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2: Design Investigation

Figure 2.0 Northala Fields near London. An existing example of the landforms similar to those investigated in this design. Source: http://www.panoramio.com/photo/18386586
2.1 Introduction

As stated previously, the method of inquiry for this thesis was to undertake a design investigation, to explore the spatial implications and design opportunities of wastewater wetlands. This chapter will present and critique the design investigation and evaluate the lessons learned in the context of the thesis questions.

The site for the design investigation is the residential red-zone of a post-earthquake Christchurch. The residential red zone is a large piece of land in the Eastern suburbs of Christchurch which has been deemed unsuitable for repair, mainly due to impacts of liquefaction (see Chapter 6). The largest swath of red zoned land is adjacent to the lower sections of the Avon River, from its mouth at the estuary all the way to the edge of the CBD (Fig 2.1).

As part of the design investigation the site was analysed and designed through several scales; from the coarse city and district scale to the finer scale of planting strategies and construction details. Seven A1 pages were prepared and presented, each focusing on different strategies of wastewater recovery and recycling via sustainable technologies. The application of wastewater wetlands to this unique site presented several opportunities for creative and innovative designs of landscape performance. This chapter describes the concept of a large urban park that integrates landscape systems with wastewater infrastructure. It then critiques the results and asks ‘so what’, and how can this design inform the research questions of the thesis.

2.2 Urban Context 1:25,000

Description

The urban context design addresses the wastewater network at a coarse scale, suggesting a distributed sewage collection and treatment system with a catchment for every 50,000 people. (Fig 2.2) These clustered treatment centres are ecological recovery zones where systems recover and convert wastes into resources such as fuel, food, energy and heat. Each clustered treatment system is located near existing economic hubs, facilitating public exposure to new waste landscapes with enhanced amenities, aesthetics and resilience.

River catchment boundaries were used as a planning framework, designing and siting wastewater systems within their existing
basins. The Avon River catchment of Christchurch was the main focus of the urban context scale and an indicative concept of a source to sea walkway was developed (Fig 2.3). This concept linked the springs of the Avon to the estuary with a bike path through patches of forests, stormwater wetlands, wastewater wetlands, detention basins, urban agriculture plots, recreation spaces, native vegetation, Canterbury University, botanical gardens and the CBD.

**Critique**

This scale is the most valuable when planning a city’s wastewater system as the system must work as a whole in an IWRM. The treatment clusters are only an indicative approach and do not consider actual populations, volumes of wastewater or area needed for wetland treatment. This information will be fully investigated in Chapter 6. Also, Environment Canterbury (ECan) regulates the proximity of wastewater discharge to surface waters and this condition was not reflected in the concept.

The residential red zone is a very atypical site with unusual opportunities such as reclaimed residential land and existing but redundant infrastructure. Designing a performance landscape in the form of a park directly adjacent to Christchurch’s celebrated Avon River required a contextual consideration of the character of place. The design intention was to use the classification of land instability adjacent to the Avon River as an impetus to reclaim the banks of the river for public access. The concept celebrated the iconic water body and protected it from contamination and pollution using a patchwork of performance landscapes that treat and recycle wastewater (Fig 2.4). This concept proved to be a hard sell as the idea of using wastewater wetlands adjacent to surface waters to protect against cross contamination is anti-intuitive. The technological approach to this scenario is further explored in Chapter 3 and theoretical approaches to dealing with public perception is investigated in Chapter 4.
Chapter 2: Design Investigation

Urban Context Not to scale.

Fig 2.4 Developed concept: a matrix of land use patches along a riparian corridor.

Fig 2.5 Location: the Avon River catchment.

Fig 2.6 Plan: increased population densities and maintained existing open spaces.
2.3 The Master Plan 1:5000 (Fig 2.7)

Description
Looking more closely at the residential red zone at a scale of 1 to 5000, the integration of wastewater wetlands and the urban environment is more defined. This design envisioned the red zone as a prototype for a new kind of park; a recovery park where wastewater infrastructure is the driver for brownfield development, recovering and exploiting wastewater as a resource. These principles informed the design response and continue to drive this research.

The land uses within the red zone are interlinked to particular social objectives. (Fig 2.8). EDUCATE is near the existing and retained Avon Girls High School and also contains an urban farm managed by the high school. EXPERIENCE holds an amphitheatre, parking, a visitors centre and the start of an 18 hole disc golf course which leads into the CREATE/RECREATE zone. Here human creativity adorns the summit of a wetland mound and large sculptures provide a unique and visible skyline (Sec 2.1). Most of the large scale wetland landforms are sited in the RECOVER zone. The PLAY area is a place for families and children. The RENEW zone offers an activation of the original Avon River bed through native vegetation regeneration and mahinga kai (eel) aquaculture.

