KIRIMOKO PARK DEVELOPMENT, WANAKA – A LIVING EXAMPLE OF INTEGRATED WSUD

Andres Roa – Director, AR & Associates Ltd
Rowan Carter – Associate - Green Infrastructure, AR & Associates Ltd
Jan Heijs – Director, Heijs Consulting Ltd

ABSTRACT

Kirimoko Park is an innovative 117-lot green-field residential subdivision that exemplifies effective integration of landscape architecture and urban design with stormwater management function.

The design of stormwater management systems within Kirimoko Park is based on a Water Sensitive Urban Design ("WSUD") philosophy. The protection of the receiving environment is achieved through the acknowledgement, preservation and use of the inherent natural landform and hydrology, and the integration of stormwater design with landscape and urban architecture elements.

One of the key objectives of the adopted WSUD philosophy is to mimic natural rainfall-runoff behaviour and maximise the use of 'surface' stormwater features such as swales, raingardens and basins, in favour of traditional underground piped infrastructure. This approach showcases the value and beauty of stormwater when used as a resource, through the visible integration of water features within open spaces. This has resulted in superior landscape architecture, urban design and public amenity, which in turn has translated to a market-edge outcome for the developer with completed lots becoming highly desired by prospective purchasers.

Piped systems provide an ongoing asset management liability with regard to operation, maintenance and renewal. They are also difficult to access, prone to blockage and structural failure and there is an ongoing risk of these underground systems receiving wastewater cross connections. These risks are eliminated with an above ground stormwater solution.

In addition to the environmental, landscape architecture, urban design and public amenity benefits offered, experience within Kirimoko Park has shown that the use of WSUD also results in a more cost effective stormwater management solution when compared to piped infrastructure. This all translates to higher cost-benefit and superior economic outcomes for the project.

The paper will discuss the design process, the implementation and lessons learned as well as customer feedback from the developer and the first inhabitants.

KEYWORDS

Water Sensitive Urban Design, WSUD, LID, Stormwater, Integration, Landscape Architecture, Landscape Design, Urban Architecture, Urban Design

PRESENTER PROFILE

Andres Roa, Founding Director, AR Civil Consulting Ltd (now AR & Associates Ltd)- Andrés has approximately twenty years professional experience with projects for both the private and public sectors throughout New Zealand and overseas. Andrés' experience covers a wide range of fields and lately has focused on integrated engineering design and WSUD.

Rowan Carter, Green Infrastructure/Associate, AR & Associates Ltd – Rowan has over 16 years' professional experience in the stormwater industry, both in local government and in the private sector. He has a passion for soft engineering, water sensitive urban design and maximizing project potential through applying a holistic approach to project development.

1 INTRODUCTION

Despite an increasing trend toward sustainable development philosophies in recent years, a large 100+ lot subdivision development based on a WSUD philosophy is still not common place in New Zealand. Conventional (piped) stormwater design dominates the construction landscape, despite the lower construction cost, improved amenity, increased resilience, greater yield and other advantages that WSUD developments can bring. The Kirimoko Park Development in Wanaka provides a much needed green tick in the WSUD box and will hopefully help to dispel some of the myths surrounding WSUD in New Zealand. This paper discusses the benefits and learnings of the Kirimoko Park Development.

1.1 BACKGROUND TO WATER SENSITIVE URBAN DESIGN (WSUD)

There are many publications and websites that explain Water Sensitive Urban Design (WSUD) e.g. MacMullan and Reich (2007), Victoria Environmental Protection Authority (2005). Although there is a large amount of agreement on what this is or should be, there is also still considerable misunderstanding and in some cases a reluctance to embrace WSUD in favour of proven, conventional systems.

