KAURI FLATS SCHOOL – RESILIENT STORMWATER DESIGN IN A CHALLENGING ENVIRONMENT

M. Buhr, A. Cooper, P. Hutton

ABSTRACT

The Kauri Flats School stormwater design was a complex and challenging process with multiple external influences, design considerations and safety requirements required to develop an innovative, resilient and flexible outcome.

The Kauri Flats School is located in the Auckland Suburb of Takanini, 30 km south of central Auckland on an extensive and deep peat field containing ancient swamp kauri. The School includes the construction of multiple class rooms, hall, carpark areas, playing fields and outdoor learning areas.

The proposed Auckland Council Takanini Cascade stormwater channel runs along the western boundary of the School which is within an extensive flood plain and surrounded by several housing developments, currently under construction.

Throughout the design process multiple stormwater, structural and geotechnical issues were identified which influenced and directed the stormwater design. Of particular concern was the possibility that any pipes in the ground would be susceptible to differential settlement. As an understanding of the issues with the site grew the stormwater system was developed and modified to provide a robust, flexible and cost effective outcome.

The stormwater design provided an innovative and resilient approach to recharge the underlying peat, manage the flood risk to the School while treating and conveying stormwater safely during construction and the ongoing operation of the School.

KEYWORDS

Water Sensitive Design, Innovative, Resilient infrastructure, Safety by Design

1 CONTENTS

2 INTRODUCTION

The Kauri Flats School is located at 181 and 191 Walters Road in Takanini, approximately 30 km south of Auckland Central, shown below in Figure 1. The site is located within an area identified by the unitary plan as an area of future growth. The area identified for development is within an extensive flood plain with underlying peat and was, until recently, farmed.

Chester Consultants was involved in the project to provide a civil engineering design for the proposed primary School.

The project faced multiple challenges to determine the most appropriate stormwater management solution, including differential settlement of the peat, ground water management, flooding and the completion of neighbouring infrastructure.

The design process for the school was not lineal, with refinements being undertaken to account for information as it became available, including lessons learned from neighbouring developments, geotechnical investigations and the developing design of the catchments public infrastructure including stormwater, roads, water and wastewater.

This paper discusses the design process for the Kauri Flats School stormwater management and how it was adapted and refined to provide a resilient and fit for purpose stormwater solution for the Kauri Flats School development.