Waltham, a neighbourhood adjacent to the red zone was rezoned as dense residential and commercial space to accommodate some of the 50,000 households displaced due to the red zoning. This change of Waltham’s character was justified as it provided more opportunities for residents of the red zone to remain close to their homes, community and place.

Section 2.1: Sculpture park and the topography of wastewater wetlands.

A central focus of this design was a cascading wastewater treatment system where water is treated just enough for its next use. The headwater of this cascading system is the sewage conveyance terminus. These termini were sited near existing pumping stations to take advantage of the existing conveyance infrastructure (Fig 2.9). Primary settling tanks receive raw sewage and can capture methane for energy. Water is pumped from the clarifiers to a controlled environment aquatics system where a diverse ecology of tropical plants treats water inside a greenhouse structure. After this treatment water is pumped through algal bioreactors where biofuel-producing algae feed off wastewater nutrients. Then staged
planning wetlands provide secondary treatment and a portion of this water is returned to the environment via subsurface irrigation of forests and orchards. The remaining water is returned to the greenhouse structure for tertiary and advanced tertiary treatments to polish the water to a quality suitable for food production in urban agriculture plots (Fig 2.10). Any water not absorbed and transpired by plants slowly permeates through to the confined aquifer. This system design has subscribed to the Cradle to Cradle principal that waste is food (McDonough, Braungart 2002).

The wastewater wetlands that provide secondary treatment in this cascading wastewater system are the main landscape feature. Constructed atop a hard fill of reclaimed earthquake rubble these wetlands are topographic features; landforms that employ gravity to assist in the ebb and flow of the wetland cells. The shape of the topographic cells are varied to explore different scales and forms that still allow for human access (Fig 2.11). They are designed with the intention of including an element of human interaction such as trails, viewing platforms, benches and social spaces. The topography itself gives a renewed identity to the red zone, providing a distinct sense of place and views to the coast, Port Hills, central city and the Southern Alps. Entrained within the wetland topography are greenhouse structures, open to the north providing solar gain for the tropical plants of the controlled environment aquatics.

In total potential of the red zone site and it’s 7.3 ha of constructed wetland under the staged planning wetland model could treat 19,000 m$^3$ a day servicing approximately 95,000 people, almost a quarter the population of Christchurch. In comparison the CWTP treats a population equivalent (PE) of 670,000 m$^3$/day using 230 ha of oxidation ponds.

**Critique**

The cascading water system and it's integration with other land uses such as forestry and urban agriculture was a challenging and exciting design opportunity. This water recycling system presented

1. Primary settling tanks remove most solids from wastewater.
2. Controlled environment aquatics systems treat wastewater with mixed ecologies of snails, microorganisms and tropical plants rafted atop tanks of wastewater in greenhouse structure.
3. Algal bioreactors grow algae in wastewater for the purpose of producing biofuel.
4. Staged planning (tidal flow) wetlands are deep (2m) wetland cells that flood and drain to treat wastewater. They require a land area of approximately 2m$^2$/pp.

For more detailed descriptions see section 3.8.
several opportunities for further research into the potential of such recycling investigations including into the geologic, hydrologic and legislative limitations and requirements. The health and safety of the public and the carrying capacity of the environment also need to be considered in greater detail.

While the Recovery Zone processes and recycles wastewater through several land-based scenarios it does not significantly address the problems of conveyance and volume. The Recovery Park is only about 2 km from the CWTP which is the existing wastewater treatment facility. One of the greatest challenges to overcome is the susceptibility of the existing sewage conveyance system to earthquake damage. However, siting a large scale wastewater treatment facility that treats the wastewater of 95,000 people, ecologically or not, still presents the challenge of resilient conveyance. Therefore, this thesis will seek a smaller scale solution to wastewater wetlands systems.

