing

Figure 8.20Detail cross section through the auditorium central steel channels
(Author 2015)

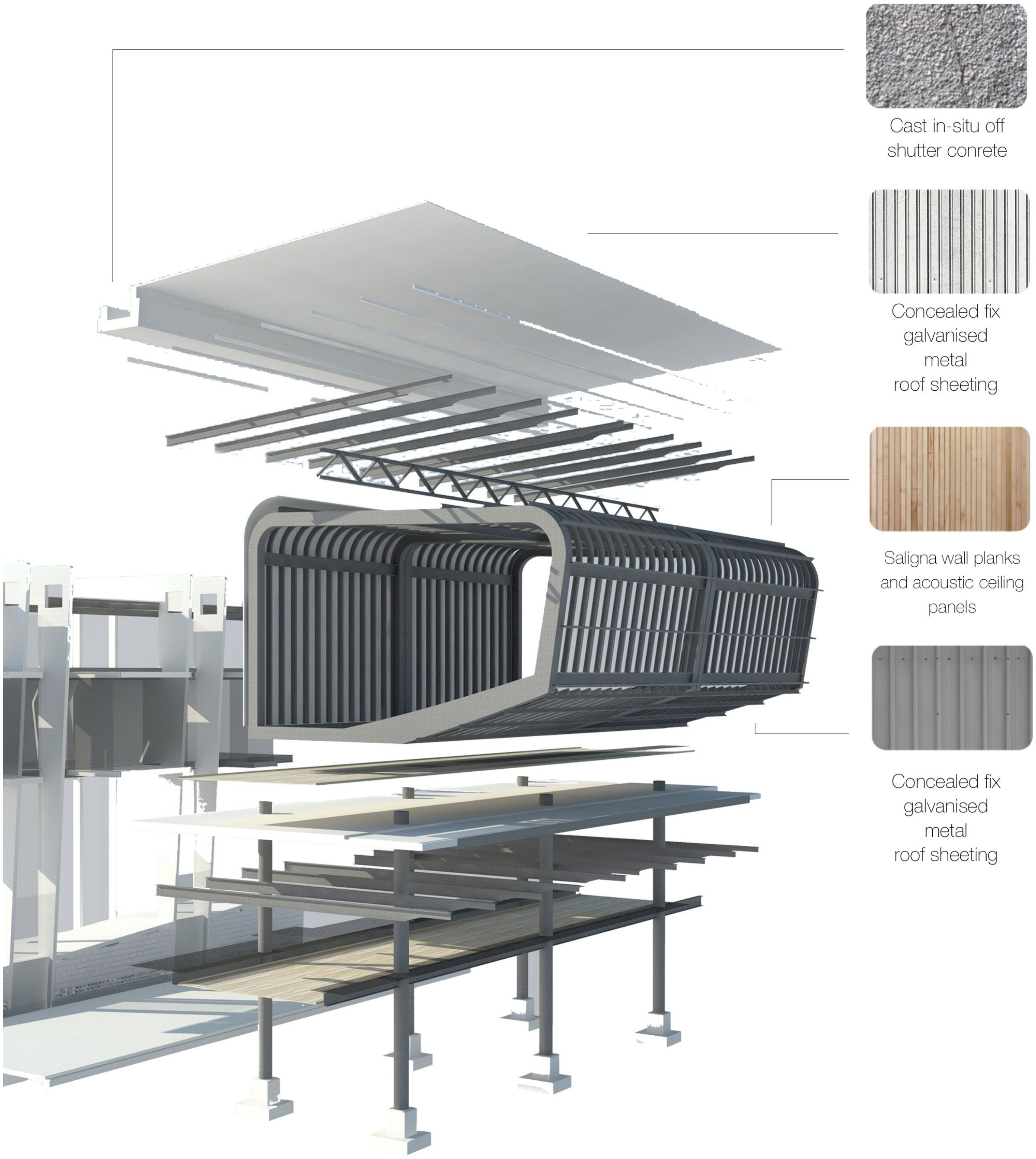


Figure 8.21: Detailed section of the auditorium structure (Author 2015)