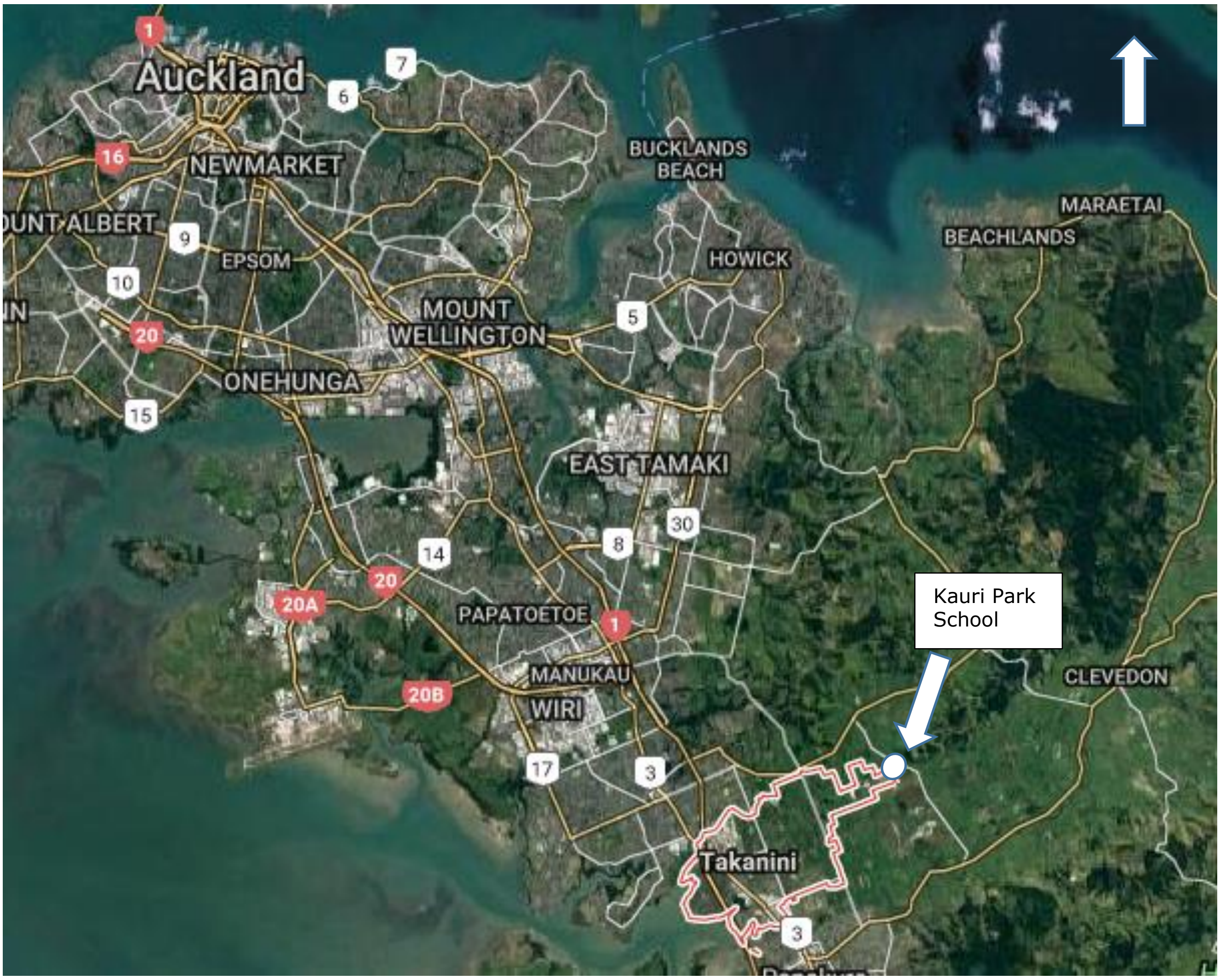

Figure 1 – Auckland Area showing Takanini and the Kauri Flats School location

3 BACKGROUND

In order to accommodate the growth of Auckland, a number of Special Housing Areas have been created to provide for the growing city's housing demand, refer Figure 2. With residential development comes the associated requirement for infrastructure, community facilities and amenities.