Also, most of the wastewater wetlands in the design investigation are staged planning wetlands, a complex and proprietary wetland that is technologically advanced and not well understood in New Zealand. While this thesis will still investigate the potential of this staged planning wetland which requires 2/3rds less land area to treat the same amount of wastewater as HSFCW wetlands, it would be more beneficial to investigate the potential of wetland typologies that are readily available, tried and tested in New Zealand. "There is reluctance for the local authority to get into this sort of thing if it hasn’t been well proven, well-engineered and they know it’s going to work for the next 100 years" (Bourke 2012). The forms, adjacencies and concepts generated through the design investigation could be adapted to suit other wastewater wetlands and the conclusions have validated the potential for wetland cells to become an integrative component of public open space.

2.4 Intermediate Design 1:500 (Fig 2.12)

Description
At this scale of the design a more detailed approach was taken to investigate how the edge of each land use could function. The site
The Intermediate Scale  Not to scale.

Figure 2.12: Plan of the Kerr's Reach area.
is a piece of land known as Kerr’s Reach which in the previous scale was designated to have the social objectives of recovery, renewal and play (Fig 2.8). At this scale the design maximises the ecological and social values of the spaces while exploring progressive theoretical approaches to landscape design.

The southern edge of the site enhances an under-utilised existing park, Avon Park. In order to breathe new life into the open spaces of Avon Park, an urban beach was created on the southern slopes of the Avon River. This urban beach’s topography unearths and replicates the nearby sand dune soils, bringing sand to water (Sec 2.2). The edge of the beach is contained by gabions and a boardwalk. The gabions create a lagoon filled with reeds that passively filters the Avon River. There is also a boat launch/swimming platform off the boardwalk.

The boardwalk continues to the West of the beach through a riparian edge planted in native bush to an existing path. These public rights of way connect to a greater network of trails, including a bridge across the Avon at the west end of the site. Across the bridge users are directed to two distinct rows of urban totara and kahikatea forests. These forests are grid planted to make intention obvious. The two forests are separated by a walkway and the line of delineation identified by the Indigenous Ecosystems of Otautahi guide (Lucas, 1996).

The recovery centre to the north of the site and its associated landforms and structures provide 3D form to the space and complex and functional design gives people another reason to visit the heart of the red zone. This space is described and critiqued further at the site scale as part of the design investigation.

From a high vantage atop a wetland landform against the western banks of the Avon, uninterrupted views to the river, Kerr’s Reach and the Port Hills are punctuated by the architecturally detailed rowing club facility. A proposed bridge connects the land forms of the recovery centre with the new rowing facility. The new Avon River Rowing Club (Fig 2.13) is built in the form of a waka (Māori canoe) to bring to light the multicultural component of New Zealand’s rowing heritage. This waka structure is also suitable for other events, allowing for multiple uses such as weddings, conference and private parties.

Critique
The shape of the wetland landforms is based on the Fibonacci series spiral as a link to the Māori culture, biological settings and to facilitate an evenly dispersed gravity flow between wetland cells. The form also offers unique ways to experience the wetlands; progressing up or down the forms enhances the feeling of gravity. A third wetland landform is an experiment in a terraced approach to wetlands. This experiment was valuable as it introduced ways in which humans could walk next to, down and over a wetland typology, although the form was somewhat out of character with the rest of the site.

The adaptation of the banks of the Avon River near Avon Park to an
At the South-Western edge of the plan the greenhouse structure wraps around the path of the sun to maximise solar gain. Its shady southern side is planted in shade-loving ferns and the roof of the structure is an extensive green roof. Extending out from the building entrance is a trellis making a cultural reference to the Māori palisades, the fences that enclosed Māori pa. These trellises protrude horizontally from the building’s entrance, casting a shadow texture on the ground and providing partial shade. A boardwalk from the urban forest runs along the northern face of the building providing access to other parts of the site. This boardwalk meanders around the subsurface wetland feature near the ground plane.

The subsurface wetland in the North-West of the plan provides secondary treatment outflow to the urban forest to the West (see intermediate scale) in addition to the staged planning wetlands seen in the spiral form. This wetland at the ground plane is a more naturalised wetland, with informal plantings of wetland species and in the middle is a water play feature (see design details). The edge of the wetland is mostly concealed below the boardwalk, providing a hidden transition between wet and dry land.

The paving that bisects the plan is of three different coloured patterns of concrete. Each colour of concrete is separated by a spacer of zinc plated reclaimed reinforcing steel. The rebar extends beyond the paving and through a bridge over water flowing from a flow form into the subsurface wetland. The bridge also indicates a change of direction, where people can continue towards the greenhouse entrance or turn up the stairs leading up the staged planning wetlands.

To the North of the stairs is a platform nestled in the bush. This seat is intended to provide an isolated perspective of the wetland, surrounded by native feature trees (Fig 2.15) (see vegetation strategy).

