From Extraction to Rejuvenation

How can architecture influence the re-purposing of quarries to suit an environmentally conscious urban environment?

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Abstract

In the pursuit of a developing city, quarries have been a source for raw material, providing employment and fundamental economic components for cities. As raw resources tend to deplete in the quarry, it subsequently harms the landscape. In the transition from a rural to urban landscape surrounding the space, the need for safe and efficient space exacerbates.

This project aims to discuss issues associated with vacant quarries. By addressing the literal ‘hole’ it leaves in the environment and discussing its environmental impact from resource extraction, this project can reflect on the destruction of the natural topography and landscape it has caused to seek positive spatial interventions for its future.

Auckland, ever-growing, has made urban development a priority at the consequence of natural the environment. An example of this is the degradation of Auckland’s wetlands, which today is estimated to be down to a remaining 10%. The re-purposing of quarries provides an opportunity for architectural solutions to both minimize the environmental impact of quarrying and to sensibly develop environmental attitudes for future generations.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.2. Defining and Harmonizing Space</td>
<td>67</td>
</tr>
<tr>
<td>4.3.3 Iteration of Environmental Infrastructure</td>
<td>71</td>
</tr>
<tr>
<td>5.0 Reflection, Critique &amp; Final Statement</td>
<td>78</td>
</tr>
<tr>
<td>5.1 Reflection</td>
<td>79</td>
</tr>
<tr>
<td>5.2 Critique</td>
<td>80</td>
</tr>
<tr>
<td>5.3 Final Statement</td>
<td>81</td>
</tr>
<tr>
<td>6.0 Final Design</td>
<td>82</td>
</tr>
<tr>
<td>7.0 Bibliography</td>
<td>84</td>
</tr>
<tr>
<td>Books &amp; Reports</td>
<td>84</td>
</tr>
<tr>
<td>Articles, Newspapers &amp; Journals</td>
<td>84</td>
</tr>
<tr>
<td>Websites</td>
<td>85</td>
</tr>
<tr>
<td>Documentaries</td>
<td>85</td>
</tr>
<tr>
<td>List of Illustrations</td>
<td>86</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION
1.1 Project Background
With the introduction of European settlers to Three Kings in the 19th century, the land developed for use in farming, education and residential occupation. It was not until the late 19th-century that quarrying of ‘Tallest King & East King’ began. By 1912, public interest was to turn Three Kings into a public park; but little came of the meetings and quarrying continued.1 Quarrying by Winstone Aggregates continued until late 1996 where it encountered ground aquifer issues, and quarrying was not viable.2

Koheraunui or ‘Big King’ is the last remaining king, currently a protected reserve for public use. The quarry remained vacant with occasional use up until 2012 when Auckland Council approved controlled fills. Previously, residential, medium-density housing and apartments have been proposed by Fletcher Living which met significant opposition from residents and surrounding communities.3

With the considerable controversy surrounding the intended and future use of the quarry, proposals were submitted to the Environmental Court. Based on the evidence presented to the Environmental Court, the interim decision saw provisional policies to be put in place to improve the development.4 To the dismay of residents, the council “generally supported Fletcher’s proposed amendments”.5 Currently, Three Kings Quarry is in the process of ‘progressive backfilling’ in preparation for residential and multi-unit development.


1.2 Research Question
How can architecture influence the re‐purposing of quarries to suit an environmentally conscious urban environment?

1.3 Project Outline
Three Kings Quarry meets the project requirements for conceptual exploration. The quarry exhibits environmental, cultural, social and political issues surrounding the past, present and future function. Responding through architecture provides an opportunity to address not only the issues present but endangered wetlands & wildlife that once resided in Te Tātua‐a‐Riukiuta.

A delicate consideration for the volcanic geology and underground aquifer that lies underneath the mountain must be taken. ‘Wetland Regeneration’ and ‘Environmental Infrastructure’ will be the focus of the project. An exploration into the environmental systems will detail architectural opportunities that can be utilized.

The project will address the quarry up to the property boundary, to the extent of quarried land ends. The purpose is to provide an alternative plan, with importance placed on future use.

Demonstrating the design challenges and possibilities that the environment fosters will create new architectural outcomes for spaces experiencing severe resource depletion.

4 Auckland Council, “Latest update on Three Kings development.”.
5 Auckland Council, “Latest update on Three Kings development.”.
1.4 Aims and Objectives
Historically, there has been strong public demand for Te Tātua-a-Riukiuta to become entirely open to the public, with earliest records dating back to 1912. The ignorance of the future implications has seen the site become a quarry for over 150 years. Recent developments to ‘cover-up’ the consequences have been to adopt poorly designed housing typologies, providing minimal benefit to the surrounding environment and society.

This project aims to address the environmental aspect of quarried land, mitigating the existing damage caused by surrounding developments and providing a foundation for a sustainable future. Furthermore, to accept that the current social structure encourages human activity and development, communities must bear the responsibility of what their actions create. Climate change must be acknowledged and acted upon; understanding the extent of the damage caused to the environment and creating practical solutions to ensure sustainability is maintained.

The quarry will function as an artificial wetland. Provisions for water treatment of the surrounding groundwater will support the sustainability of the wetlands. Growth of the artificial wetland over time will provide a safe, controlled environment for endangered wildlife to prosper. Spaces designed for demonstration and observation will inform the public about environmental infrastructure and its role, ensuring sustainability through education for future generations to come.

With the outline of requirements, to create an appropriate and efficient architectural style that suits the cultural, social and political themes that Three Kings Quarry presents.

1.5 Scope and Limitations
1.5.1 Scope
The project will define the site extents within the property boundaries of the quarry, identified by excavated soils. Design considerations will be analysed for flexibility to connect public spaces and facilities that would see a future or on-going benefit that will enrich the architectural design. Project requirements have been identified as:

- Environmental Infrastructure systems that can provide mutual benefit to the surrounding environment
- Considerations for social, cultural and political contexts
- Facilities that provide mutual benefit to the environment and occupants

1.5.2 Limitations
As of the current year 2019; Three Kings Quarry is under development with stormwater, wastewater, service infrastructure being installed. The quarry is undergoing a combination of fills to provide suitable ground for residential and medium density construction for future stages.

Geographical data and construction of Stage 1A of Three Kings Quarry had been completed with a mixture of apartments, terraced housing and small business. The research project will assume Stage 1A was not constructed and will take place dated 2005 when the quarry was surveyed as per the Auckland Council GeoMaps data.
1.6 Methodology
The approach will describe the iterative process that will happen during the evolution of the project. The process will break down the key elements of how information is presented, analysed, and used to progress the project further leading to a successful architectural outcome.

Site Analysis
The site analysis will be one of the main drivers of this project, due to the unique conditions that Three Kings Quarry presents on the site. On top of the environmental considerations, there is a programmatic structure that will develop.

There is a need to address the urban context around the quarry, the requirements of access, and consideration of how best to use the site’s topography to benefit the existing system. Local Iwi must have critical attention paid to their advice and concerns. In addition to these requirements, there must be a preliminary analysis of the site showing how the water path can influence the placement of specific infrastructure, that in future, will benefit the site.

Historical Records
A resource of historical documents will need to address the obligations of local Iwi and to implement the Te Aranga design principles. The government website www.teara.govt.nz will be a primary source of information regarding the Three Kings site. The aims and objectives of the project will incorporate historical information to aid in the final architectural solution.
Literature
From the texts in the literature review, there are multiple arguments, ideas and design components which can influence the re-purposing of Three Kings quarry. All ideas will be investigated and deconstructed to demonstrate the value each brings to the project and ensures a comprehensive theoretical design. Then a framework of design values will be established with objectives listed underneath to give a specific and measurable outcome. Design values will then be tested on an observable scale to determine if the design achieved its intended objectives.

Design
As previously mentioned, design implementation will be an iterative process. Site considerations based on research, text and historical records will be the primary influence on design. From there, an exploration of the constraints of the site will be implemented. This will develop an understanding of how adjacent spaces will interact and the way intended spaces will flow. Design decisions will be programmatically driven and aided by CAD and BIM management.

1.7 Terminology

Eutrophication: “Excessive richness of nutrients in a lake or other body of water, frequently due to run-off from the land, which causes a dense growth of plant life.”

Koheraunui: ‘The large-leafed kohe tree’ The Māori name of the mountain traditionally named ‘Big King’. Referred to in some tales as the ‘Great King’.

Polder Landscape: Artificial body of water, forming a hydrological entity. Commonly used in land reclamation and agriculture.

Sediment: A byproduct of erosion, weathering and environmental conditions. The matter that is broken down and settles at the bottom of a liquid.

Tamaki Makaurau: Also known as ‘Tamaki-the bride sought by a hundred suitors’ is the ancestral name for the Auckland Isthmus. Many tribes have flourished here as the volcanic soils provided nutrient-rich material for gardening consistently across the Isthmus.