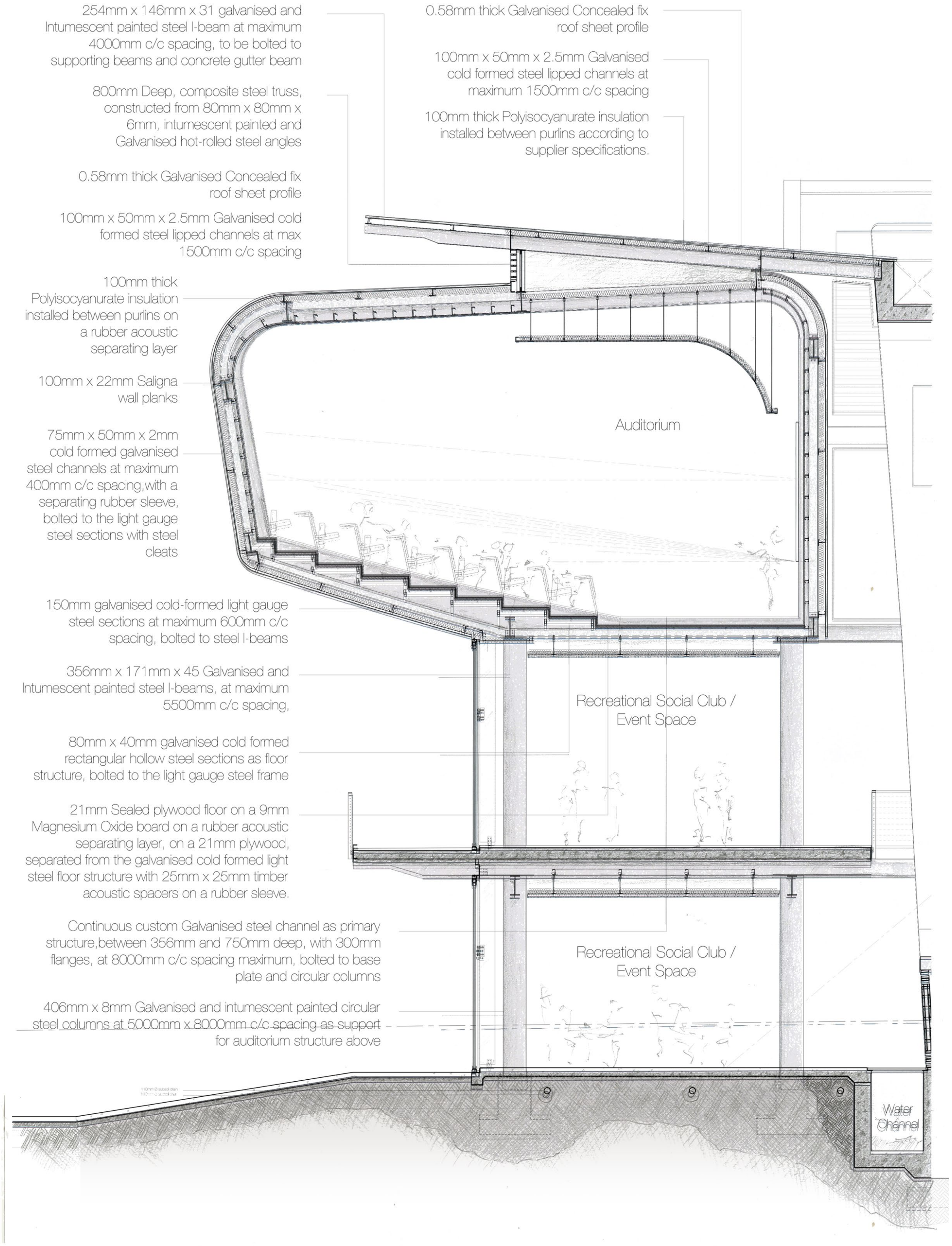


Figure 8.22: Detailed section of the auditorium structure. (Author 2015)

8.6

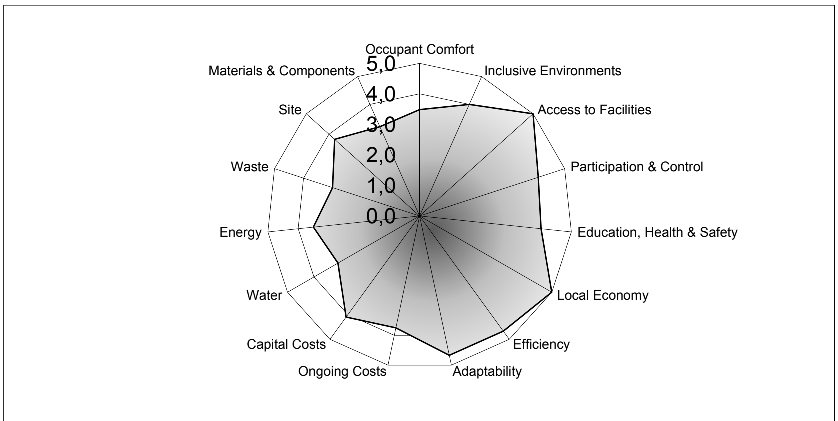
Water as Service and Environmental System

The reinvention of existing and new infrastructure with a focus on water systems and processes from the outset of the project is continued to the environmental systems and services of the site and building. The approach of the project is to employ a decentralised strategy of service areas that harvest and re-use rainwater locally and are unified and equalised through the ground water channel, wetland and reservoir system that harvests, treats, conveys and stores stormwater runoff as well as re-cycled greywater.

Harvested rainwater as well as water from the reservoir is used for services such as the flushing of water closets and irrigation of the productive greenhouses and recreational landscape, as well as environmental systems such as indirect evaporative cooling strategies during summer and water heating strategies during winter. All treated surplus yield is fed back into the Apies River, extending the influence of the ecological potential to the scale of the river, providing a quantitative and qualitative improvement to the river that supports agricultural production on the northern boundaries of the city.