Continuing up the stairs, people can touch the stones in the gabion façades of the wetland cells or listen to the sound of flow forms.
Figure 2.14 The Recovery Centre.
cascading treated wastewater down from the landform’s high point. The flow forms help oxidise water while providing a multisensory element. The meditative sound of the flow form can be experienced on most of the site.

At the top of the stairs another bridge indicates a change in direction at the edge of a wetland cell. Here people can continue up the path along the base of the cell until reaching the top edge of the wetland. A perforated steel gangway provides access over the wetland leading to an observation platform. This space allows for views across the site to the Port Hills and other water treatment landforms in the Recovery Park. This platform is intended for educational demonstrations, spectators of rowing competitions and

Figure 2.15 A wastewater recovery centre with a greenhouse structure holding a controlled environment aquatics system, constructed wetland and water play feature

for quiet seating and reflective space. Coming back off the platform users can walk on the grass of the wetland’s void spaces (Fig 2.16). An accessibility ramp connects the greenhouse structure with the top of the topographic wetland form. At the base of the ramp a pond collects water from the flow forms. Water pools for a short time and is released into a series of subtle 2 mm deep troughs which allow water to flow slowly from the pond to the wetland. These troughs are a representation of Canterbury’s braided rivers and provide another interesting and unique way to experience water when visiting the site.

Critique
This detailed plan touches on many of the opportunities wastewater treatment wetlands present; it is a modern design that balances naturalised plantings and messy ecosystems in orderly frames.
Wastewater Wetlands

Figure 2.16 The grassy voids between wetland cells.

(Nassauer 1995) to provide memorable experiences. There are many limitations to the design however. The subsurface wetlands are actually redundant and would not perform any useful function for treating wastewater with a proximity to staged planning wetlands. Also the rate of flow and descent for the flow forms and the issues of safe contact with the water are not fully addressed. (The issues of public exposure to contaminated waters will be explored later in this thesis.)

While this site is designed for people, the actual attraction may not be enough to bring significant numbers of users. The site is in a remote corner of the residential red zone and while educational groups may use such a site and it could have visitors due to occasional events at the nearby rowing club, the actual usership may not warrant the costs of the over-design. Therefore in future design of such spaces the design must consider the potential user numbers and design accordingly.

2.6 Details Strategy

Description
A detailed construction strategy was part of this design investigation. The water-play feature (Fig 2.17 and Fig 2.18) in the site plan was detailed to explore how to treat the edge of wastewater wetlands and maximise public exposure to education, inspiration and memorable experiences.

A cedar façade was chosen to soften the transition between hard and soft materials along the edge of the wetland. (Fig 2.19) The same cedar was employed as a seating material as it is resistant to moisture and is a warm colour. A locally available vinyl material that is able to be cut into any shape, allowing for patterns and shapes to be used in the design, was used as the ground surface of the water-play feature to make a soft, non-slippery floor. Eight large water jets were specified to have an inscription which would bring attention to the importance of water (Fig 2.20). This water play feature is a concrete island in the middle of the wetland.

Figure 2.17 Water-play feature.
Critique
Detailing this water feature was an opportunity to design in-depth ways in which people, and especially children, could experience water. These experiences are intended to be fun and memorable and begin to address theoretical approaches to perception of wastewater and the “yuck factor” (see Chapter 4). Safety is of course a primary concern and the use of wastewater treated on site to a potable quality then used in a play feature at the treatment facility is another experiment in perception and trust. If the feature is so unique, so much fun and enticing that kids can't resist playing in it and the safety concerns of parents are met with trust, the idea of waste can be transformed.

Perhaps energy may have been better spent exploring how wastewater wetlands could facilitate social norms such as incorporating a bench or how the wetlands could be sited against parking areas or carriageways. The detailing of a play feature, while fun, does not significantly aid in the understanding of how wastewater wetlands can be designed acceptably.

Figure 2.18 Water-play feature.

Figure 2.19 Detailed plan of a water-play feature.