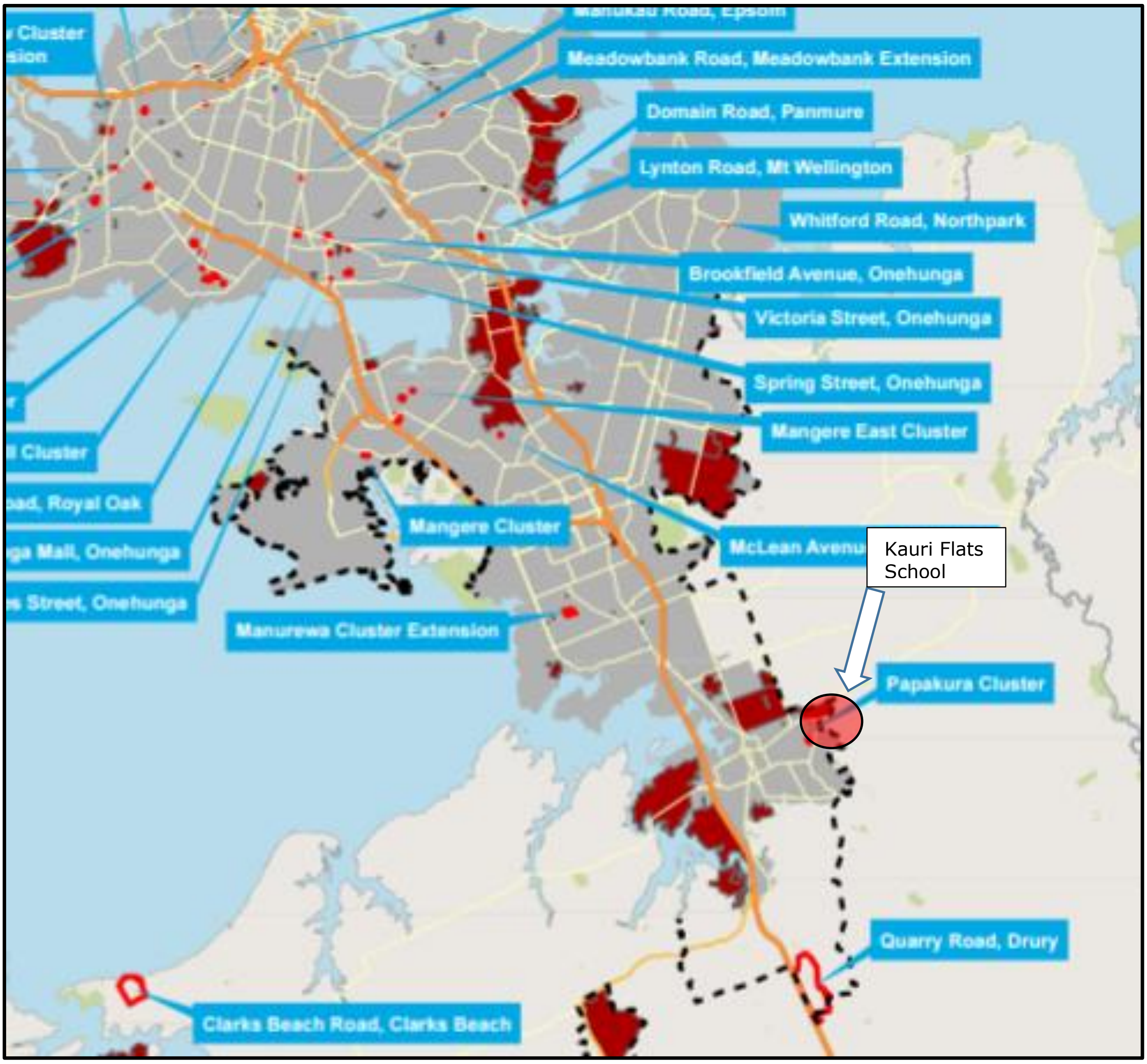

Figure 2 – Special Housing Areas (Auckland Council, April 2016)

Historically the area was occupied by an ancient kauri forest and extensive peat swamp. With Maori and then European settlement the region was used extensively for agricultural purposes including flax milling.

With the arrival of European settlers, the extensive swamp area was eventually drained and used for farming and market gardens. The area still receives stormwater flows from the Hunua Ranges and is subject to extensive flooding.

To meet the growth demands of Auckland, the area has been identified as an area for development, and consequently development is well underway in this area. As the area is flat and subject to extensive flooding the Takanini Cascades stormwater diversion channel is being constructed by Auckland Council Healthy Waters to mitigate the risks of flooding in the area by 2018.

The Kauri Flats Primary School is due to be fully operational by the end of 2017 and is adjacent to the future Takanini Cascades stormwater diversion project. The Takanini Cascades Framework plan (2016) demonstrates the development surrounding the proposed School and Channel, shown below in Figure 8.

Figure 3 – Takanini Cascades Framework Plan.

4 PROJECT DESCRIPTION

The Kauri Flats School is located at 181 and 191 Walters Road and is approximately 3.2 km east of the Takanini town centre and 30km south of central Auckland. The site is on the southern edge of Walters Road located between Cosgrove and Grove Roads. The future Takanini Cascades stormwater channel is along the western edge of the site, refer Figure 4.