Taurangi (South King/Highest King): the Māori name of the mountain to the South. Now a part of the Winstone Quarry.

Te Onekiri: The Māori name for the King that resided on the eastern location of Three Kings, closest to the location of Mount Eden Road. Now a part of the Winstone Quarry.

Te Tātua-a-Riukiuta: The Māori reference to “The Three Kings”. Previously known as Te Tatu o Mataaho (the war belt of Mataaho). Commonly refers to ‘Big King’ Reserve and the general location of the quarried mountains previously resided.

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2.0 HISTORY OF THREE KINGS QUARRY
2.1 The Past

Te Tātua-a-Riukiuta; known as Three Kings was once three mountains referred to as Koherauui (Big King), Taurangi (Tallest/ Highest King) & Te Onekiri (East King) by Felton Mathew, New Zealand’s first surveyor-general. Part of Auckland’s volcanic field, Three Kings, exhibited unusual geographic behaviour unique to other neighbouring volcanoes. Three Kings had three scoria cones or ‘peaks’ with a ‘tuff ring’ that surrounded the natural landscape, and high levels of volcanic ash in the soil surrounding the mountains. This unique geology created deep depressions between lava streams where swamps would form.7

Three Kings is a core part of Auckland’s volcanic landscape. The interconnected lava flows to Mount Eden, Mt Albert, One Tree Hill and surrounding volcanoes creates a unique geology of dormant volcanoes. The lava flows create a permeable filter which allows the underground aquifer to form.

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Figure 4. Volcanic Field of Auckland – diagram by Hayward (Auckland, NZ.: Auckland University Press, 2011.)
2.1.1 Pre-Settler Occupation

Many stories and recollections reveal that tribes were inhabiting Tāmaki Makaurau preceding the first European settlers. Many inactive volcanoes were identified in the vast landscape from the east to west coasts, also described as ‘The Auckland Isthmus’. The arrangement of volcanoes provided nutrient-rich and fertile lands, supporting the development of the first tribes as they flourished.

Thirteen tribes or Iwi were mentioned having inhabited or crossed over the Three Kings mountains; three tribes had a significant influence in the Treaty of Waitangi Settlements of 2014.

Ngāti Te Ata has recorded claims to have inhabited in the Manukau Harbour, Awhitu Peninsula, Waiuku, Waikato River, Huia and the Waitakere Ranges.8

Te Ākitai Waiohua has claimed to inhabit many Southern areas of Tāmaki Makaurau, important areas including Drury, Pōkeno, Papakura, Ramarama, Wiri, Pūkaki and Ītāhuhu.9

Te Kawaeru a Maki have recorded claims to have lived in the Kaipara Harbour and general area, Waitakeres, Paruroa and Southern Manukau.

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2.1.1.1 ‘A Legend of Te Tauta Pa’

The formation of ‘Stone walls’ on Te Tātua-a-Riukiuta have two different perspectives. Records reveal the origins of the stone wall.

The Stone walls on Te Tātua-a-Riukiuta was theorized to be defensive systems of the previous inhabitants. Hugh Boscawen, the chief clerk for the Land and Surveying Department mentions “The natives seem in olden days to have used rocks in constructing their fortifications, evidence of this can be seen in the South of South Cone” meaning the rock fortifications have been excavated long ago. The approximate location of the stone wall bordered the Western Hillside, near the Māori College that previously resided on the site.¹⁰

George Graham a politician for Newton 1861-1869 sought to “sheds some further light upon the history and customs of those times and preserves the record of several proverbs and name place of local applications now almost forgotten”.¹¹ and customs of those times and preserves the record of several proverbs and name place of local applications now almost forgotten”.¹² Upon Graham’s research, Māori revealed the tales of the stone wall.

George Graham describes the story of Te Rau-iti. The youngest of his brothers marries the cousin of his Uncle Han-kore. Te Rau-iti’s brothers caught wind of the cousin’s desires and sought to destroy his reputation. The brothers lived in earthen rubble nearby and composed ‘annoying songs’ to taunt him in the event he heard their melodies.

“His brothers continued, nevertheless, to taunt and jeer, saying “This fine fellow living with his stone walls thinks himself so secure, how conceited he is.” This was because Te Rau-iti’s pa was in part defended by these stone walls, not earthen rubble parapets as usual. These stone walls are intact to this day where the pa of Te Rau-iti was. Whilst those parapets of earth and rubble elsewhere are much in ruin, hence the proverb mentioned hereafter.”¹²

Te Rau-iti never heard the taunts or ‘annoying songs’; and the proverb was said: -

“Nga waiata whakaara ahureka o Te Rau-iti-pai.”

“The vigil chants so pleasant of Te Rau-iti the dignified”.¹³

The story of the stone wall provides a wealth of wisdom that has nearly been lost; not only should we dismiss words that seek to taunt or aggravate, but words that are spoken shall also be in good faith and bring positive and meaningful change.

¹¹ The Journal of Polynesian Society, “A Legend of Te Tatua Pa”.
¹² The Journal of Polynesian Society, “A Legend of Te Tatua Pa”.
¹³ The Journal of Polynesian Society, “A Legend of Te Tatua Pa”.
A Legend of Te Tatu Pa. 167

(Carly the tears, i.e., the mourning offerings of men, precious garments and weapons who were about to proceed to Moehau.) On such occasions offerings were brought as condolences for those dead since last meeting, such offering was called cinematea.

VISIT TO MOEHAU, DEATH OF WHOA-NOA, AND HIS SONS' RETURN.

Thus this people set out for Moehau, and came to their relatives there. During their sojourn there te Wha-rou died, and was buried with his elders at Wai-kawan, near Cape Colville. Thereafter his children returned with some of their relatives. There were many intermarriages as the result of this visit, hence it is that Ngati-hurere had residential rights living at Ngahau-wera (8), Koranga-oraiti (9) and in Hoonti (10) as well as at Orakei.

FURTHER QUARRELS AT TE TATUA BETWEEN THE BROTHERS.

On the return of the brothers to Te Tatu, from Moehau, further disputes arose because Te Rau-it was desired by his cousins as a husband, they preferred him to the elder brothers. These were the two daughters of Hauro, his uncle. Rau-it married these women, and lived in own pa as heretofore. His brother lived in their fortified homestead near by, where they meditated continuously how they might eventually burlite their younger brother, who maintained, nevertheless, his mana; for it was he who had replied to the shock of his father, and fulfilled his dying wishes, which they sang in chorus in the still nights, so that Rau-it might hear them. Also sang such airs upon the puaka (flute), and blew sounds upon the puaka (trumpet). In olden days such sounds conveyed meanings, and in the hands of an adept, were a favourite method of beguiling the evening hours, being replied to from pa to pa. However, Te Rau-it replied thereto, “E aku tawhau! E! Ko ho ko pare eua, ko tu ko pare-taha. Ko waka katoa, koe e takitaka nga maire.” “Oh! my elder brothers—Alas! earthen parapet will indeed crumble, but stone parapet endure—dove-tailed cause will not unloosen its lashings.” These expressions have turned into proverbs nowadays.

THE STONE WALLS OF TE TATUA.

His brothers continued, nevertheless, to taunt and jeer, saying, “This fine fellow living within his stone walls thinks himself so secure, how conceited he is!” This was because Te Rau-it’s pa was in part defended by stone walls; not earthen or rubble parapets as usual. These stone walls are intact to this day, where was the pa of Te Rau-it, whilst those parapets of earth and rubble elsewhere are much in ruin, hence the proverb mentioned hereafter.


JOURNAL OF THE POLYNESIAN SOCIETY.

THE CURSE OF TE KAWERAU.

A party of Te Tatu and other people went to Wattemata for the sharks then in season. There was also came there a party of Te Kawerau from inland for the same purpose. These parties began gilding and jockeying one another; but it was the foolish words of Rau-it’s elder brother that provoked Te Kawerau, who had caught a shark. They grumbled at Te Kawerau, who losing patience, said, “Oh! Behold the large schnapper eyes of those low-born men.” This was a curse, but had been provoked by the unwarranted action of the elder brothers—their action was a provocation. Hence the proverb—

“Nga waiaha nga uri i Te Wha-rou.”

“The ill advised acts of Te Wha-rou.”

But the curse must be avenged, and involved Te Rau-it’s hope, which was not present at that fishing incident.

WAR AGAINST TE KAWERAU.

In due course a war-party set out, proceeding by Wattemata to Inland Makarau. Here, on the Kupara harbour, Rau-it advised his brothers to camp near the deserted cultivations of Te Kawerau. They, however, determined to show their superior military knowledge and pressed on against Rau-it’s advice. Te Rau-it formed his camp near, by the Kanohi station, called formally “Ngawharunui—Te Rau-it.” (“The camping sheds of Te Rau-it.”) The foolish brothers met Te Kawerau, they were ambushed in fact, and fled back to where Te Rau-it’s unconsidered party were securely camped. As the elder brothers fled, they sang out, “O Rau! The mat pins of Huare have become unfastened.” (“E Rau! E! Kia makere nga aitahi o Huare.”)