In the context of this paper, WSUD is the integration of the water-cycle into urban planning and design, using or mimicking natural processes at source. WSUD is also about building in flexibility, diversity and adaptability in its solutions. WSUD is a good example of Green Infrastructure (GI), often rendering benefits outside of stormwater management, with significant contributions to the general live-ability of an area. From a stormwater management point of view, the purpose of WSUD is to maintain the hydrological characteristics of an area by maintaining, wherever possible, existing flow patterns and behaviours, using natural resources such as streams and wetlands to avoid/reduce changes in runoff and to provide a stormwater quality treatment function before the runoff is discharged into the environment.

WSUD requires a multidisciplinary approach where stormwater is embedded into other design elements of a project such as urban design, landscape design and roading, during their planning, design, construction and operation and maintenance processes. It requires stormwater to be considered upfront and as an integral part of the design planning, rather than being dealt with in isolation or as an afterthought. The key focus is to manage stormwater on the surface and through its interaction with naturalized urban environment before it enters the pipe.

The paradigm shift is that stormwater is no longer considered a nuisance but a resource. This requires consideration from the start of any planning process. Working with nature becomes the norm.

Stormwater management is an essential part of the water cycle and WSUD. In the past, stormwater effects were seen as a nuisance (flooding) or an impediment to land-development (e.g. streams) and as a result quickly 'piped away'. More recently, end-of-pipe devices such as communal ponds were introduced to reverse some of the adverse effects of stormwater discharges. This approach has not always worked, and in some cases has not effectively addressed adverse effects on catchment hydrology or receiving environments.

WSUD doesn't result in the same solutions in every location. It is more a process that will result in a set of methods that meets WSUD principles, based on the individual merits of a given development site including topography and hydrological characteristics. It should be noted that WSUD involves careful consideration to integrated design and maintaining natural characteristics of the site and its design should therefore be done in recognition of this. Solely introducing treatment devices without context to the site and other design objectives does not necessarily translate to WSUD.

1.2 BARRIERS TO ADOPTING WSUD IN NZ

Despite some very successful examples of implementation of WSUD in New Zealand and around the world, there are still many barriers to adopting WSUD as mainstream practice in New Zealand. We believe that the existing barriers to adopting WSUD fit into four key areas: institutional capacity of Councils, weak regulatory planning frameworks, a lack of leadership within regulatory bodies and the perceived relative expense of building WSUD over other conventional systems.

1. **Institutional Capacity:** Although there is a general understanding of WSUD within public sector stormwater professionals in New Zealand, often WSUD is considered as a stormwater management only approach, or worse just a group of treatment devices, not across the full water cycle and not as an integrated part of urban planning. While WSUD principles are sometimes briefly considered, a full understanding from non-stormwater professionals (such as roading engineers and planners), together with the recognition of the need to use a multidisciplinary WSUD approach from the start of a project, is seldom evident. Further awareness, training and certification in WSUD may go some way towards overcoming this barrier.

2. **Planning Frameworks:** Because the requirement for WSUD is very loosely worded in Regional and District Plans, there is a great level of uncertainty as to how this will be interpreted by consenting teams. This has led to a lack of clarity in terms of what is required, delays in the regulatory process, changes to scope of works, and supports a 'risk-adverse' approach of opting for conventional practices, which is often adopted by Councils when challenged by developers. Developing a set of national guidelines with objectives / policies / rules / methods for councils and applicants to use would help resolve this issue.

3. **Leadership:** Councils have very seldom led by example in WSUD. If they do it is often due to specific circumstances rather than following a deliberate policy to apply a broad reaching WSUD design process in every council initiative. For example, roads are mostly still designed very much the same way as they were before WSUD was introduced or required.

4. **Perceived Economic Viability:** A key impediment to implementation of WSUD is the perception that WSUD is always more expensive than conventional design, both in the short term (construction and development costs) and the long term (operation and maintenance costs). The amount of available research on life cycle cost comparisons between WSUD and conventional piped design is somewhat limited; however there is evidence that through sound engineering design, WSUD can offer significant cost advantages over conventional piped systems during the construction phase (Koru Environmental Consultants Ltd, 2009). Experience in New Zealand would tend to indicate that the project cost savings of using WSUD versus conventional design could range from 20% to 30% (Auckland Regional Council, 2010).