Figure 2.20 Detail of water jet.
Figure 2.21
Design Details
Not To Scale
2.7 Vegetation Strategy

Description
A final requirement of the design investigation was a detailed planting plan and an overall vegetation strategy. The recovery zone comprises many different types of vegetation, from food products grown in the urban agriculture areas to the naturalised ecologies of native vegetation occurring mostly along the river banks (Fig 2.22). The most striking vegetation feature is the grid arrangements of mono crops in native forest planting (see intermediate scale). These are examples of “hypermature” - an exaggeration of constructed nature” (Meyer 2008 p. 17). This mono crop mimics the New Zealand tradition of grid planting wood lots but instead uses slow growing native species. Grid planting a native forest may at first seem obtuse, but its purpose is to reveal the objective for many future generations. These slow landscapes will take centuries to develop. In the future their intentionality will remain, leaving an

Figure 2.22 Naturalised plantings of native ecologies along the banks of the Avon River.
enduring, living reminder of this generation’s foresight.

In the detailed planting plan (Fig 2.23), endemic plants are used to soften the rise of the elevated tidal wetlands. Large trees are used both as feature elements and as screens for the tidal wetland walls. The levels of formality of plants slowly graduate from very structured plantings along the path to more naturalised planting arrangements on the slope above.

Wetland species are central to the function of the tidal wetlands in the Recovery Zone. Arrangements of native and occasionally introduced wetland species process wastewater and provide habitat for many kinds of insects and animals while providing an aesthetic element to an otherwise taboo infrastructure. These species were selected based on the Tanner, Headey, Dakers (2011) wetlands design guide.

Critique
The vegetation strategy employed many progressive landscape theories that are further elaborated on in Chapter 4. As landscape architects are the experts in planting design it is imperative that the vegetation strategy is one of the strongest points of the entire design. The concepts in this strategy mix natural and formal arrangements to bring attention to designed ecologies. The qualities of blatant row plantings of indigenous forests, framing of wetland
Chapter 2: Design Investigation

Wastewater Wetlands

Plants and naturalised native planting will be explored more in Chapter 4. Planting design and particularly designs that reveal the performance of the landscape while embracing cultural values is something that needs to be explored further to understand how aesthetic and intentional arrangements of plants that perform practical functions can provoke emotional responses from the viewer.

Figure 2.23 Detailed planting plan.

Figure 2.23 Rendered planting plan.

Figure 1.24 Plants used in planting plan.
2.8 Critical conclusion

Design projects are stressful, adrenalin fuelled environments facilitating the birth, fruition and death of ideas. This cycle of birth and death occurred several times during the creative process and scrolls of butter paper fill the recycle bin and redundant computer files clog the hard drive. As with probably all critiqued design projects, given the opportunity a designer would change a few things. This thesis presents the opportunity to learn from the design processes and apply those lessons to research questions. In this case the design of an ecological wastewater recovery park has given life and death to several ideas and creative concepts that can now be pursued through further research to try and determine how best to present wastewater treatment wetlands in an urban context.

One idea that will not be discussed further in the rest of this research is the use of a staged wetland typology, a technology unknown by most designer and engineers in New Zealand. Although the designed requirements, loading restriction and performance capabilities of these wetlands is understood, they are not tried and tested in New Zealand and as Mike Bourke (2012) explained the Christchurch City Council is reluctant to do anything on the leading edge. This wetland type does however represent a significant technological advancement and their potential application is extremely valuable, mostly due to the reduced area requirements. Therefore this typology is an option needing more research and development to be considered for New Zealand applications. This thesis will acknowledge the designs and scenarios tested in the design investigation, but will seek an approach which has been tested and proven in New Zealand.

The residential red zone was a useful site to examine the potential for ecological recovery systems, forms and land-use adjacency but the unusual situation that the red zone presents and the uncertainty of its future make it a site with unique values that cannot be easily replicated. Directing much of the city's wastewater to the residential red zone for treatment is not a step away from a centralised conveyance and treatment system which has been the source of many of the failures of Christchurch's wastewater stream. This thesis will further explore the concepts outlined at the urban context scale on how wastewater wetlands can function in a clustered, city wide sewage configuration.

Project advisor Tony Milne commented that the master plan was a "grandmother's mantel piece"; i.e., that it had one of everything but they didn't work well together. That unfortunate design characteristic will be considered in the redesign process for this thesis to represent, simple, functional and elegant designs structured to the conditions of place.

This design investigation provides a base for further research into the role of landscape architecture in the design of a city's wastewater infrastructure. Several concepts have been tested with varying degrees of success. Perhaps the greatest successes were those that deal with the spatial and design implication of systems that recover and convert wastes to resources. This thesis will further investigate the spatial requirements of wastewater wetlands, other landscape applications and uses for the resources, and theory and design approaches to public acceptance and appreciation of such systems.