They were descended from Huare, but they now recognised that their disunion was responsible for their unsheeply revenge. Rau-it replied thereto, “E aku tawhau! E! Ko ho ho pare eua, ko tu ko pare-taha. Ko waka katoa, koe e takitaka nga maire.” “Oh! my elder brothers—Alas! earthen parapet will indeed crumble, but stone parapet endure—dove-tailed cause will not unloosen its lashings.” These expressions have turned into proverbs nowadays.

BATTLE AT KANOHE.

The children of Wha-rou then rallied, and under Te Rau-it’s direction defeated the impetuous charge of the opposing Kawerau at that place—Kanohe. Its full name is Kanohe-tamure-ani. (“Large schnapper eyes.”) Because the curse was then avenged. Also, another name of that battle is “Hauing-tea-rou.” “The scattering of brains.” This latter is also the name of our aro (buried with Nga-hardihe, our father, at Taupiri)—formerly kept by us here at Awataha (North Shore, Auckland) in the tree trunk called Nga.
Huru-a-Taiki (11) (Taiki’s hair), a sacred place of concealment formerly. Hence the proverb in respect of things well concealed or lost—“Kia aorero ki te pata a Taiki.” Lost within the tree hole of Taiki.”

Another proverb concerning those elder brothers is “Nga tama poukaha e Whao-rae.” (“The jealous sons of Whao-rae.”) Said of jealous people. As to Te Ran-iti, whose forbearance towards his brothers was life-long, he is remembered in these proverbs and mottoes: “Te maunawai o Te Ran-iti”; also “Te Ran-iti maunawatanga raee” (i.e., “The enduring patience of Te Ran-iti,” and “Te Ran-iti of long enduring patience”).

**FINAL HISTORY OF THE BROTHERS.**

Rau-iti and his brothers lived in the times of their elder cousin Kiwi Tamaki. His troubles involved them also. When was fought the battle of Titirangi, all these brothers then perished, hence one name of that battle. “Te Rangi-hinganga-tahi” (The day when all fell as one). Their sons, then grown to manhood, also fell with them: only their sister, Te Horo-pomuanu, who had a Kawaran husband, was spared with her family on the destruction of Te Tatu, also Te Momona and his children who went to Te Huuna and Wairau, south of Auckland, living there with our relatives Ngai-Tai. Hence our genealogical table.

1. Ihenga-ringrings-ware. This serves to further identify this grandson of Tamaki-te-kapaue, reputed to have lived in Kaipara as well as hereabouts.

2. “Nga-Riu tatau tahi,” another form of this tribal pepeha: i.e., descendants of Riu—bombed with one girdle.

3. “Olaki.” Instructions given by an aged person to his children to be observed on his death, but often given long before his actual decease.


4a. Puke-huhu: “Grub hill,” one of the summits of the Waitakere Ranges, whence, as the name implies, large quantities of an edible grub, the *huhu*, were obtained.

5. Their sister—Te Horo-pomuanu, was their elder—a waikino oriki. The association of women with axes and the sharpening thereof is of Hawaikian origin. *Tide Various myths to Hine-tua-houanga*. White, Vol. I., folio 69, etc.

6. Dove-tailing (Katuitanga). I have not elsewhere heard any special reference to this method of joining, but probably identical with that mentioned in “Journal,” Vol. XXIII., p. 119.
2.1.2 European Occupation of Three Kings

Upon the arrival of European settlers in the 19th century, Europeans sought to organise and formalize the ownership of land they had acquired from the Māori; and allocated to an individual, business or entity. Records of deeds and titles record the use of land, from 1848, as simple requirements such as education, farming and residential homes. Transactions at the time were simple and informal, leading to the fast adoption of boundaries and land bought in and around the Three Kings area.

“The transfer of property was simple in those days: the Māori chief who happened to be the vendor pointed out two boundaries the purchaser handed over the consideration agreed on, and the affair was closed without intervention of law courts or lawyers.”

The Three Kings lots were used primarily for farming sheep and crop harvesting, with ownership changing hands many times over the 19th century. Most of the land, that would later become the quarry, was acquired upon the death of its then-owner, W.J. Conelley in 1920.

Quarrying of the site was a continuous process and did not have a definitive beginning. Site surveys from the early 1920s suggest quarrying was underway, with the first photographic evidence of the site in the 1940s. During the quarrying process, public opposition was present, but unfortunately, there was no action, and quarrying continued.

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2.2 Present – The Quarry

Three Kings Quarry “was probably the most complex of Auckland’s Volcanoes,” as described by *Volcanoes of Auckland* by Bruce Hayward et al., Erupting approximately 28,500 years ago, the Three Kings made the largest ‘tuff ring’ crater in Auckland with traces of the eruption showing up as far away as Remuera.

Once standing three mountains Koheraunui, Taurangi and Te Onekiri, two of the mountains have been quarried for their basalt and scoria aggregate.

The mountain to the north Koheraunui “Big King” mountain, is currently an open public reserve, with many residents using the area as a dog walking park which allows off-leash play, challenging slopes and picturesque views at the top of the mountain.

In addition, ‘Big King’ Reserve contains water pumping infrastructure for the community. Water is transferred from natural flowing dams, fed by gravity to the pumping stations located north of the Quarry. Water is pumped to the top of the reservoir and provides a localized pressure system for the surrounding residential and commercial buildings, thereby reducing demand and increasing efficiency of available potable water.

Residential properties reside near property boundaries of Big King Reserve, with walkways overlooking the main living spaces of the properties below.

There is restricted entry into some parts of the park containing a critically endangered wetland, zone WF7, which contains a puriri forest. The unique geology is the source of the forest’s growth.

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The basalt rocks underground occur in volcanoes with skeletal soils separated by the lava formations underneath. Nutrients in the soils above and the volcanic material which is free draining (permeable) and often stony, providing ideal, yet sensitive growing conditions.

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2.2.1 Social, Cultural and Political Issues

Historically the quarry has been a significant subject of political arguments. Use of the land has been exhausted from quarrying over the years, leaving a hole in the environment. During the excavation of the mountain, there has been a drastic change in the landscape with large residential and light commercial lots surrounding its property boundary.

Three arguments highlight the tension of the quarry;

1. Three sacred mountains acknowledged and respected by the Māori, sold off and quarried for the basalt and scoria underneath. Once the existing use had dwindled, left ‘abandoned’ with disastrous effects on the ecosystem and environment to an unknown scale.

2. The current inhabitants are light commercial industry and low-density housing surrounding the property, with some green space to the west of the site left minimally managed. Construction associated with the site created an ‘eyesore’ for residents, in addition to the construction noise over the years.

3. The environmental consequences of the site have not been accurately recorded and, the extent has not been identified. Little forethought has left the quarry in an undefined state, and surrounding inhabitants are desperate for the space to have a functional purpose.

Figure 12. Three Kings Quarry Unitary Plan Zones, Data obtained by Auckland Council GeoMaps, 2019.
Three Kings Quarry legal battle enters Environment Court

The Three Kings quarry proposal is not the way decisions should be made. Anne Gibson’s article of February 4 provides details of Fletcher Building’s proposal to develop the Three Kings Quarry site, 142m below road level, this is the largest site in central Auckland. It is now being filled at a relatively slow rate and the company is seeking to fill it partially and to develop it to a high density.

The $1.2 billion development of Auckland’s Three Kings quarry can go ahead, after an agreement announced this morning between parties involved in the big new housing scheme.

$1.2 billion development

Three Kings community seeks cash for quarry fight

Dick Bellamy: Three Kings quarry avoiding consultation process

Figure 13. News articles relating to Three Kings Development, Image by Author
2.3 Future - The Current Proposed Masterplan
Fletcher Living, in combination with multiple exterior consultants, has proposed to turn the quarry into medium-density housing and apartments. The masterplan details terraced housing, along the boundary bordering Mount Eden Road, and further stages are still in conceptual development.

There is an agreement that the quarry will have stormwater and wastewater systems to prevent flooding, and a mix of hard and compacted fills to reduce the contour disparity the quarry currently presents.

Fletcher Residential, the developer in the process of obtaining relevant permissions to develop the land, received feedback from the local community criticizing the intensification of the land and the amount of housing and apartments that were proposed. With conditional approval from the Environment Court, Fletcher Residential has made minor amendments to the masterplan to reach consensus. Geography, flooding, daylighting and the contours were ultimately too challenging for a medium to high-density design.