The following sections in the paper will introduce the Kirimoko Park site, philosophical approach to the development and lead through to a discussion on the learnings attained through the design and build process.

2 KIRIMOKO PARK

2.1 SITE INTRODUCTION

Kirimoko Park is located approximately 2km north of the Wanaka town centre and about 1km east of Lake Wanaka (see Figure 1).

Figure 1: Location of the Kirimoko Park Development in Wanaka

The overall Kirimoko Park development boundary is formed by existing residential areas to the west, and the ring road formation of Kirimoko Crescent to the north, east and south – encompassing an area of 11.86 hectares. The Kirimoko Park site and the adjoining land was historically used for high country farming activities and zoned 'Rural General', before Plan Change 13 to the District Plan – resolved on 4 July 2008 – led to the now low density residential zoning for the site.

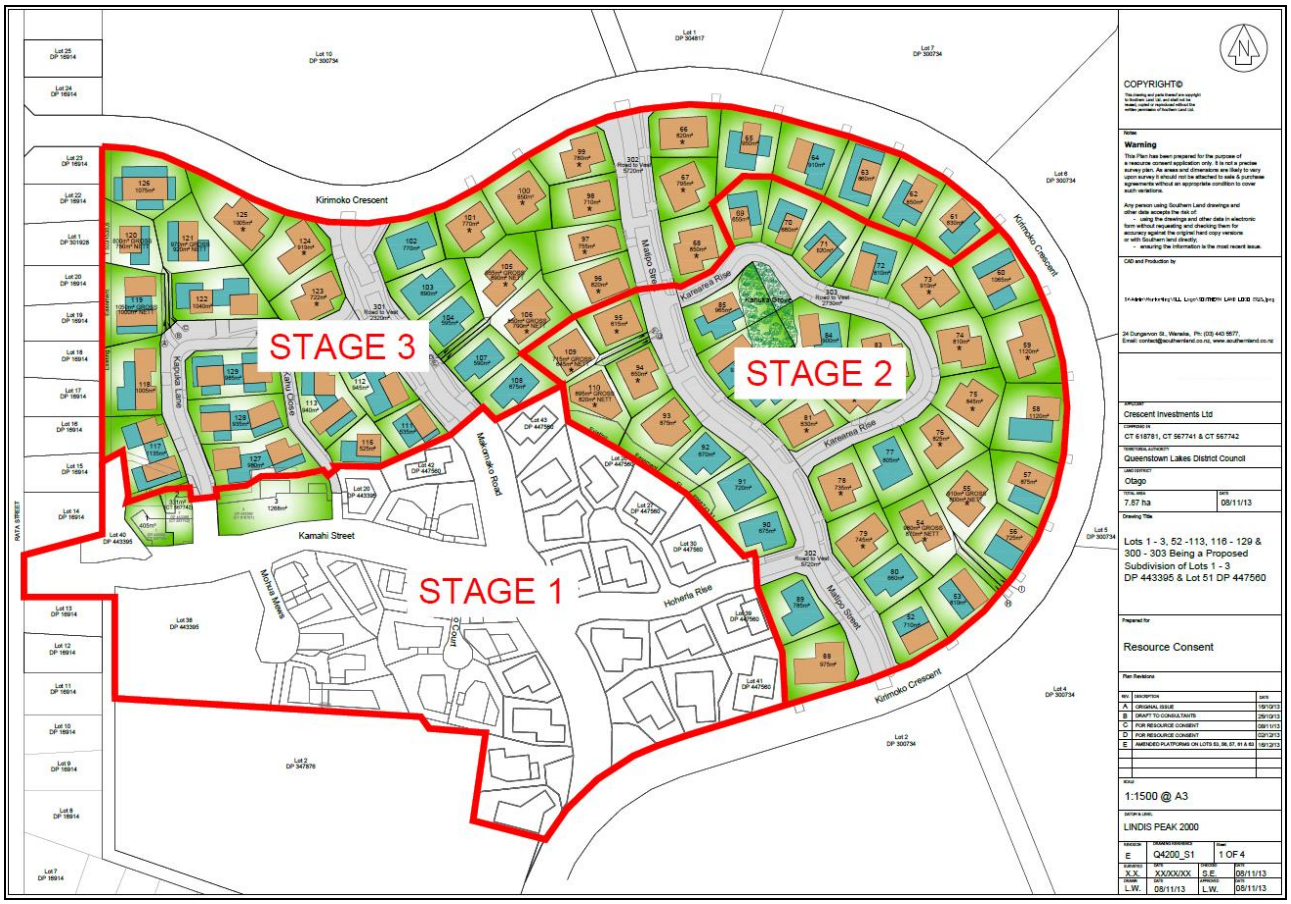
The site is situated above the shoreline of Lake Wanaka by a minimum of 30m, with the topography characterised by undulating gradients, gently sloping at grades of between 2 and 18% towards Lake Wanaka to the west. The localised geology of the site and surrounding environment is composed of loess and glacial till material. The New Zealand Geological Survey (NZGS) geological map indicates that the underlying strata contains outwash gravels, morainic deposits and fan talus. Soils throughout the site are dominated by sandy silts and silty sands of varying degrees of permeability. Infiltration tests undertaken prior to development concluded that infiltration rates across the site would be in the order of 50mm per hour. This conclusion was backed up through investigations on one of the constructed raingardens within Stages 1a and 1b. However, localized variation in permeability has been encountered across the site as is typical of morainic geology.