Figure 4 – Kauri Flats School Area

The School has a total area of 4ha, and when completed will include administration buildings, classrooms, hall, parking, access roads and playing fields.

There are multiple future residential developments currently being constructed immediately east, west and north of the site which, along with the School's stormwater, will discharge to the Takanini Cascade stormwater channel when completed, shown below in Figure 5.

Figure 5 – Artist impression of the Takanini Cascades stormwater channel (Auckland Council March, 2017)

5 STORMWATER DESIGN CHALLENGES

Multiple design challenges were experienced throughout this project's design to deliver a resilient and sustainable stormwater solution for the Kauri Flats Primary School including:

- Enabling works for the School
- Neighbouring developments
- Peat and the requirement for ground water recharge to reduce the effect settlement on building foundations.
- Revisions of the School's development scheme plan

- The management of stormwater from the site during earthworks construction, during School operation, and on completion of the Takanini Cascades stormwater channel.
- Land ownership and easements required to construct servicing developments

5.1 ENABLING WORKS, NEIGHBOURING DEVELOPMENT AND PROGRAMMEME

The Ministry of Education construction programme required the School to be opened by early 2017, fully operational by the end of 2017, and with completed playing fields by February 2018. Providing a total investigation, design, consent and construction period of approximately 11 months to deliver the first phase of works.

The ultimate objective of the School's stormwater design is to direct stormwater flows to the Takanini Cascades channel. The School is to be operating by early 2017, however the estimated completion date for the Takanini Cascades channel was early 2018. This required the School to temporarily manage flows and flood water until channel completion.

5.2 PEAT

The extensive peat within the construction area required groundwater recharge, to reduce the risk of ground settlement. The design required the first 15mm of rainfall to be directed to recharge the groundwater throughout the School. The use of the Takanini Cascade channel to convey stormwater from the development required the consideration of effects as a result of groundwater table drawdown.

Neighbouring developments provided insight into infrastructure and how it performed within the peat environment. Of particular interest was how standard piped networks had the potential to fail due to differential settlement of the peat. As an example, a neighbouring development showing the extensive peat soils and ground water depth is shown below in Figure 6.

Figure 6 – Condition of peat soils on site

5.3 CONSTRUCTION AND ENABLING WORKS

The School development was staged so the School operating by early 2017, fully operational by the end of 2017 and with completed playing fields by February 2018. The stormwater solution needed to be adaptive to accommodate the staged approach of the School's development. The School was required to maintain pre-development flows for up to the 1 in 100-year event during earthworks and School operation, until completion of the Takanini Cascades stormwater channel.

A priority for the design team is the safety of students and staff and in particular the concern of open bodies of moving water adjacent to the development, flooding and construction machinery. Developing a stormwater management solution that had safety at the forefront, particularly with regard to open areas of water posed a particular challenge for the design team.

As part of the stormwater management during construction the design team provided sediment and erosion control devices to receive sediment laden stormwater and treat it prior to discharging from site to table drains adjacent to the site, refer Figure 7.

Figure 7 – Temporary Pond sediment retention pond and ground water

The neighbouring developments and associated infrastructure and public road projects in the area affected the design of the School's wastewater, stormwater, site access. Much of the critical infrastructure in the area is in its design phase, and being able to communicate ideas with Watercare Services Limited, Auckland Transport and Auckland Council was extremely valuable.

The communication also highlighted risks as they arose, potentially minimising issues during the construction phase. The Takanini Cascades Framework Plan (2016) demonstrates the development surrounding the proposed School and Channel, shown below in Figure 8.

Figure 8 – Takanini Cascades Framework Plan.

The Takanini Cascades stormwater channel required a construction corridor along the Schools western boundary to convey the catchment's stormwater safely from the wider development area. Whilst the School site is relatively large the inclusion of the channel along the western boundary had a significant impact upon the School. As such a number of meetings and iterations of the design occurred for both the channel and the School layout. The outcome is a 20m wide easement along the western boundary for the channel.