Figure 14. Masterplan Proposed by Fletcher Residential, Plan by DKO Architecture (NZ), 2017.
3.0 STATE OF KNOWLEDGE

3.1 Literature Review
3.1.1 Sustainable and Resilient Communities: A Comprehensive Action Plan for Towns, Cities, and Regions (2011)
Stephen J. Coyle & Andre Duanys’ book ‘Sustainable & Resilient Communities’ provides a simple, yet comprehensive structure to introduce sustainable concepts to a community, town or city. The concept of “Conventional/High-Carbon & Resilient/Low-Carbon” built environments are defined & analysed for their qualities and consequences.

Resilient/ Low Carbon
The definition of (RLC) is closely related to the historical development and settlement patterns of towns and neighbourhoods.17 The design of RLC’s follows the exploitation of nearby shared resources. The community share the functions of the resources. As the requirements and demands change for the built environment; the building’s function becomes flexible, with the architectural fabric being responsive and adaptive. The development of the environments is not definitive, with a “continuum or morphing attributes, as communities outgrew or jumped beyond their original boundaries.”18

Conventional/ High Carbon
The common traits that define (CHC) community-built environments demonstrate definitive and “organized clusters”.19 Buildings within the built environment also consist of “Single-use” buildings that are designed with function in mind.20 These single-use buildings expand as the inhabitant’s requirements change, creating “superblocks”. Issues arise as the design of open space is left bare due to local regulations and difficult to design footprints and topography. This limitation reduces the functional efficiency of the land occupied.

3.1.2 Green Urbanism in Asia: The Emerging Green Tigers (2012)
Written by Peter Newman and Anne Matan, Emerging Urbanism in Asia explores the developments in sustainable design within Asia and the contextual issues that brought the environment to the forefront of design. Notably, they dissect the different forms of sustainable design and how their unique qualities differentiate each other.

The distributed city is identified by “the development of distributed power and water systems aims to achieve a shift from centralized power and water systems to small-scale and neighbourhood-based systems in cities.”21

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3.1.3 Principles of Brownfield Regeneration

In ‘Principles of Brownfield Regeneration’ by Justin B. Hollander, Niall G. Kirkwood, and Julia L. Gold highlights and attempts to resolve the issues associated with contaminated, derelict and dangerous to occupy the land.22 One of the main problems associated with brownfields, sites commonly located near urban environments, is sea and air contamination.23 The authors propose that the brownfield space must be addressed traditionally, mitigating all existing pollutants in the area, before redesigning and constructing a new built environment. The differing methodologies for this text would be beneficial in the use of cleaning existing spaces but it does not give a comprehensive understanding of the re-purpose and adaptability of the space in the future.

For this text to be useful in the project, existing pollution of Three Kings Quarry must be addressed, using the methods and techniques listed in the book, but to keep design considerations in mind.

3.1.4 Green Buildings Pay

In ‘Green Buildings Pay’ by Brian W. Edwards and Emanuele Naboni defines and examines existing ‘green architecture’ and the patterns that are developed to produce efficient and successful designs. The text focuses on the ‘real world effect’ of theories that are formed from the perspective of the Architect, client and user.24 Critique is formed from the function of the green building systems that are used in buildings, with emphasis on efficiency, cost, benefit and aesthetic implementation. The text further discusses the legislative procedures that limit or expand the ability of ‘green’ design.

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3.1.5 The Philosophy of Sustainable Design
In ‘Philosophy of Sustainable Design’ by Jason F. McLennan
discusses the main influences and issues that have promoted
green design over the past 30 years. McLennan also gives
crude definitions of what is “sustainable design and a
framework to provide specific design principles to be considered
’sustainable’”.

Sustainable design takes many forms that provide efficient and
sustainable outcomes through different methods. These methods
come naturally through the site constraints, and the approach
decided upon in the design stage.

McLennan explains the evolution of sustainable design through
simplistic forms of energy conservation and transfer which
provide a service or benefit to the user within the building or
space.

3.1.6 Recycling the City
In ‘Recycling the City’ by Yesim Sungu-Eryilmaz and Rosalind
Greenstein analyse the procurement and restructuring of vacant
land in the surrounding urban environment. The book offers an
economic perspective into the reasons why land is left derelict,
mainly due to neighbouring underutilized infrastructure.

It focuses on the community engagement of programmes
dedicated to the redevelopment and interests of the
neighbouring community at hand.

The book considers the local body regulations and addresses the
needs of surrounding sites. The main driver of the book’s
argument is to provide a service to land parcels and connect
smaller communities. Programmatic structures have been
mentioned, which supports the implementation of Community
Development Coordinators (CDC’s) instead of a property
development manager or other management entities.

27 Sungu-Eryilmaz, and Greenstein, *Recycling the City: The Use and Reuse of Urban Land*, 159-161.
3.2 Precedent Review
3.2.1 The Eden Project

The Eden Project by Grimshaw Architects was established within an existing vacant quarry, like Three Kings. The purpose of the project was to make use of the existing contours of the quarry and give a structural opportunity for the architecture to encompass the space. The biodome structure is sealed with ETFE foil to enable light to penetrate within the space, this also acts as a barrier, giving the interior space a climate with increased humidity, suitable for the growth of tropical plants.

The project aspired to minimize the environmental impact on the site while providing an amenity that would contribute to the local economy. Construction methods of the ‘biomes’ were unique, utilizing the hexagonal structures to offer a long-spanning frame that could be revised according to the changing quarry geography. The treatment of foundations followed the changing form of the structure, providing footings at structural frames meeting finished ground, minimizing the amount of concrete required.

The philosophy taken from this precedent addresses the issues associated with resource extraction and excavation of land. The implementation of education facilities in conjunction with interactive spaces provides direct outcomes of environmental systems implemented. Understanding the design parameters, application of methods can be implemented to stagnant, polluted water issues.

The architectural solution is innovative and can be applied to a larger scale. The influence of ‘The Eden Project’ can be applied to the Three Kings site. For the purposes of the project, some architectural ideas will be taken to assist the wetlands within Auckland.

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31 Grimshaw Architects, “The Eden Project: The Biomes”.
Figure 18. Site, Elevation, Section and 3D detail of The Eden Project - The Architecture of Eden, Diagrams by Grimshaw Architects.

3.2.2 Dutch Pavilion at Hanover (MVRDV, 2000)
As an experimental form of sustainable architecture, MVRDV embarked on creating a form of architecture that integrates architecture, landscape, water, ecosystem and infrastructure. As a reference to the poetic response to “the paradoxical notion that as diversity increases, so too might cohesion”\(^{32}\). Further elaborating on the idea that as population density and density increases, the architectural ideas presented provide a precedent to reference or inspire future projects.

Spaces are divided by floors, where separate ‘environments’ cohabitate on the high-rise floor plan. Landscapes mesh with human-occupied environments, with gradual transitions from earthy, rough textures to light, smooth and soft materiality and concepts.


Figure 23. Dutch Pavilion Sectional Diagram – Figurative notes by Author
3.2.3 Gardens by The Bay

Located on the coast of Singapore’s central business district; lies 250 acres of reclaimed land. To improve the quality of life of residents of Singapore, Gardens by The Bay combines architecture, engineering, landscape and ecology.

Design ideas form transitioning indoor and outdoor spaces. The reclaimed area is separated into three sections; Central, East and South Bays, with the South Bay being its largest and most significant component to the gardens. Divisions of the green space create biodiverse landscapes encouraging interaction, complimenting the business hub of Singapore through tourism.

The complimenting environmental systems are focused on the glass biome ‘greenhouse’ structure. With controls for light, air circulation and water dispersal at the forefront of design.

Mechanisms introduced into the design considered ‘Low energy’ consumption solutions first, with ‘High energy’ high output solutions secondary and with traditional servicing systems last. In essence; minimizing the energy consumption through the exchange of organic and inorganic matter, known as nutrient cycles.

‘Low energy’ systems included the biome structure where the light is filtered and held in the ‘greenhouse’ structure to be utilized by the biodiverse ecosystems in place.

‘High energy’ systems were identified as utilizing partial aspects of ‘low energy’ systems with minimal input of infrastructure to provide beneficial servicing of spaces. Air conditioning and cooling of concrete inside the building benefitted from cool water circulated and then absorbed solar heat gain, to be used for hot water storage.
Traditional service infrastructure such as air conditioning was used sparingly where both low and high energy systems could not fulfil the service requirement. The methodology overall is environmentally realistic and makes Gardens by the Bay financially, ecologically and practically viable.33

3.2.4 Wasit Natural Reserve Visitor Centre
The Wasit natural reserve visitor centre is a place that protects and educates people about the delicate ecosystems that have been created, detailing the local birdlife and animals that reside in the wetland.\(^{34}\)

Formerly a dumping site for wastewater and rubbish from the local area; the site was defined as a brownfield. The reclamation process of removing toxic waste, and revitalizing the land began in 2005 where it was transformed into a natural habitat for nature to thrive.\(^{35}\)

The success of the facility has been from the support of creating delicate ecosystems in the United Arab Emirates. The ecosystems are created through the building orientation. Site topography is considered, and buildings are formed in accordance with function and visual permeability. Diagrams explain the design iteration and the ratios of viewing, service and restaurant/café areas.