Due to the minimum 30m elevation above highest water levels within Lake Wanaka together with the comparatively coarse and permeable nature of the soils, groundwater levels have not been encountered during the development. These features are supported by existing geotechnical investigations undertaken in support of the development.

Stages 1a, 1b, and 1c of the development were completed between 2011 and 2013, and have occurred within the south west corner of the site across an area of approximately 4.15 hectares. Stage 2 was more recently completed (2014-2015) and covers an area of approximately 4.17 hectares.

The Stage 3 component of works will result in the culmination of the Kirimoko Park subdivision development, with the development of the last 26 lots encompassing an area of approximately 3.54 hectares (see Figure 2). Earthworks have recently commenced on Stage 3 at the time of writing this paper.

Figure 2. Kirimoko Park Development Showing Various Stages of Development



2.2 BACKGROUND

Kirimoko Park was conceived in 2006 when a plan change was proposed to rezone the wider area, which was previously zoned Rural General and known as the "Kirimoko Block", into Low Density Residential, for the creation of an innovative, sustainable, environmentally sensitive and socially responsible residential subdivision.

The adoption of the plan change (being the Queenstown Lakes District Council (QLDC) Plan Change 13) in 2008 resulted in the creation of the Kirimoko Block Structure Plan, which provided a development platform that collaborated with the existing landforms, took advantage of the remnant vegetation and delivered a 'relaxed' hydrological system virtually free of underground pipe network.

This vision was achieved through the incorporation of high quality urban environments and WSUD principles. The WSUD design principles captured the various visual, ecological, environmental and sustainability requirements for the project, in recognition of the context of Kirimoko Park, its physical characteristics and its surroundings.

In leading the way with Kirimoko Park as the first development in the Structure Plan area, the owners, John May and Don Church of Crescent Investments Ltd continued to direct the development philosophy towards a sustainable and environmentally and socially responsible focus.

This was to be a landscape-led development that would deliver building platforms and infrastructure congruent with the incredible landscape offered by nearby Lake Wanaka and the backdrop of Mount Roy, Mount Alpha and the Buchanan Range to the west.

A landscape assessment and catchment analysis was undertaken and it was agreed that the natural values of the Kirimoko Block were to constitute the palette for a Water Sensitive Urban Design (WSUD) development. The European influence of the landscape architect together with the owners was also the catalyst for a socially integrated roading design that would cater for mixed use in a low speed environment.