6 DESIGN APPROACH

The design team regularly discussed the project risks and effects of the development to determine a solution that would meet the Ministry of Education's requirements for delivery, resilience and safety while the team worked with neighbouring developments to integrate the design with surrounding areas.

Much of the critical infrastructure in the area is currently in the design phase and is being regularly refined as risks such as geotechnical are identified. Having the ability to communicate project risks and ideas with different parties provided valuable design input to managing the stormwater of the development.

The stormwater design of the Kauri Flats School experienced several revisions as information of the site and surrounding developments became available. Below is a summary of the design phase and outcomes.

The stormwater design approach throughout this project underwent three key phases, namely the initial design, followed by a review of the proposed piped solution, and finally the value engineered and collegial design. The design approach captured and caters for as many facets of the constraints as possible including the neighbouring developments.

6.1 CONCEPTUAL DESIGN

The conceptual design phase quickly identified the flat nature of the development area and underlying peat, as a design challenge, refer Figure 9. The Takanini Cascades stormwater channel, adjacent to the site, was also identified early as a challenge to the design team.

Figure 9 – Image demonstrating the site topography.

Limited information was available upon the project's inception, and very few constraints surrounding the serviceability of the site were known. The preliminary stormwater design was based on limited information including a geotechnical desktop study and architectural concept plans, in line with specifications from the designation for the land use.

The information available showed a deep peat soil profile, a sensitive and variable water table, a table drain within Walters Road as a means of stormwater disposal, as well as other services available within the road reserve close to the site.

It was thought the development leant itself to surface water management devices for conveyance and ground water recharge. Preliminary discussions included the use of open channels and on site attenuation basins, built up above the existing ground to make use of the soil's soakage properties and maintain the pre-development flow discharged from the site. The option of open channels was not preferred due to safety concerns for children, and the risk open channels and basins would pose. The result was a traditional (piped) solution designed to drain to temporary attenuation basins to maintain pre-development flows from the site and comply with the network discharge consent.

Enquiries were made to Auckland Council to clarify the design of the Takanini Cascades channel which would determine a suitable discharge point and elevation from the School. However, as the channel was still in the design process this information was not available.

As the site was flat any earthworks would heavily impact the design of stormwater infrastructure. While providing cover over a pipe network was beneficial in maintaining gradient the differential settlement expected of the peat soil from the additional weight had to be considered.

Peat soils are typically high in acidity, making the pouring and setting of concrete against insitu material problematic. At the time of the design, no information was available on the acidity of the soil raising an issue with the use of concrete infrastructure for this development.

6.2 INITIAL DESIGN PHASE

During the initial design, there remained limited geotechnical and groundwater modelling information available. Discussions with Auckland Council Healthy Waters over the Takanini Cascades easement, land ownership and construction costs was still being confirmed as the design progressed.

To deliver the development to programme it was required to continue the design of the School and stormwater infrastructure and develop a stormwater solution which would enable the School to operate until the Takanini Cascade was completed. The outcome of this was to assume the Takanini Cascade channel footprint / easement and manage all stormwater on site during construction and operation of the School. The result was a series of temporary attenuation ponds and pumps throughout the School, designed to manage stormwater discharge and flood risk while managing ground water until the completion of the Takanini Cascade channel.

Stormwater recharge and ground water management was critical to minimise the risk of differential settlement of the School buildings and pavement areas. The effect of the School's impervious building and pavement areas limited the opportunity for ground water recharge. Recharge pits were designed to receive surface flows from buildings and pavement areas and discharge the first 15mm to the ground with overflows directed to the reticulated networks.

The initial method to convey stormwater to the management bunds was via a stormwater reticulation network. The stormwater reticulation network would direct flows from recharge pits and reuse tanks to the sumps where it would be pumped off site. The proposed stormwater network would provide for the staged implementation of the School and be simply integrated with the proposed buildings, footpaths and roads.