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\(^{35}\) ArchDaily, "Wasit Nature Reserve Visitors Centre".
Figure 31. Building Layout, Diagram by X Architects, Accessed June 29, 2019, https://www.archdaily.com/784055/wasit-natural.reserve.visitor-centre-x-architects

Figure 32. Design & Building Methodology, Diagram by X Architects, Accessed June 29, 2019, https://www.archdaily.com/784055/wasit-natural.reserve.visitor-centre-x-architects
3.2.5 Stonefields, Auckland

Originally part of Winstone’s Mt Wellington quarry, Stonefields was the main source of Auckland’s aggregate supply. After closing commercial supply in 2001, changes to the site topography were made through filling and compacting soil, reducing the drastic changes to the ground level. Stonefields was then the ideal site for residential and small commercial development.

The site boasts enough properties and commercial development to sustain the 6500 occupants intended for the site. With a mix of unit, apartment, and light commercial buildings, with amenities, and lake space for wetlands, Stonefields is an example of a vacant quarry repurposed into a residential development with some considerations for environmental consequences. Originally designed to operate like a small town within a large city, Stonefields intended for the site to be accessed mainly by vehicles, with residential housing close to commercial buildings for convenience.

Stonefields is one approach to the response of site excavation in an urban landscape. Despite being an economical solution, the development of Stonefields has had significant environmental consequences. With the number of resources and energy were used to transport soil to fill the 110-hectare site, before building on top of said soil is a wasteful exercise.

If the site had been left barren, issues such as groundwater would arise, in addition to geotechnical, access and functional aspects. Land-use Options for Winstones Quarry Site by David E Hollands states;

“it can be anticipated that the majority of the quarry pit which did not become flooded would, within a relatively short time, become heavily infested with weeds. This would be followed with pampas grass, fennel, gorse, ginger and other herbs and grasses, and be followed by woody shrubs and trees. Eventually, there would be significant areas of weed forest smothered by creepers and vines”.

Documentation of conceptual master plans was provided to the local council, with multiple propositions that took advantage of the existing landscape. Three main options were proposed with the project scale and complexities in accordance with the infrastructure and services required, and labelled “Do Nothing”, “Do Minimal” and “Fill with Other than Refuse”.

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Option A
Gross Realization: $70.84 million NZD
Residential : Office : Industrial = 1 : 15 : 28

Option B
Gross Realization: $56.76 million NZD
Residential : Office : Industrial = 2 : 4.5 : 1

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39 Hollands, “Land use Options for Winstone’s Quarry Site Mount Wellington”, 55.
40 Hollands, “Land use Options for Winstone’s Quarry Site Mount Wellington”, 56.
Option A comprised of partial development of the site, with a proposed residential, office/industrial and industrial area including stormwater and building infrastructure. Partial subdivisions were excluded from this development, with a remaining 14 hectares undeveloped.\textsuperscript{42}

Option B comprises of similarities of Option A, with the proposed changes to the ratio of residential/office/industrial area. Development ratios as below;

Option C proposed that the quarry would remain undeveloped. This would result in a mixture of wetland & lakes that may contribute to the biodiversity of the environment. Land bordering the quarry would then be developed with the proposed development ratio as follows;

Overall, the proposed design for designated use spaces is reminiscent of Conventional/High Carbon built environments (CHC’s). Due to the general nature of the masterplan, mixed-use buildings are hard to develop and account for the changing needs of the inhabitants, this is exacerbated by the scale and speed of the development.

Construction of the different masterplan options is difficult to compare post-construction and gives a general indication of the complexities involved. The environmental impact imposed on each of the corresponding developments has not been taken into account; one can assume from development areas in hectares in comparison to green space would result in increased sustainable viability in the future. Following the analysis Option C would be the optimal and viable option to proceed.

\textsuperscript{41} Hollands, "Land use Options for Winstone’s Quarry Site Mount Wellington", 56.

\textsuperscript{42} Hollands, "Land use Options for Winstone’s Quarry Site Mount Wellington", 54.
4.0 Design Process
Figure 37. Site Photos of Big King Reserve, By Author
4.1 Site Analysis

The original contours of the Three Kings are unknown; and the geography of the site can only be interpreted from historical comments, references, artists’ impressions and photographs. The earliest photograph recorded was during the excavation process of the site. During the consultation process of the Fletcher residential development, an interpretative contour was carried out by Winstone Aggregates. In addition to the interpretive contour, geographical analysis carried out in Volcanoes of Auckland the accuracy of the location of the mountains can be referenced with accuracy.

The contours provided show that the South King had a sloped point, where the peak of the mountain was located on the Eastern area of the quarry. The ridge of the mountain tapers down lower into the Western area of the site with a natural sweep that points in the direction of the existing soccer field neighbouring the quarry.

East King is located in the North-Eastern area of the quarry, with a simple single peak that has a gradual slope to the Southern and Big King. The mountains contours cross over the existing quarry property boundary into the commercial properties.

The Three Kings formed a complex geotechnical system with a combination of soil, clay, basalt rock and a mixture of small minerals. Early reports indicated that the three peaks formed a concaved space between the three mountains, with stories of water being unable to drain, forming small ponds during a downpour. Other reports have stated that the land was free draining with a mixture of volcanic soils that allowed vegetation to grow substantially faster with larger yields.

Figure 39. Site Analysis - Important Viewpoints, By Author

Figure 38. Site Geology, “Three Kings Renewal, Contaminated Land Overview”, Report by Winstone Aggregates, 2014.
It can be assumed that the site had a combination of free-draining and slowly permeable soils. The basalt, scoria and minerals allowed water to drain, within the central concave of the three mountains. The contours channeled rainwater (an overland flow path) to the centre of the concave, exceeding the drainage flow of soil. Alternative ideas allude to clay build up or soil within the concave, concealing basalt and rock channels and slowing drainage potential.

Figure 41. East-West Cross Section of Three Kings Quarry in relation to Big King, By Author

Figure 40. North-South Cross Section of Three Kings Quarry in relation to Big King, By Author
4.1.1 Site Geography

The geographical contours on Three Kings Quarry have a drastic change in levels; with steep 20°-70° batters, for the purposes of natural retaining to stabilize the site during quarrying. Consequently, the geography creates unusable space. This slope also contains no natural planting, making susceptible to soil erosion and possible cliff-fall in the future.

With these deep contours on site, there are also areas identified as flood planes, overland flow paths & flood-prone areas, mainly caused by the deep excavation on the site. Underneath the quarry is an aquifer which travels through the North point of the CBD and then travels through the porous scoria of the volcano and exits through the South channel near Onehunga. With the combination of steep contours and an underground aquifer, the end stage of quarrying proved to be difficult as the site required active pumping of water to prevent flooding to the site.

4.1.2 Access to the Site

Three Kings Quarry presents itself with some challenging access issues. Because of the urban context and mixture of commercial, residential and landscape, this has led to limited access points to the site. Vehicular access is utilized by Mount Eden Road, which only covers the Eastern part of the quarry. Existing landscape such as Big King Reserve, Three Kings Football Field 2 and Bare land opposite Three Kings Reserve give opportunities for access to the West and South portions of the site.

To overcome this challenge of access, restriction of existing walkway and road infrastructure is detrimental to the site. Existing walkways on Big King Reserve provide adequate access from roadways, which lead to the North West precinct of the quarry.
4.1.3 Eutrophication
Eutrophication is one of the elements in an artificial wetland that must be considered and carefully controlled. Essentially; the imbalance and excess nutrients in the water that cause the algae growth. The growth of algae can have a stack-on effect; the most significant consequence is a reduction of the oxygen content in the water.

There are different types of eutrophication specific to Three Kings Quarry. The Cultural Eutrophication which consists of human activity, clearing of landmass and construction and specifically, the impervious surfaces created. Natural Eutrophication is created when the natural geography favours still, temperate waters; creating new algae spores and decomposing dead algae, further enriching the waters.

The contours the quarry presents has a combination of both natural and cultural eutrophication. The stormwater runoff from Mount Eden Road and vehicle traffic is the main contributor to the water quality of the site. In addition to this issue, the surrounding household water runoff contributes to a lesser extent.

4.1.4 Underground Aquifer, Oil and Sediment
Travelling from the Western Springs volcanic aquifer to the Onehunga volcanic aquifer, Three Kings Quarry acts as the ‘channel’ for water to flow under the site. The aquifer has the potential to create a permanent water level within the concave of the quarry.

The quarry borders Mt Eden Road, commercial buildings, residential housing and open public spaces. Oil and sediment runoff from Mount Eden road and the bordering commercial and impervious surfaces are hazardous to water quality within the quarry. To retain the water quality of the underground aquifer, oil and sediment must be filtered from flow paths entering the site.