The original Kirimoko Park Master Plan resulted in a framework that enabled low impact design and sustainable development to be developed and implemented within the subdivision. The statutory requirements around sustainability were led by a series of objectives and policies and, to a lesser degree, rules that were incorporated into the District Plan through the plan change process to encourage innovative, sustainable design while retaining some flexibility for development.

One of the key products of Kirimoko Park's design-led approach was the introduction of sustainability covenants, to be registered on the lots, which underpin the overarching philosophy and vision for the project. The covenants encourage lot owners to consider sustainability when designing their home and require that they choose from a catalogue of sustainable features for implementation in their individual properties.

Additionally, as a unique approach to this development, WSUD practices and other stormwater assets are vested into council upon completion, but maintenance remains the responsibility of the property owners by way of a management company which is managed through a Residents Association. The costs of operating and maintaining stormwater practices and landscaped areas throughout the subdivision are shared among the residents by way of an annual levy which is paid into the Residents Association on top of the annual rates payable to the Council.

2.3 DEVELOPMENT OBJECTIVES

The Kirimoko Park development incorporates unique landscape and urban architecture characteristics, integrated with a range of WSUD and sustainability principles. The WSUD initiatives are integral to the overall design of this development, being limited not just to the subdivision infrastructure works but extending also to building construction.

The stormwater management design approach for Kirimoko Park is fully integrated with the urban design, landscaping and roading elements of the project, which are in turn guided by the principles set out in QLDC's Plan Change 13. These principles seek to acknowledge and retain the site's natural elements including the natural landform and its inherent hydrology, ecology, and visual characteristics.

Objectives and policies were developed during the Plan Change, including the overarching objective; Objective 7 – Kirimoko Block, Wanaka, which reads as follows:

- *Kirimoko Block – Wanaka – To create a liveable urban environment which achieves best practice in urban design; the protection and incorporation of landscape and environmental features into the design of the area; and high quality built form.*

Policy 7.10 describes the broad objectives with respect to stormwater management:

- *To design for stormwater management which minimizes runoff and recognises stormwater as a resource through the re-use in open space and landscape areas.*

These objectives and policies were developed further through the original site-specific stormwater concept design undertaken by Pattle Delamore Partners Ltd (PDP) in 2009. PDP outlined the overall vision and philosophy for concept stormwater design, which formed the original basis for the overall WSUD design. The site layout and design hinged on the minimization of earthworks and the development of urban and landscape elements around the utilization of existing natural features to achieve stormwater, landscape and amenity objectives. These concepts included the use of natural ground depressions for the provision of stormwater detention areas and maintaining existing runoff patterns in order to minimize changes to the hydrological regime.

The location and approximate extent of the stormwater management devices described in the PDP report is based on early landscape master planning work developed by Morgan + Pollard Associates. This included the objective to maximize the use of swales and open channels for the conveyance of flows, showcasing the sustainable management of water and making water visible with cascading flows and other features, in favour of using traditional piped systems wherever possible.

The specific principles and objectives surrounding stormwater and WSUD for the subdivision are further described by a conference paper by Lauenstein, Kruger & Pennington (2010). These principles are summarized as follows:

- *Encourage slowing of stormwater surface runoff and utilize [stormwater] for the protection and enhancement of remnant and planted areas.*

- *Avoid fast discharge to engineered stormwater devices.*

- *[Make use] of roads, footpaths and car parking areas…. [to] foster stormwater infiltration, slowdown of runoff and retention of water.*

These guiding principles heavily influenced design throughout the life of the project.

2.4 DESIGN PHILOSOPHY

The principles of sustainable and water sensitive urban design have been applied to this project to create a community with a distinctive character. Through the use of existing landscape features, varying lot sizes, densities and open spaces a variety of residential 'clusters' were created, each with its own unique character and all resulting in a vibrant and appealing living environment with a cohesive design theme.

The integration of WSUD into this overall urban design vision, together with the use of comprehensive landscape planting and innovative materials results in a unique and sustainable residential environment.