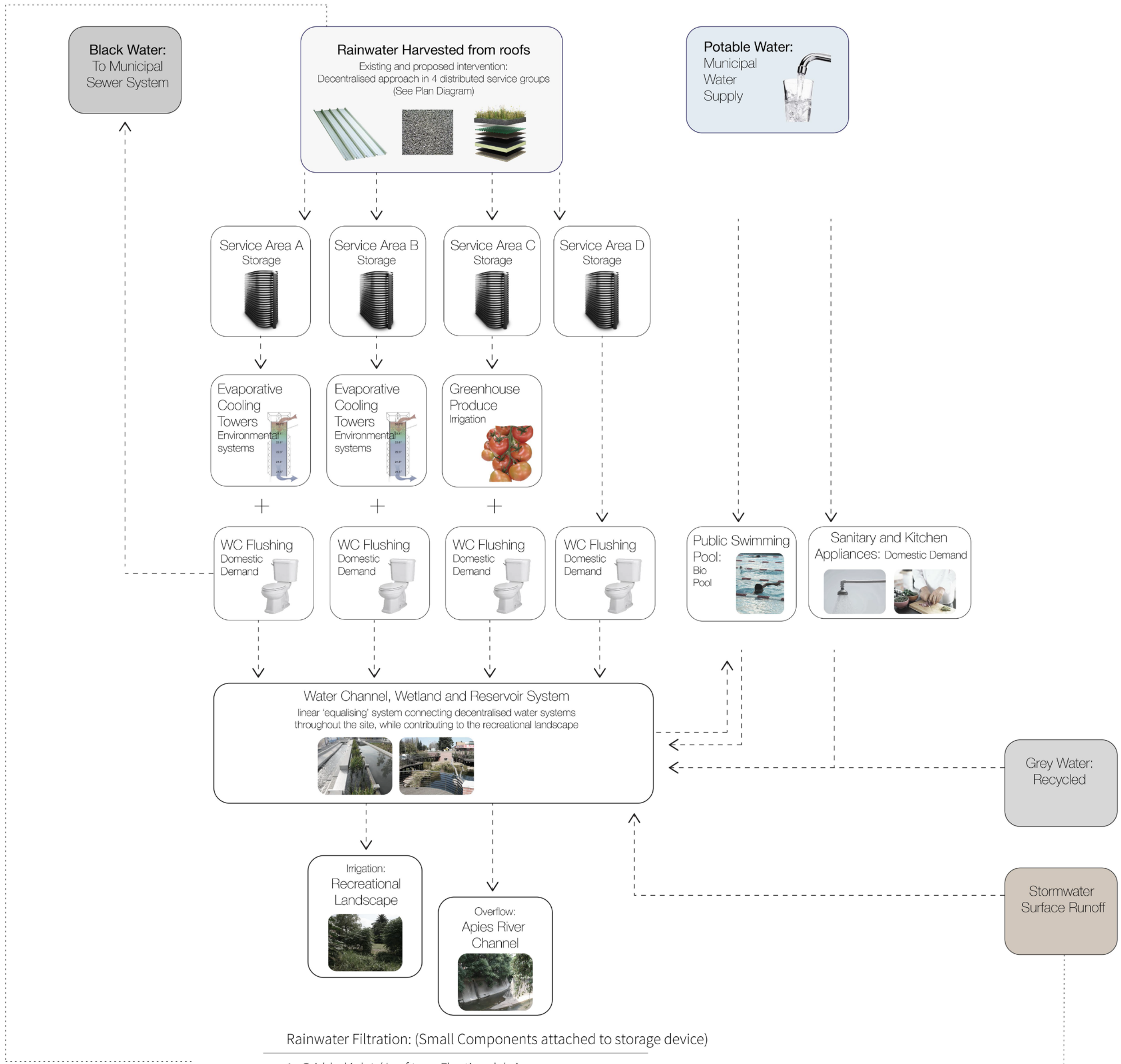
SUSTAINABLE BUILDING ASSESSMENT TOOL (SBAT- P) V1

PROJECT		ASSESSMENT		
Project title:	Apies River Urban Arena	Date:		2015-10-01
Location:	Pretoria CBD	Undertaken by:		Charne Nieuwoudt
Building type:	Mixed	Company / organisation:		UP Boukundie
Internal area (m2):	2495 m²	Telephone:	Fax:	
Number of users:	Appr. 750 at peak capacity	Email:		



Social	4,1	Economic	4,4	Environmental	3,3
Overall	4,0	Classification	Good / Excellent		

Figure 8.23: SBAT investigation of the site's sustainability potential (Author 2015)



Rainwater Filtration: (Small Components attached to storage device)

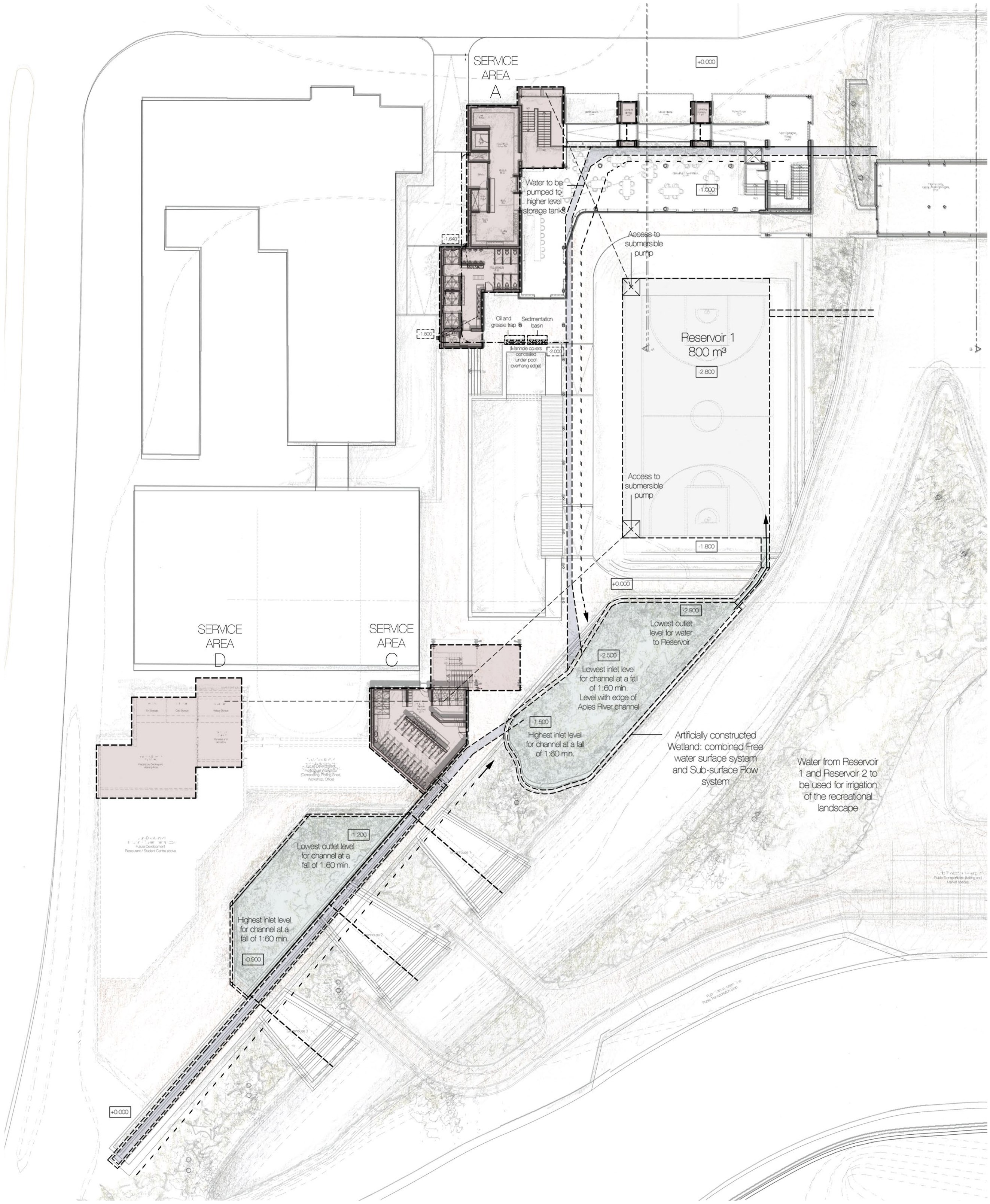
1. Gridded inlet / Leaf trap: Floating debris
2. 40mm ø First flush diverter: Solid Particles
3. 50micron Sediment Filter
4. 100 micron In-tank filter: Sedimentation
5. Carbon filter: Odor and Colour (Optional for WC flushing purposes)