4.2 Program Requirements
With the site context and constraints accurately identified, program requirements for the masterplan can be defined and measured;

An Artificial Wetland
Wetlands that encourage endangered wildlife to habituate where they can grow, and be observed by the public in a controlled manner to understand the environmental effects

Wildlife Observation Spaces
Space for the public or facility workers to see the wildlife that educates with minimal interference to the habitat while maintaining the safety and quality of life of the wildlife within the controlled environment.

Visitor/ Community/ Education Centre
Facilities that accurately interpret historical information, with spaces to learn and understand the environment.

Natural Filtration Infrastructure
Design for the existing groundwater, flood plains and stormwater from surrounding impermeable surfaces and retaining walls. Water purification systems put in place to ensure water can be reused and maintain a level of water quality suitable for its use.

Organic Food Harvesting
As a byproduct of the nutrient-rich water purification, plants grow at an increased rate. In combination with wetland planting, opportunities for vegetables, herbs and greenery can be grown sold and consumed by the community. The spaces would interact with the public and provide mutual benefit for the environment and the wetlands below.

Publicly Accessible Path
A public pathway that enables the public to interact with the environment in a controlled manner, which educates and maintains the safety and security of wildlife.
4.2.2 Construction of the Natural Water Treatment Facility
During the excavation of Three Kings Quarry; quarrying encountered an underground aquifer in which thousands of litres of water was pumped out of the quarry so that extraction of the basalt and scoria could continue.

The aquifer is an essential component to addressing the environmental issues of Three Kings Quarry. As the site stands currently; if pumping of the water ceased, over time, the quarry would fill with water from surrounding impermeable surfaces, general surface stormwater flow and water flowing from the underground aquifer. When not addressed; the water would stagnate and begin the process of eutrophication.

For wildlife to flourish, the environmental systems must provide a constant purification and flow of water. Existing artificial environmental systems, like natural environmental cycles, refer to plant and fine mineral and rock systems that filter the contaminants and harmful minerals within stormwater.

4.2.3 Developing an architecture to inhibit the environment
With the environmental considerations appropriately defined and managed. The architecture must create a space that the inhabitants can occupy.

The architectural issue with the site is outlined by the actions in which the quarry was created, the short-sightedness from the generations before. To remedy this issue; education and the understanding of what the environment was like before quarrying is at the forefront of the design. To educate the public on the environment and ensure future actions are well-thought and have sustainability in mind.

- To introduce the public; a visitor’s centre to welcome all that seek to understand the history and context of Three King.
- A community centre where the community can occupy the space, provide functions and a general area to address local issues.
- An education space that allows people to develop their sense of understanding; the education space is not limited solely to environmental issues, but community issues surrounding Three Kings and surrounding local communities.

Figure 43. Filtration Sketch Diagram, By Author
‘Building Greener’ details green roof systems for deep-rooted plants. “Intensive” green roofs detail a ‘drainage layer’ with potential for design iteration. Modification of the diagram to function in the research project, containing under-flowing water filters.

Water filtration is achieved by allowing water to pass through the soil, filtered through the geotextile fill and tree roots. Root barriers are laid under the geotextile fill. ‘Filtered’ water falls through drainage mesh where water flows freely. Protecting the concrete flooring trays is achieved by an impermeable surface layer below the water-proofing layer tray decking. To create a functional growth system, the trays act as portable ‘modules’ that allow for efficient lifting/lowering of planting trays. Following the flow of the filtration systems, the modules further function as growth circulation for areas with a higher nutrient density existing within the water.
Figure 45. Structural Iterative Design, By Author
Square forms provide the most efficient and easy-to-construct ‘tower’ forms. The design of the structure may work; but the way the contours are formed make it challenging to fit the towering structures in the deepest section of the quarry, making corners and triangular shapes hard to address.
Figure 48. Conceptual Shape Development, By Author

Figure 49. Conceptual Shape Development, By Author
Inspiration from the pre-existing contours from the mountains that used to reside within 3 Kings Quarry provides an adequate solution. The sweeping slope and complicated structure of the mountain can be extrapolated and influenced in the curved form, which can be used efficiently in the design of the bio-filter design.
4.2.1 Developed Design - Critique

For the public to understand the environment that was once there; the architectural result must reference and reflect the location of the two excavated mountains.

The indicative location of the mountains can be marked by a column or peak, which references the height and magnitude of the mountain. The design of the column or peak structure also has the advantage of the minimal effect on neighbouring residents with sunlight angles maintained in most areas and creating a minimal disturbance. Permeable cladding and structures can be used to create an indicative contour of the mountains.

The weakness of the column design is that the function is purely aesthetic and does not provide a service for the environment and residents. While it does give an indicative height of the mountains that were once there; the column design cannot describe the more complex tapered ridge contour of the South King, requiring a translucent or netted structure/ cladding which communicates a ‘tent-like’ structure.

To provide an appropriate reference to the Southern and Eastern King, the structure must be able to span vast distances while communicating a curved structure that can describe the unique contours.
Figure 52. Site Plan, By Author
Figure 53. Design Development – Render, By Author
Figure 56. Design Development – Sections, By Author
Preceding designs took inspiration from the tapered structure of the Gateway Arch in Missouri, United States. The concrete form allows the arch to form the structure and span distances of up to 200m. Criticisms of the design included the complexity of the structure and cost, with minimal function involved in the design. The proceeding iterations of the design need to consist of three fundamental concepts to provide viability:

1. Appropriate function to justify an investment
2. Simplicity in construction
3. References the historical context

To improve and iterate on the 'arched' concept; functions of the structural system must be defined. Functions can be obtained from the program requirements, and the appropriate requirement must be selected. With the outlines of the arch appropriately listed; the wildlife observation space meets the requirements of the structural function.

The wildlife observation space requires extensive constructed area; with requirements of wildlife to roam freely while in a controlled, safe environment free from predators. Design development will follow ‘The Eden Project’ creating large open spaces with the assistance of PTFE membrane & steel structure. Internal spaces allow deep root plants to grow, with controls for humidity, light and airflow.

Structural components will be constructed with tubular steel, providing the requirements of the simplicity in construction; with steel formed into a space-frame structure to ensure the maximum span potential, simplicity in uniform components reduced structural weight and potential for bracing between arched spans. Between the arched spans will contain netting that creates an enclosed structure that birds can habituate within a safe environment. This allows at-risk & endangered wildlife to occupy space while minimizing the effects of their quality of life.

With the function of the arch outlined as a part of the wild-life observation and conservation structure; the arch is justified, is efficient and logical in construction.
4.3 Design Iteration
4.3.1 The Architectural Form
The biofiltration system aims to educate the users and occupants of the building to understand the environmental system in which the project aims to bring awareness to. The site contours encourage a multi-level form that allows the environmental system to operate at a scalable proportion which also allows the structure to provide access to the inhabitants.

Figures 57. Conceptual Design of Water Filtration Infrastructure, By Author

Designs of the bio-filter design while efficient and address the issues present a further complication in the design of the swept towered structure. The form has aesthetic beauty and references the location of the mountains in a sensitive and considerate manner; it does not provide enough daylight hours required for the plants in the lower towers below. Splitting the structure into the horizontal segments and rotating these into angles that allow the maximum amount of light, without over-impeding on the site area, will enable it to gain the optimal amount of sunlight. It also retains the qualities of water purification and ‘aesthetic beauty’ as described previously. In addition to rotating the segments that reference the contours of the mountain; it allows for additional points for the stormwater lines to connect in a meaningful and un-convoluted manner.

4.3.2. Defining and Harmonizing Space
Boundaries surrounding the quarry are varied in their scale and function. Considerations of how space is encountered can influence the placement of buildings function and form. Environmental systems present can function with changing spaces, presenting further opportunities for spatial development.

Figures 58. Quarry sketch in Section, By Author

A Venn diagram provides a framework of how spaces can be organised. Functions of the spaces have been separated into their respective ‘circles’.

The project identifies the following; Green Space, Natural Filtration Infrastructure, Wildlife Observation Spaces, Wetlands, Education Centre, Community Centre.
Some spaces in the diagram have no intentional overlap, defining a distinctive separation or irrelevance of space. The positioning of the overlapping spaces indicates a transition; these spaces can be simplistic or function under both ideas. The spaces with overlap present significant architectural interest, as they dictate how smooth or dramatic the transition can happen. The lines of intersecting circles delineate the transition occurrence.

The ‘transition’ between spaces can be identified by many ideas or objects.

**Material transitions** are the simplistic method of transition and often harsh. Cladding, framing or linings can end between each other, forming a definitive line and often gives a distinction between spaces. They can also be subtle with appropriate material choices, cladding options that provide cantilevers or flexible ending points. The materials may change in colour, in relation to position, light or reflectivity.