As previously mentioned, the subdivision design criteria hinged on maintaining natural landforms and the development of urban and landscape elements around the utilization of existing natural features to achieve stormwater, landscape and amenity objectives.

The roading network was designed around the contour of the land, thereby resulting in a curved road network with no straight lines. The specified road carriageways were integrated with on-street parking bays and the various urban and landscape design and shared use elements, resulting in reduced imperviousness through narrower carriageway widths.

Another important factor of the overall WSUD design philosophy for Kirimoko Park included the objective to maximize the use of swales and open channels for the conveyance of primary and secondary flows, thereby reducing the use of pipes. Swales provide a reliable, resilient and visually attractive solution for the management of primary and secondary stormwater flows, which is in line with international best practice.

In the Netherlands, for example, there has been an initiative for above ground disconnection of 'clean' runoff from combined sewer systems which has been in place for more than 20 years. Another example is the Highpoint development in Seattle (about 10 years old) which showcases WSUD in many ways, including the discharge of roof-water to ground.

At Kirimoko Park, virtually all primary and secondary stormwater flows are managed on the surface, through swales, raingardens, detention / infiltration basins and fords, with very little or no piping. This approach has allowed WSUD practices to form an integral part of the urban landscape where stormwater becomes an attractive resource with visible water features, showcasing stormwater as a resource rather than a burden. Importantly, as already mentioned this has also translated into significant construction cost savings for the project.

The principles relating to the stormwater management aspect of the design can be summarized as follows:

- Minimisation of earthworks and maintaining existing natural drainage patterns and hydrology. This was primarily achieved by allowing the road network to follow the natural contour of the land, thereby limiting earthworks to the formation of road corridors only rather than comprehensive re-contouring of the land.

- Avoidance of pipes wherever possible.

- Encouraging the slowing of stormwater runoff, thereby promoting biofiltration and infiltration.

- Maximising the visibility of stormwater as an amenity.

- Utilisation of stormwater for the protection and enhancement of remnant and new planted areas.

- Promotion of dispersed flow patterns and avoidance of fast and concentrated discharges.

- Making use of roads, footpaths, car parking areas and other urban design elements to foster stormwater infiltration, slowdown of runoff and retention of water.

- Making use of stormwater design elements to fulfil other urban design and engineering functions, such as the use of raingardens as landscape elements or fords as traffic calming measures.

- The overall integration of stormwater design with urban architecture and landscape design.

2.5 GAINING ACCEPTANCE OF THE KIRIMOKO PARK PHILOSOPHY

The delivery of a structure plan that would drive WSUD throughout the development was received with great interest at QLDC. Council engineers were keen to see something new and innovative, and Council planners were accepting of the proposal to demarcate a range of lot sizes, while maintaining the average lot size of 700m^2 allowed under the Low Density Residential zone.

The community however had concerns about the development proposal. The Wanaka Residents Association did not accept the concept, thinking that the reduced lot sizes would encourage compact development and as a result would detrimentally affect house prices in the area.

While the development proposal was eventually accepted by QLDC, this approval didn't come without compromise. QLDC were encouraging of the WSUD design philosophy (as is the district plan) and the construction of WSUD devices to manage water quantity and quality. These devices would be vested in council but QLDC would not accept the ongoing maintenance responsibilities. This disconnect between the planning desires of QLDC and what their Stormwater Operations division was willing to inherit, is a contradiction also seen in other regions of New Zealand.

To overcome this hurdle the Kirimoko Park Residents Association was formed and has taken responsibility for the maintenance of stormwater devices, which are located both in the road corridor and within private lots. Each owner who buys into the development signs up to a 'Kirimoko Park Code' that, among other requirements, outlines an agreement requiring payment of an annual levy towards this ongoing maintenance of WSUD features, including stormwater management practices and landscaping.