At this point of the design phase the Ministry's desire to achieve a green star rating for their development was noted. To provide ground water recharge and rainwater harvesting volume a siphon detail was developed to direct the first 15mm to ground water recharge, and the remaining flows to harvesting tanks for reuse.

The initial design phase ended with a proposal submitted to the Ministry of Education's Design Review Panel to assess its suitability. This allowed for a critical review of the proposal both internally and externally. The review raised questions in the following areas;

- Challenges associated with the recharge of groundwater and consequent conveyance of stormwater seemed over complex, and relied on small margins within changes of level at inlet and outlet locations between the piped stormwater network and the recharge trench outlets.
- Under the designation, reuse of stormwater was required, however, this was not quantified. There is a priority to recharge the groundwater, before capturing stormwater runoff for reuse and then discharging into the receiving environment. The recharge of groundwater allowed for movement of water out of and into the recharge trench or pit. This would then surcharge and enter the retention tank. Potentially contaminating the water, and amplifying potential effects related to sedimentation within the tank. Additionally, green star rating of the project was sought, an element of which is water reuse. The need to recharge the groundwater took precedence and the concepts developed to divert flows to reuse with minimal contamination was developed.
- The buildings and associated foundations directed the methodology of earthworks. The initial design presented the concept of preloading the soil prior to constructing the foundations of the buildings to minimise adverse settlement effects. Later iterations looked at piled foundations, and finally to a combination of piled and raft solutions were adopted as part of the value engineering exercise for the project. This affected how much soil could be imported on the site. The quantity of fill affected the cover over the reticulated network at the upper reaches of the catchments, resulting in a shallow gradient in the stormwater network.
- As a result of the stormwater network shallow gradients and cover the network was susceptible to any settlement. With little error in the design and the susceptibility to settlement a different stormwater solution was required. The issues noted on other sites in the area lead to the desire by the client to have a system that reduced the risks of settlement of stormwater systems. Consequently, the design team investigated options for an open channel network across the site.
- While stormwater infrastructure is a relatively minor cost to the development in relation to buildings, a review of the budget required a review of the infrastructure. Comparing the piped gravity network to the open channel network also suggested that a network of open channels is better suited financially, providing a value engineered solution suited to the environment.

6.3 REVISION

As the engineering review was being undertaken ongoing negotiations with Auckland Council Healthy Waters continued to resolve the design details and construction timing of the Takanini Cascade stormwater channel.

The points raised by the design review including the sensitivity of the reticulated stormwater network to outlet invert and geology were considered.

As a result of the review and information from Auckland Council Healthy Waters as the Takanini Cascades design was developed, it was concluded the stormwater design solution needed to:

- Maximize ground water recharge.
- Provide resilience to ground settlement and be flexible to an outlet invert level still being developed i.e. the Takanini Cascades.
- Minimise influence from neighbouring developments as they come online

- Maximise on the ability to utilise the proposed Takanini Cascade stormwater esplanade area for temporary attenuation volume.

A value engineered and collegial design saw the application of a swale network through the School, (Figure 10) graded at 0.5% to direct surface water to the future Takanini Cascade stormwater channel.