**Functional transitions** rely on the accurate positioning and relevance of neighbouring amenities or functions. Along with the function defining the nature of the transition, the spaces can be public, semi-public, semi-private and private. The focus of functional spaces is to affect the occupant’s movements and actions in a meaningful manner. Following from the occupant’s actions, accepted behaviors are established within the space.

**Spatial Transitions** support the functional and materialistic transitions by expanding or contracting space. Spaces can have many definitions being wide or narrow, open or closed. Space is commonly identified in architecture as indoor, sheltered and outdoor space. The spatial transition can influence the occupant to lead, follow or wander through the space.
Spacial layouts of the building are defined by the flat façade, seen in most traditional buildings. The walls and openings create defined and sometimes harsh finishes between spaces. The definition of space can be utilized to restrict or present authority when entering and exiting spaces.

Movements of the façade expand and contract the space accordingly. Floors and vertical channels are created. Functional space is contracted and internal transitional spaces are formed. The lines between functional and transitional space are undefined, but can be produced or extenuated through different spacial defining methods.

Further experimentation with 'pushing' and 'pulling' façade lines at ground level create different forms of transitional space. Transitional space can be interior, partial exterior connection and sheltered exterior connections. The transitional spaces offered can produce almost seamless changes of spatial function when used in combination with materialistic and functional layouts.

Shadows cast upon traditional building layouts exhibit deep shadows in the centre of the building. Deep floorplans require light tunnels or atriums placed in the centre to allow light to enter the space. Functional space is reduced and options for functions are limited.

Stepped façades allow light to enter elevated space. The light cast upon the lower spaces is reduced, where the opportunity of low-light functions may operate. The elevated space also defines an outdoor space, producing transitions between interior and exterior space.
Developing the internal spatial layout of the stepped façade, a ‘light well’ or partial atrium may be introduced. Translucent roofing may be introduced, with the benefit of diffused light deep within the floor plan. Consequences of spatial layouts and materiality reduce the functional capacity of the space and light on elevated floors over-expose, making spaces prone to overheating and ultraviolet lights.

Interior spaces and transitional spaces are equally defined, with functional spaces reduced to increase the indoor and outdoor transition. Opportunities are presented for atrium spaces on elevated spaced and sheltered space. Central spaces provide an opportunity for sheltered greenery, increasing air quality where required and providing ambience.

Increasing the central floor to reduce the courtyard space increases the spatial opportunities for green spaces. Courtyard spaces above become intimate spaces and accessibility is increased. An exploration into transitional of green space, functioning in the transitional and functional spaces.
4.3.3 Iteration of Environmental Infrastructure

Mineral extraction from the quarry has left the environment baron, with once fertile and immense biodiversity occupying the land now gone. The land and geography that remains in Three Kings Quarry has steep topography which proves a difficulty in using traditional brownfields regeneration methods.

In addition to the steep topography; the underground aquifer passing through the soil of the mountains fills the site which requires active pumping, which provides added complexity to the systems involved; but introduces a unique architectural and environmental resolution that can be developed upon.

The cultural, political and environmental circumstances surrounding the Three Kings Quarry development conclude that a wetland is one of the many solutions the issues the quarry presents.

A wetland has the following requirements.

- Flood Flow
- Water treatment concerning the quality
- Detention of surface, ground or stormwater
- Fine filtration
- Remove contaminants from stormwater runoff

The concept of bringing the environment and supporting the architecture with the aid of engineering is the perfect example of an architectural precedent that can where developed, refined and function for the contextual requirements the project and the quarry presents.

Design iteration is instigated by ‘The Dutch Pavillion’ as a culmination of architecture, engineering and environment. Trees occupy elevated levels and provide a ‘relief space’ for the occupants and purifies the air through photosynthesis.

Three Kings contains air quality issues near neighbouring commercial and residential property along north the east boundary. Formation of the wetland, carbon emissions, and light cast upon the site provide opportunities for air and water purification on a large scale.

The article ‘Floating Treatment Wetlands’ by Chris C. Tanner, Games Sukias, Jason Park, Charlotte Yates and Tom Headley provides a controlled and tested method of ‘biofiltration’ which can aid in the water purification required by Three Kings Quarry. The article details the use of wetland plants and

https://www.researchgate.net/publication/266892416_FLOATING_TREATMENT_WETLANDS_A_NEW_TOOL_FOR_NUTRIENT_MANAGEMENT_IN_LAKES_AND_WATERWAYS.
marshes made buoyant by a raft or mat substrate in which roots are permeable to the buoyant material. Roots are in direct contact with the waterways that are contaminated or specific to the article ‘nutrient-rich’ waterways.

Controlled testing of the ‘Floating Treatment Wetlands’ shows decreased ammonium nitrate, nitrogen, phosphorus concentrations over a week-long period, though it is noted that algae growth from the shading mechanisms provided by the plant medium and wetland plants contributed to the change. ‘Flow-through mesocosms’ where water flowed through in a stream of water, however, were recorded over nine months and showed significant reductions in nutrient density as demonstrated in their data.

Figure 71. Floating Treatment Wetland Diagram, “Floating Treatment Wetlands: A New Tool for Nutrient Management In Lakes And Waterways”, Image by Hedley & Tanner, 2011), 1, Fig.1, https://www.researchgate.net/publication/266892416_FLOATING_TREATMENT_WETLANDS_A_NEW_TOOL_FOR_NUTRIENT_MANAGEMENT_IN_LAKES_AND_WATERWAYS.

Conclusions from the study noted that the FTW system is a new tool to aid in the development of wetlands, consideration and great care must be considered to justify the use of FTW system. The FTW system can be retrofitted, the depth of the floodwaters

must be considered, and control of the ‘flow’ of the water must be controlled to prevent the destruction of the plant roots, substrate and buoyancy devices used.

The creation of a ‘biofiltration’ system is required to respond to and fulfil the requirements. ‘Building Greener’ by Newton, J; Gedge, D; Early, P; Wilson, S provides a beginning point for which the environmental system can operate. ‘Intensive’ Green Roofs as described by ‘Building Greener’ shows an environmental system diagram that details a substrate of between 150mm to 1500mm, which is adequate for the biofiltration system required.

‘Intensive’ green roof systems designed are described “comparable to open spaces at ground level and can allow human access... the depth of the substrate, and the ability of the substrate to hold significant volumes of water.” Alterations to the design involved allowances for the flow of water to be considered and ease of maintenance and usability.

Designing and developing an environmental system that can filter the water, therefore improving the water quality of the site is of immense importance. To allow the wetlands plants to obtain the excess nutrients from the water as a byproduct of purifying; it will enable the plant to grow more freely and efficiently. This method of water purification also opens additional possibilities, including using the ‘biofiltration system’ to graft plants used for cloning and growing fruits and vegetables.

To bring the function of the ‘biofiltration system’ to the surrounding environment; there are possibilities of allowing the porous surfaces to drain into the quarry, which it currently does. Pre-filtration pre-requisites involve a ‘catch filter’ to prevent oil spill-off and hazardous contaminants entering the filter.


Connecting local stormwater systems to the water filtration systems includes the added benefit of reduced demand on the public stormwater system during heavy rain; allows ‘grey water’ to be used efficiently with minimal treatment required, in comparison to turning the stormwater into potable water. Inclusion of the local stormwater system also allows a consistent flow of water to be used throughout the site, improving water flows, preventing eutrophication and supporting the sustainability of the artificial wetland environment.

Oil and Sediment analysis dictates that sources come from the Southern, Eastern and Northern boundaries of the quarry. Run off from Mount Eden Road and commercial facilities pose a serious issue to water quality. Water treatment systems developed must have the ability to ‘filter’ the pollutants.

Oil by nature floats on the surface of water, and sediment having a higher density falls beneath water. Taking advantage of physical properties can be used to benefit the filtration systems developed in the quarry.

Diagrams of oil and sediment filtration systems calm water flows and allow contaminants to separate naturally. Proceeding forward, the system ‘skims’ oil from the surface and stored in an isolated chamber. Water is pumped or natural pressure allows contaminated water to proceed into filtration or runoff.

The proposed environmental diagram describes the filtration process of contaminated run off from land beyond the quarry boundary. The steep formed slopes from quarrying provide an opportunity for the system to ‘step’ allowing the oil, water and sediment to drain more efficiently. Natural planting above and below provides a natural boundary preventing obstruction or damage of the system.
To provide adequate water pressure to transport water to the elevated water filtration towers, a system is required to transport water to higher elevations. Two among the five filtration towers require force pumped water. Traditional pumping systems require electrical or hydraulic services, which is contradictory to the philosophy of the project.

‘Ram pumps’ provide an environmentally conscious design to deliver pressurized water to elevated areas. Ram pumps utilize natural water pressure from tanks or reservoirs. Two valves control the quantity of water delivered opening & closing in opposition. This provides a continuous flow of water above the natural water line of the reservoir.