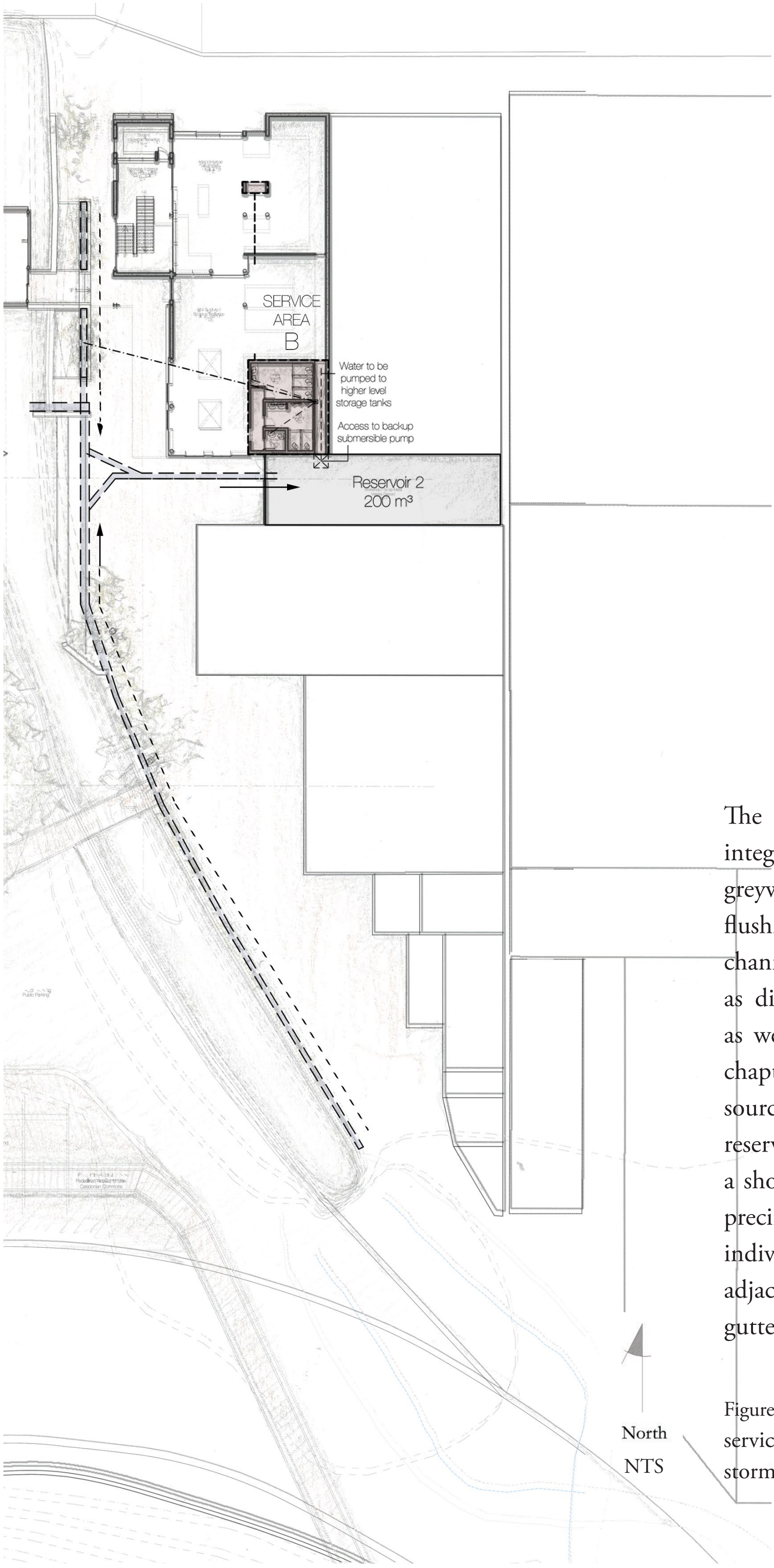
50 mm ø Downpipe connection to storage tank

Stormwater Run-off and Grey water Filtration:

1. Gridded inlet / Leaf trap: Floating debris
2. Oil Trap: Contaminants lighter than water
3. Sedimentation basin: Water to be stilled to settle contaminants heavier than water
4. Wetland: Nutrient uptake through plant species

Figure 8.24: Diagramme of the integration of water services and environmental systems of the site. (Author 2015)


SERVICE AREA A
Water to be pumped to higher level storage tanks
Access to submersible pump
Reservoir 1 800 m³
Oil and grease trap
Sedimentation basin
Access to submersible pump
SERVICE AREA D
SERVICE AREA C
Lowest outlet level for water to Reservoir
Lowest inlet level for channel at a fall of 1:60 min. Level with edge of Apies River channel
Highest inlet level for channel at a fall of 1:60 min.
Artificially constructed Wetland: combined Free water surface system and Sub-surface Flow system
Water from Reservoir 1 and Reservoir 2 to be used for irrigation of the recreational landscape
Lowest outlet level for channel at a fall of 1:60 min.
Highest inlet level for channel at a fall of 1:60 min.