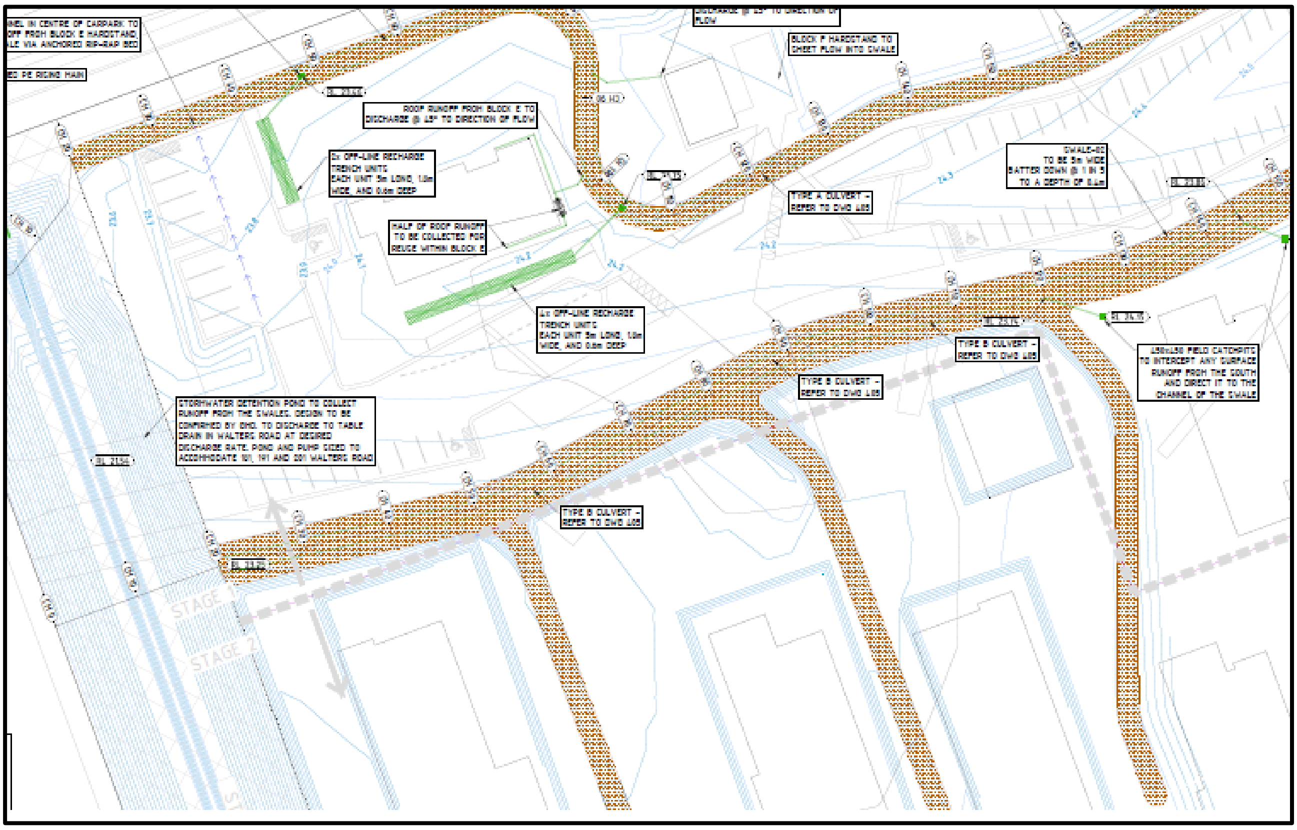

Figure 10 – Proposed Swale Network

As the swale design was progressed the refinement of peat soils recharge to reduce the risk of differential settlement within the development was also refined. To achieve a larger soakage area the conveyance swale was integrated with a scoria / recharge trench, refer Figure 11.