Figure 74. Ram Pump Diagram, Diagram by Author
Figure 75. Design Iteration – Site Masterplan, By Author
Figure 76. Environmental Systems Diagram Development, By Author
Figure 77. Design Iteration – Environmental Diagram, By Author
5.0 Reflection, Critique & Final Statement
5.1 Reflection

Reflecting upon the design process of the project, many complexities arose that made fundamental design ideas challenging to produce. Unique site conditions enforced strict limitations to traditional design.

Literature was limited, with traditional ‘fields’ relating to environmental design, brownfields regeneration and legislative procedure. Designing within quarries is an unexplored area and demands further research and experimentation. Overcoming this shortfall required an iterative design process, where documentation and media explored the design processes of building. ‘Eden: The Complete Inside Story’ and ‘Land Use Options – Mount Wellington’ provided a genuine design philosophy that exposed errors which the project could learn and develop from.

The architectural precedent selection was limited and approaches to design varied extensively. To ‘open’ more precedence, projects were deconstructed into fundamental functions which addressed contextual, environmental, social and political issues. While select projects applied design methodology in unison with the research project, deconstruction of building functions strengthened the foundations which design development would derive.

Stances on the development of Three Kings quarry constrained design development. Due to the financial, political and sometimes emotional investment in the site, ideas presented in conceptual stages are open to criticism. Architectural ideas require substantial refinement, even in the preliminary stages.

To overcome the criticism of conceptual ideas, the project’s understanding of environmental systems and technical detailing required improvement. Execution of the environmental systems mentioned is not the purpose of the project, but to address the need of environmental systems in the architecture and landscape. Fundamentally, the environmental systems operate from a mechanical engineering standpoint.
5.2 Critique
The project aims to address the environmental issues associated within and surrounding Three Kings quarry. Outcomes of the final design influence the social, cultural and political context of the site with positive intent. The project proceeds further to address the environmental degeneration of Auckland’s wetlands, albeit smaller in scale.

Functions of the project include natural water filtration infrastructure, artificial wetlands, visitors, community and an education centre. Supporting elements of the architectural functions include wildlife observation spaces and vegetation and succulent growing spaces.

Transitions of spaces resolve the inconsistent flow that the quarry contours and boundaries create. Utilizing the site constraints such as the underground aquifer to create a function brings a sense of ‘life’ to the site.

Remediation of the quarry in a considerate and efficient manner encourages the use of water; it is filtered, purified and pumped into building services. Functional growing areas for edible plants provides a beneficial purpose for the community, with opportunities to create interactive public spaces. This kaupapa follows to the functions of the visitors and education centres, where occupants are educated in the process of how plants are grown, the environmental benefits of wetlands, water purification and how human activity influences the quality of water.

The project assumes that the growth of Auckland will remain at a constant, steady pace. As the wetland plants, greenery and landscape matures, the density of the urban fabric surrounding the site will increase. It can be assumed that surrounding land will be developed into high density residential and commercial space. The new ‘artificial wetland’ will create a place of relief from the congestion and pace of the city that surrounds the site.
5.3 Final Statement

Resources and literature within architecture are limited regarding quarry and wetlands design. Design iteration of context, culture and environmental design creates endless possibilities where architecture can expand into the most challenging of sites. The research project demonstrates one of many design resolutions that can be created within Three Kings Quarry.

With an open mind, an environmental infrastructure is a tool that can be utilized in the field of architecture. The influence of infrastructure can fundamentally change how architecture operates. Instead of sealing and concealing services, infrastructure can co-habituate in space as a tool within the architectural discipline.
7.0 Bibliography

Books & Reports


Hollands, David E. Land Use Options for Winstone’s Quarry Site Mount Wellington, 1990.

Kirk, Thomas, On the Flora of the Isthmus of Auckland And The Takapuna District in Transactions and Proceedings of the New Zealand Institute, 1870, vol.3,


Articles, Newspapers & Journals

Websites


Documentaries
List of Illustrations

Figure 1. Authors Diagram = Underground Aquifers of Auckland 10
Figure 2. Authors Diagram – Three Kings Quarry 10
Figure 3. Three Kings Site Photos – 1868, 1920 and 2009, Photograph by Auckland Museum, Richardson Album V.5 & V.24, 143, (Auckland, NZ.: Auckland University Press, 2011.) 14
Figure 4. Volcanic Field of Auckland – diagram by Hayward (Auckland, NZ.: Auckland University Press, 2011.) 15
Figure 5. Diagram of Māori OccupationDiagram by Te Puni Kōkiri http://www.tkm.govt.nz/iwi/te‐akitai‐waiohua/ 16
Figure 6. A Legend of Te Tatua Pa, Text by George Graham, http://www.jps.auckland.ac.nz/popup.php?wid=1130&pn=168. 18
Figure 7. A Legend of Te Tatua Pa, Text by George Graham, http://www.jps.auckland.ac.nz/popup.php?wid=1130&pn=167. 18
Figure 8. A Legend of Te Tatua Pa, Text by George Graham, http://www.jps.auckland.ac.nz/popup.php?wid=1130&pn=170. 19
Figure 10. Site Photo of Three Kings Quarry ca. 1940 - City of Volcanoes, Photograph by Whites Aviation, 145, (Auckland, NZ.: Auckland University Press, 2011.) 20
Figure 11. Reservoir Diagram, diagram by ‘TappedIn’ Watercare – An Auckland Council Organisation, 2017. 21
Figure 12. Three Kings Quarry Unitary Plan Zones, Data obtained by Auckland Council GeoMaps, 2019. 22
Figure 13. News articles relating to Three Kings Development, Image by Author 23
Figure 14. Masterplan Proposed by Fletcher Residential, Plan by DKO Architecture (NZ), 2017. 24
Figure 15. Three Kings Stage 1A by Fletcher Residential, Plan by DKO Architecture (NZ), 2017. 25
Figure 16. Site Image of The Eden Project, Photograph by Tasmyn Williams https://edenproject.com/sites/default/files/ep‐t1/HERO‐Eden_by_Tamsyn_William_0.jpg. 32
Figure 17. Image of Eden Project Interior Photograph by https://www.edenproject.com 32
Figure 19. Dutch Pavillion Site Photo, Photograph by MVRDV, 2000. https://www.mvrdv.nl/projects/158/expo‐2000. 34
Figure 20. Spatial diagram of The Dutch Pavillon By Author 34
Figure 23. Dutch Pavillion Sectional Diagram – Figurative notes by Author 35
Figure 26. Gardens by The Bay Environmental Systems Diagram, “Sustainability Efforts” By Gardens By The Bay, Accessed February

Figure 28. Wasit Nature Reserve Interior Photo, Photograph by Nelson Garrido


Figure 30. Wasit Nature Reserve Site Photo, Photograph by Nelson Garrido


Figure 32. Design & Building Methodology, Diagram by X Architects, Accessed June 29, 2019, https://www.archdaily.com/784055/wasit-natural-reserve-visitor-centre-x-architects


Figure 34. Stonefields Masterplan Option A "Land Use Options for Winstone’s Quarry Site Mount Wellington” diagram by David E. Hollands

Figure 35. Stonefield Masterplan Option B, “Land Use Options for Winstone’s Quarry Site Mount Wellington” diagram by David E. Hollands

Figure 36. Stonefields Masterplan Option C, “Land Use Options for Winstone’s Quarry Site Mount Wellington” diagram by David E. Hollands

Figure 37. Site Photos of Big King Reserve, By Author

Figure 38. Site Geology, “Three Kings Renewal, Contaminated Land Overview”, Report by Winstone Aggregates, 2014.

Figure 39. Site Analysis - Important Viewpoints, By Author

Figure 40. North-South Cross Section of Three Kings Quarry in relation to Big King, By Author

Figure 41. East-West Cross Section of Three Kings Quarry in relation to Big King, By Author

Figure 42. Geomaps Data of Site Hydrology, Data obtained by Auckland Council GeoMaps, 2019.

Figure 43. Filtration Sketch Diagram, By Author

Figure 44. Green Roof Systems Diagram, “Types of Green Roof”, Diagram by Building GREENer

Figure 45. Structural Iterative Design, By Author

Figure 46. Filtration Sectional Detail, By Author

Figure 47. Concept Tower, By Author

Figure 48. Conceptual Shape Development, By Author

Figure 49. Conceptual Shape Development, By Author

Figure 50. Conceptual Shape Development, By Author

Figure 51. Conceptual Shape Development, By Author

Figure 52. Site Plan, By Author

Figure 53. Design Development – Render, By Author

Figure 54 Design development – Render by Author

Figure 55 Design Development – Render, By Author

Figure 56. Design Development – Sections, By Author

Figure 57. Conceptual Design of Water Filtration Infrastructure, By Author

Figure 58. Quarry sketch in Section, By Author

Figure 59. Venn Diagram of Masterplan Layout, By Author

Figure 60. Material Transitions Sketch, By Author

Figure 61. 'Traditional' Section, By Author