The water strategy at ground level is proposed as an integration system for all treated stormwater runoff, greywater recycled and surplus rainwater not used for WC flushing or environmental systems. The constructed water channel as continuous organisational and animating entity as discussed in the design development chapter (eight) as well as sub-section 9.3 of the technical development chapter, collects all treated water from the three different sources to be diverted to the wetland and stored in the reservoirs for supplementing the service area demands with a shortage of rainwater as well as reuse within the larger precinct. The western and eastern parts of the site have individual ground level systems that provide to both their adjacent precincts. The building structure and continuous gutter integrates the two systems at roof level.

Figure 8.25: Site diagramme illustrating the integrated water services and systems throughout the site, including rainwater, stormwater runoff and greywater. (Author 2015)

Water Supply Roof Rainwater yield calculation - Service Area A			
	Avg. monthly perceptation	Area of catchment weighted	Total Roof Rainwater yield (m³)
January	0,104	1402,698	145,880592
February	0,113	1402,698	158,504874
March	0,083	1402,698	116,423934
April	0,044	1402,698	61,718712
May	0,018	1402,698	25,248564
June	0,009	1402,698	12,624282
July	0,004	1402,698	5,610792
August	0,003	1402,698	4,208094
September	0,021	1402,698	29,456658
October	0,071	1402,698	99,591558
November	0,108	1402,698	151,491384
December	0,108	1402,698	151,491384
Total	0,686	16832,376	962,250828

	Environmental Systems Demand	Domestic demand
January	17,67	104,398
February	17,1	96,064
March	17,67	104,398
April	11,4	101,62
May	5,7	104,398
June	0	101,62
July	0	104,398
August	0	104,398
September	5,7	101,62
October	11,4	104,398
November	17,1	101,62
December	17,67	104,398

Water Supply Roof Rainwater yield calculation - Service Area B			
	Avg. monthly perceptation	Area of catchment weighted	Total Roof Rainwater yield (m³)
January	0,104	1320,72	137,35488
February	0,113	1320,72	149,24136
March	0,083	1320,72	109,61976
April	0,044	1320,72	58,11168
May	0,018	1320,72	23,77296
June	0,009	1320,72	11,88648
July	0,004	1320,72	5,28288
August	0,003	1320,72	3,96216
September	0,021	1320,72	27,73512
October	0,071	1320,72	93,77112
November	0,108	1320,72	142,63776
December	0,108	1320,72	142,63776
Total	0,686	15848,64	10872,16704

	Environmental Systems Demand	Domestic demand
January	14,26	19,964
February	13,8	18,032
March	14,26	19,964
April	9,2	19,32
May	6,9	19,964
June	0	19,32
July	0	19,964
August	0	19,964
September	6,9	19,32
October	9,2	19,964
November	13,8	19,32
December	14,26	19,964

Water Supply Roof Rainwater yield calculation - Service Area C			
	Avg. monthly perceptation	Area of catchment weighted	Total Roof Rainwater yield (m³)
January	0,104	1039,95	108,1548
February	0,113	1039,95	117,51435
March	0,083	1039,95	86,31585
April	0,044	1039,95	45,7578
May	0,018	1039,95	18,7191
June	0,009	1039,95	9,35955
July	0,004	1039,95	4,1598
August	0,003	1039,95	3,11985
September	0,021	1039,95	21,83895
October	0,071	1039,95	73,83645
November	0,108	1039,95	112,3146
December	0,108	1039,95	112,3146
Total	0,686	12479,4	8560,8684

	Irrigation Demands	Domestic demand
January	31,8	58,821
February	27,295	49,364
March	26,765	58,821
April	22,525	58,1
May	22,525	58,821
June	18,55	58,1
July	15,9	58,821
August	18,55	58,821
September	26,5	58,1
October	26,5	58,821
November	30,475	58,1
December	31,8	58,821

Table 8.3: Water calculations of Service Areas A, B and C (Author 2015)

Service Group A - Water Budget

Total Yield and Demand to be used from Rainwater (m³)

Total Rainwater demand	Total Rainwater Yield	Balance	Water to be pumped from / released to Reservoir	Left over in tank y1	Water to be pumped / released from / to Reservoir	Left over in tank y2
122,068	145,880592	23,812592	0	23,812592	-40	39,32342
113,164	158,504874	45,340874	-7	62,153466	-40	44,664294
122,068	116,423934	-5,644066	0	56,5094	0	39,020228
113,02	61,718712	-51,301288	55	60,208112	55	42,71894
110,098	25,248564	-84,849436	80	55,358676	80	37,869504
101,62	12,624282	-88,995718	80	46,362958	80	28,873786
104,398	5,610792	-98,787208	80	27,57575	80	10,086578
104,398	4,208094	-100,189906	80	7,385844	80	-10,103328
107,32	29,456658	-77,863342	80	9,522502	80	-7,96667
115,798	99,591558	-16,206442	0	-6,68394	0	-24,173112
118,72	151,491384	32,771384	0	26,087444	0	8,598272
122,068	151,491384	29,423384	0	55,510828	0	38,021656

Service Group B - Water Budget

Total Yield and Demand to be used from Rainwater (m³)

Total Rainwater demand	Total Rainwater Yield	Balance	Water to be pumped / released from / to Reservoir	Left over in tank y1	Water to be pumped / released from / to Reservoir	Left over in tank y2
34,224	137,35488	103,13088	-40	63,13088	-70	56,5048
31,832	149,24136	117,40936	-120	60,54024	-115	58,91416
34,224	109,61976	75,39576	-75	60,936	-75	59,30992
28,52	58,11168	29,59168	-30	60,52768	-30	58,9016
26,864	23,77296	-3,09104	-10	47,43664	-10	45,81056
19,32	11,88648	-7,43352	0	40,00312	0	38,37704
19,964	5,28288	-14,68112	0	25,322	0	23,69592
19,964	3,96216	-16,00184	0	9,32016	0	7,69408
26,22	27,73512	1,51512	0	10,83528	0	9,2092
29,164	93,77112	64,60712	-50	25,4424	-50	23,81632
33,12	142,63776	109,51776	-120	14,96016	-120	13,33408
34,224	142,63776	108,41376	-100	23,37392	-100	21,74784