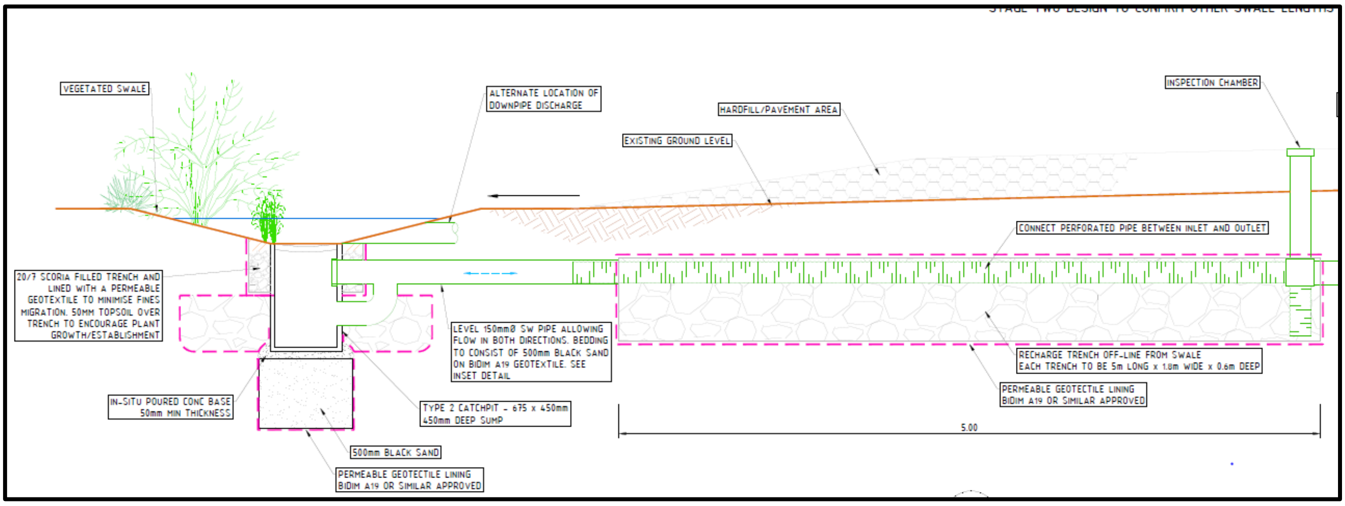

Figure 11 – Typical swale with recharge detail

The concerns of open channels through the School and questions of design safety were managed by working the detail of the design with the architectural and landscape features, refer Figure 12.

Figure 12 – Concept impression of School and swales (MOAA, 2016)

The stormwater design provided for the School is adaptive to staging, resilient to ground settlement, and able to service the School throughout its intended design life. It has the added benefit of simple maintenance and adjustment which may be required as settlement occurs.

The third and final phase of the design incorporated all the design constraints mentioned, to provide a resilient solution that is incorporated with the receiving environment. The final design is easily monitored and adaptable for differential settlement as the school grows.

The introduction of the swales throughout the School required the development for pedestrian and vehicle bridges. The design of the bridges needed to take account of the significantly low bearing capacity of the site, the likely differential settlement and additional cost to the project.

6.4 SUMMARY

The design remained fluid throughout the design process and was revised as information became available during the investigation of the site and as the Takanini Cascades Channel design was developed.

Due to the programme delivery constraints the design process could not define preliminary information, such as neighbouring developments, geotechnical constraints and arrangements with large scale public infrastructure to direct the design from inception.

As a whole the design team maintained regular communication with the neighbouring developments and Auckland Council to refine the design and react to new information as it came available.

As a result of the design process, and its flexibility to external influences, the stormwater design provided a resilient and robust solution that is successfully being applied.

7 CONCLUSIONS AND LESSONS LEARNED

The Kauri Flats School stormwater design provides a sustainable and resilient stormwater solution that can be adapted as infrastructure to the area is completed and maintained as settlement occurs.

Due to time constraints for construction and incomplete information the design process experienced several iterations which mitigate the risks identified and provided a value engineered solution.

The design team, as a whole, were able to adapt their approach to account for a number of external influences and risks that arose as the project progressed

The apparent risks at the onset of the project included geotechnical and stormwater. An adaptive and fluid design process enabled the design team to revise the design to accommodate the design risks as they were revealed.

The construction of adjacent developments, such as the Takanini Cascades stormwater channel, affected the design and staging of the development and required design revisions to be developed as information became available.

In addition to these revisions ongoing collaboration was maintained between the design team and a number of external bodies, including the neighbouring developers, Auckland Council, and Auckland Transport to develop the stormwater solution.

The project has reiterated the importance of defining the client’s design drivers, and directing expectations and communicating options, costs and challenges to implement sustainable and resilient engineering solutions with limited information.

8 ACKNOWLEDGEMENTS

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