Service Group C - Water Budget

Total Yield and Demand to be used from Rainwater (m³)

Total Rainwater demand	Total Rainwater Yield	Balance	Water to be pumped / released from / to Reservoir	Left over in tank y1	Water to be pumped / released from / to Reservoir	Left over in tank y2
90,621	108,1548	17,5338	0	17,5338	-15	58,2435
76,659	117,51435	40,85535	0	58,38915	-40	59,09885
85,586	86,31585	0,72985	0	59,119	0	59,8287
80,625	45,7578	-34,8672	10	34,2518	0	24,9615
81,346	18,7191	-62,6269	50	21,6249	60	22,3346
76,65	9,35955	-67,29045	70	24,33445	60	15,04415
74,721	4,1598	-70,5612	70	23,77325	70	14,48295
77,371	3,11985	-74,25115	70	19,5221	70	10,2318
84,6	21,83895	-62,76105	65	21,76105	65	12,47075
85,321	73,83645	-11,48455	0	10,2765	10	10,9862
88,575	112,3146	23,7396	0	34,0161	0	34,7258
90,621	112,3146	21,6936	0	55,7097	0	56,4194

Rainwater harvested from the existing and proposed roof structures are collected, treated and stored at roof level for the use of WC flushing and the indirect evaporative cooling towers. The surplus rainwater from service area B are conveyed to the ground water channel system. Water is pumped from the reservoir to additional storage tanks at roof level for Service Areas A, C and D with a shortage of rainwater harvested. Table 9.1 and Table 9.2 illustrates the rainwater yield and demand at the various service areas as well as the total water budget for the western and eastern ground level water systems.

	Environmental Systems Demand	Domestic demand
January	0	31,682
February	0	28,616
March	0	31,682
April	0	30,66
May	0	31,682
June	0	30,66
July	0	31,682
August	0	31,682
September	0	30,66
October	0	31,682
November	0	30,66
December	0	31,682

	Irrigation Demand Recreational Landscape	Total Demand
January	360	360
February	360	360
March	360	360
April	320	320
May	240	240
June	240	240
July	240	240
August	240	240
September	320	320
October	360	360
November	360	360
December	360	360

Water Supply Roof Rainwater yield calculation - Service Area D			
	Avg. monthly perceptation	Area of catchment weighted	Total Roof Rainwater yield (m^3)
January	0,104	450	46,8
February	0,113	450	50,85
March	0,083	450	37,35
April	0,044	450	19,8
May	0,018	450	8,1
June	0,009	450	4,05
July	0,004	450	1,8
August	0,003	450	1,35
September	0,021	450	9,45
October	0,071	450	31,95
November	0,108	450	48,6
December	0,108	450	48,6
Total	0,686	5400	3704,4

	Irrigation Demand Recreational Landscape	Total Demand
January	27	27
February	27	27
March	27	27
April	24	24
May	18	18
June	18	18
July	18	18
August	18	18
September	24	24
October	27	27
November	27	27
December	27	27

Rainwater Roof Runoff Coefficients:

0.90	Sheet Metal,Concrete or asphalt
0,85 - 0,8	Builtup tar or gravel
0,4	Green Roof - Lawn Perennial Small Shrub
*0,6	50/50 Green Roof and gravel / hard landscape coverage

(Source: http://www.coolrooftoolkit.org/wp-content/uploads/2012/04/Green-Roof-Policy-

Table 8.4: Water calculations of Service Areas A, B and C (Author 2015)

Service Group D - Water Budget

Total Yield and Demand to be used from Rainwater (m³)

Total Rainwater demand	Total Rainwater Yield	Balance	Water to be pumped / released from / to Reservoir	Left over in tank y1	Water to be pumped / released from / to Reservoir	Left over in tank y2
31,682	46,8	15,118	0	15,118	-15	45,788
28,616	50,85	22,234	0	37,352	-25	43,022
31,682	37,35	5,668	0	43,02	-5	43,69
30,66	19,8	-10,86	0	32,16	0	32,83
31,682	8,1	-23,582	0	8,578	0	9,248
30,66	4,05	-26,61	30	11,968	30	12,638
31,682	1,8	-29,882	30	12,086	30	12,756
31,682	1,35	-30,332	30	11,754	30	12,424
30,66	9,45	-21,21	20	10,544	20	11,214
31,682	31,95	0,268	0	10,812	0	11,482
30,66	48,6	17,94	0	28,752	0	29,422
31,682	48,6	16,918	0	45,67	0	46,34

Water Budget (Western Site)

Total Yield and Demand for Wetland Reservoir System (m³)

Stormwater Surface Run-off Yield	Greywater Recycling Yield	Total Yield	Service Area Demand / Yield	Balance	Reservoir 1 Size	Overflow to Apies River	Overflow to Apies River after Y1	Overflow to Apies River after Y2
227,7236	479,108	706,8316	0	346,8316	800	-453,1684	2238,4425	346,8316
247,43045	441,52	688,95045	-7	682,78205	800	-117,21795	229,61365	682,78205
181,74095	479,108	660,84895	0	983,631	800	183,631	866,41305	983,631
96,3446	460,91	557,2546	65	1155,8856	800	355,8856	1339,5166	1155,8856
39,4137	479,108	518,5217	130	1304,4073	800	504,4073	1660,2929	1304,4073
19,70685	460,91	480,61685	180	1365,02415	800	565,02415	1869,43145	1365,02415
8,7586	479,108	487,8666	180	1432,89075	800	632,89075	1997,9149	1432,89075
6,56895	479,108	485,67695	180	1498,5677	800	698,5677	2131,45845	1498,5677
45,98265	460,91	506,89265	165	1520,46035	800	720,46035	2219,02805	1520,46035
155,46515	479,108	634,57315	0	1795,0335	800	995,0335	2515,49385	1795,0335
236,4822	460,91	697,3922	0	2132,4257	800	1332,4257	3127,4592	2132,4257
236,4822	682,703	919,1852	0	2691,6109	800	1891,6109	4024,0366	2691,6109

After year 2 the reservoir reaches full capacity: Balance to overflow

Water Budget (Eastern Site)

Total Yield and Demand for Wetland Reservoir System (m³)

Stormwater Surface Run-off Yield	Greywater Recycling Yield	Total Yield	Service Area Demand / Yield	Balance	Reservoir 1 Size	Overflow to Apies River	Overflow to Apies River after Y1	Overflow to Apies River after Y2
77,22	6,82	84,04	-40	97,04	200	-102,96	749,695	97,04
83,9025	6,16	90,0625	-120	280,1025	200	80,1025	177,1425	280,1025
61,6275	6,82	68,4475	-75	396,55	200	196,55	476,6525	396,55
32,67	6,6	39,27	-30	441,82	200	241,82	638,37	441,82
13,365	6,82	20,185	-10	454,005	200	254,005	695,825	454,005
6,6825	6,6	13,2825	0	449,2875	200	249,2875	703,2925	449,2875
2,97	6,82	9,79	0	441,0775	200	241,0775	690,365	441,0775
2,2275	6,82	9,0475	0	432,125	200	232,125	673,2025	432,125
15,5925	6,6	22,1925	0	430,3175	200	230,3175	662,4425	430,3175
52,7175	6,82	59,5375	-50	512,855	200	312,855	743,1725	512,855
80,19	6,6	86,79	-120	692,645	200	492,645	1005,5	692,645
80,19	6,82	87,01	-100	852,655	200	652,655	1345,3	852,655

After year 2 the reservoir reaches full capacity: Balance to overflow

Indirect Evaporative Cooling Towers

Environmental systems employed within the building, exploits the potential of water as illustrated in "Figure 8.25: Diagramme of the integration of water services and environmental systems of the site. (Author 2015)" on page 186, through the use of indirect evaporative coolig towers.

The evaporative cooling towers as proposed is contained within the structural and service spine of the building and water is supplied from the storage tanks containing the harvested and treated rainwater.

The structure of the evaporative cooling towers consits of the concrete cast-in situ strutural fins, lined with a galvanised steel plate to prevent water penetration or absorption into the concrete fins. The concrete fins are encolsed with structural glazing to allow for the visibility and exposure of the cooling system from the internal and external spaces with air supply openings into the adjacent internal spaces. The cooling tower termnates into the constructed water channel at ground floor to capture and drain all excess water away from the internal spaces.

A precedent analysis of Council House 2 in Melbourne, by DesignInc, illustrates the use of this cooling strategy in a similar scale and programmatic condition.

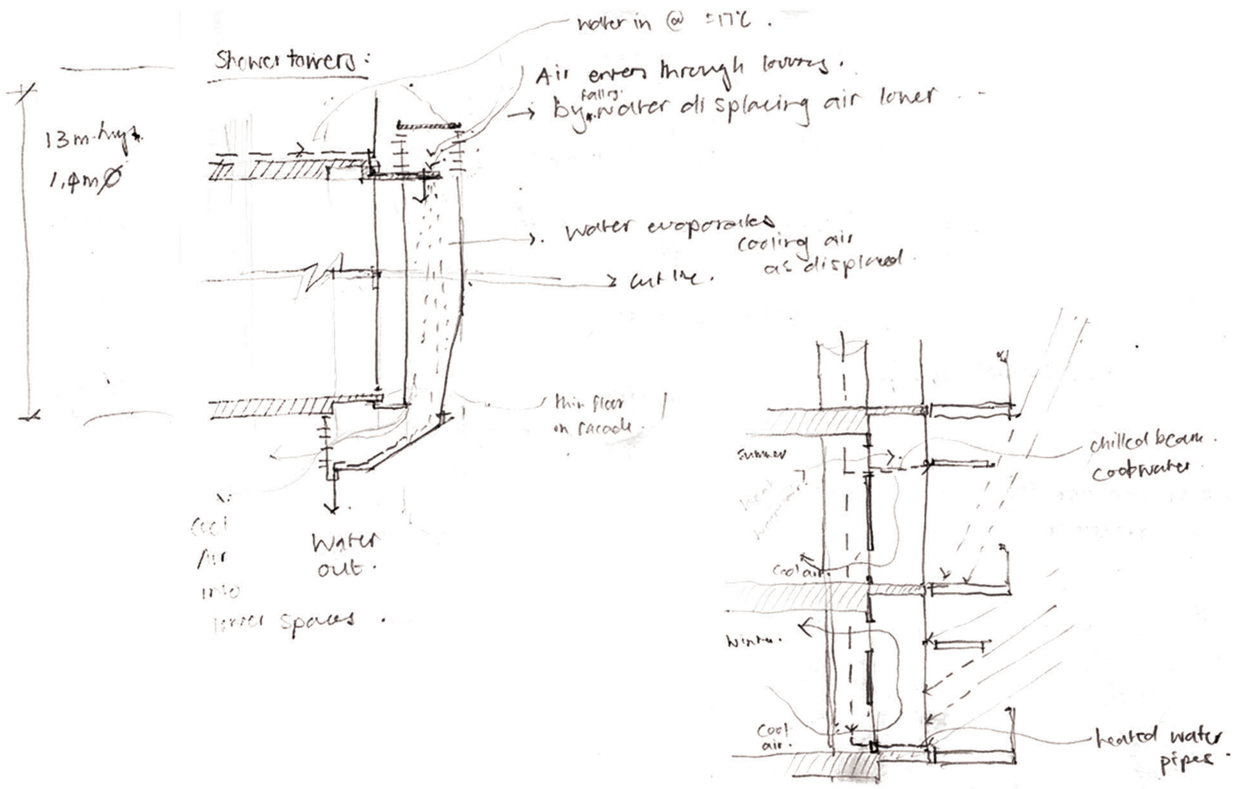


Figure 8.26: Diagrammatic investigation of the cooling tower requirements (Author 2015)

Design Inc, Council House 2 , Melbourne

Figure 8.27: Photograph of the CH2 cooling towers lit up at night, Photo by Dianna Snape (CH2 2013)

Project Information:

Location: Melbourne, Australia
Completion Date: 2006
Client: City of Melbourne
Project team:
Architects: Design Inc
Consultant Team:
Structural and Civil Consultant: Bonacci Group

Relevance: Environmental Systems Employed

Designed as a collaborative project with the City of Melbourne, the aim of CH2 was to create a holistic system that promotes an integrated approach between the city and natural system's potential to passively assist in the activities of the building.

The environmental system focus of this project investigates the indirect evaporative cooling strategy used with water as a coolant through lightweight fabric tubes.

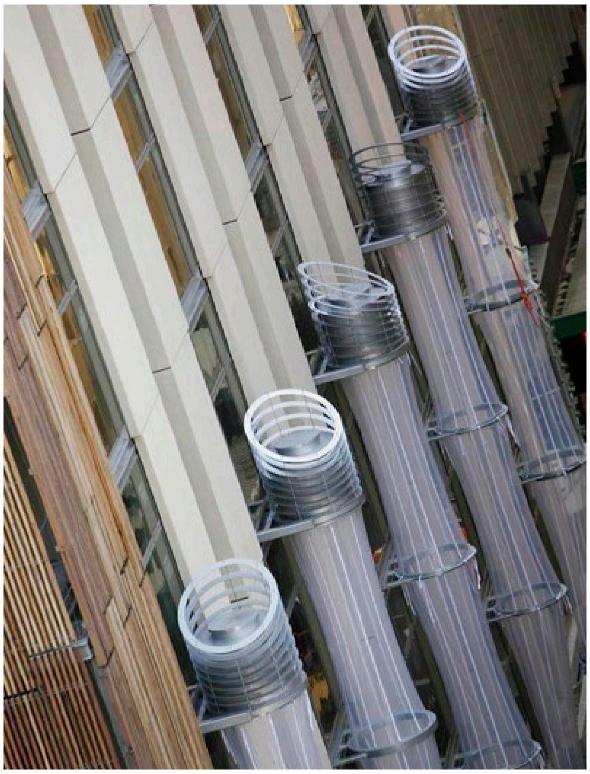


Figure 8.28: Photograph of the air inlets at the top of the cooling towers, Photo by Melbourne Council House, Australia (Ecofriendly architecture 2014)

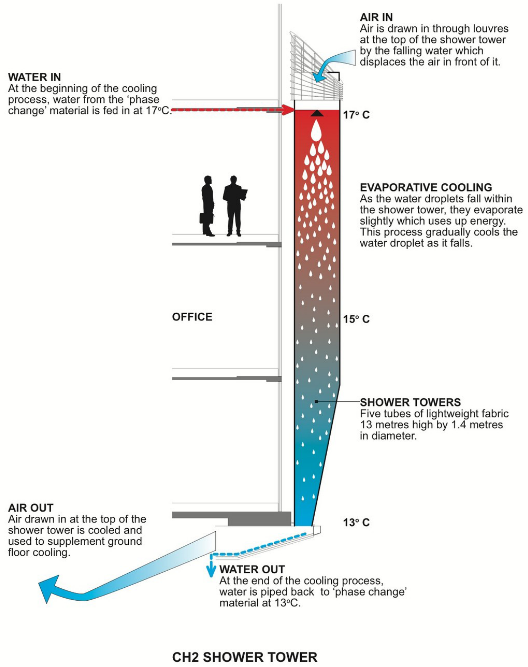


Figure 8.29: Diagrammatic illustration of the cooling towers, by DesignInc (CH2 2013)

Vegetation considerations

Considerations for the artificially constructed wetland, bioswales and greenhouse filtration edges:

- Filtration and nutrient uptake characteristics to be considered. Plant species should be able to be harvested when fully absorbed with nutrients and allow for regrowth.
- Aquatic plant species to be used for areas with permanent or high water levels.
- Wetland plant species to be selected according to seasonal requirements and be able to withstand dry periods.
- Size of plant species to determine aesthetic considerations of the constructed wetland as well as be used as vegetated boundaries to unaccessible areas.
- Planting rehabilitation strategy to be implemented in a phasing process to allow for a succesful transition

Potential plant species proposed for the greenhouse filtration edges:

1. Higher edges - Bulrush (Good aesthetic barrier)
2. Lower edges - Schoenoplectus Corymbosis (Higher water levels)

Seasonal plants for the constructed wetland:

3. Aristida Junciformis (Overhanging plants to soften the concrete edges)
4. Calamagrostis Epigejos
5. Erythrina Zeyheri
6. Gunnera Perpensa (Medicinal Potential)

Figure 8.31: Existing vegetation on site to be retained (Author 2015)

Figure 8.32: Existing vegetation on site to be removed (Author 2015)

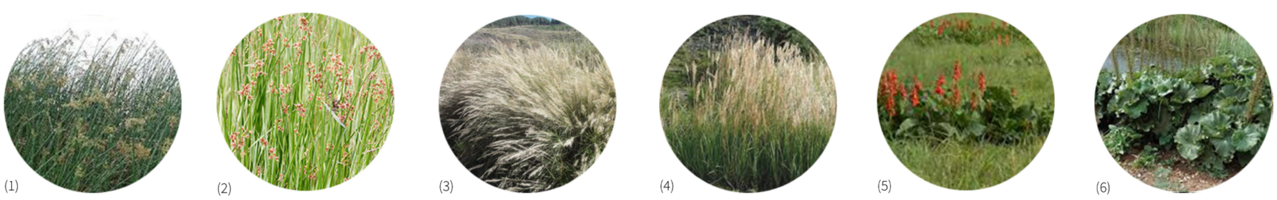


Figure 8.30: Potential proposed plant species to be used (Author 2015)