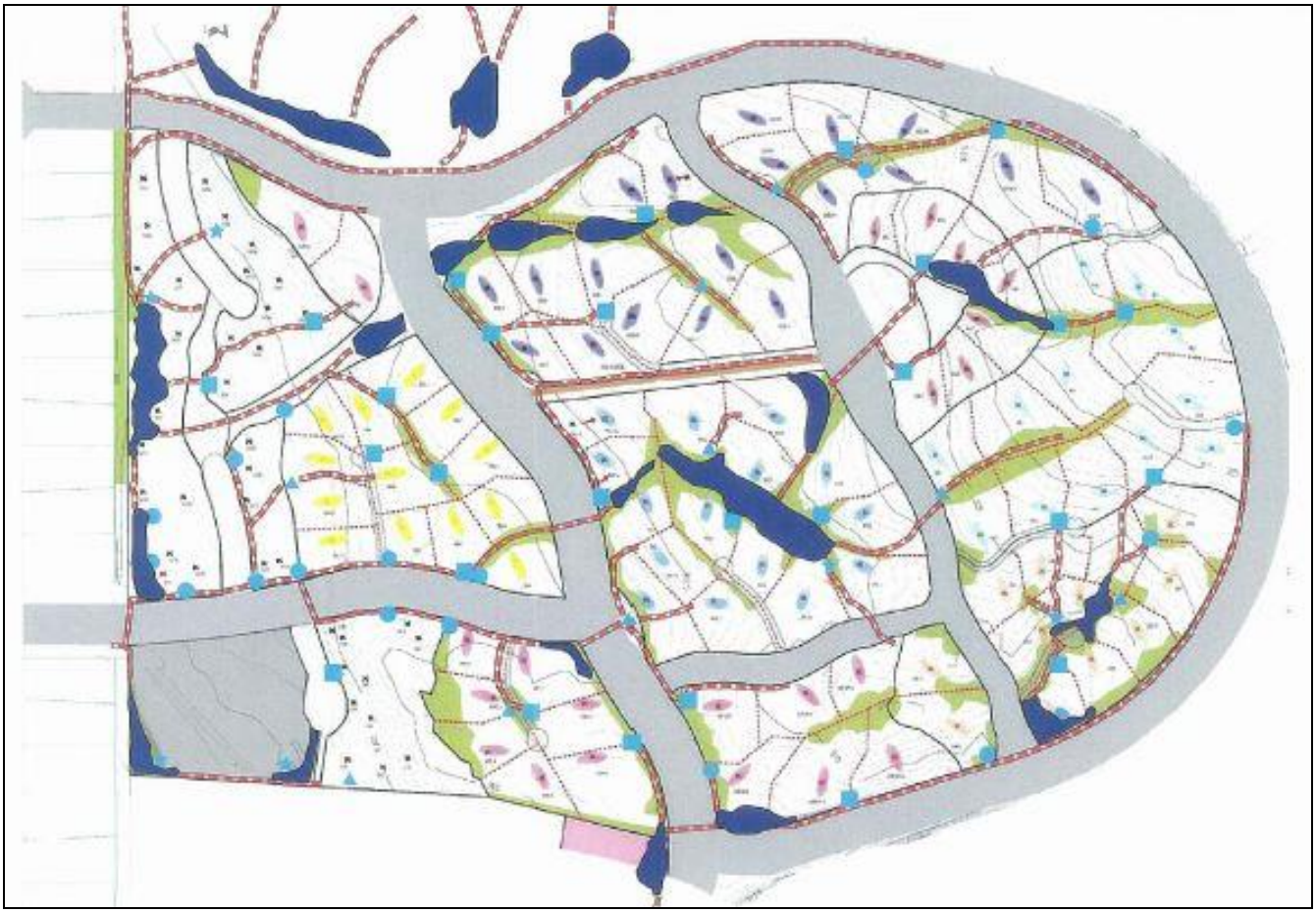
The developer is hopeful that through the acceptance of this 'Code', residents will become more environmentally responsible and lead to some level of community participation in maintaining/monitoring WSUD devices. Despite the additional cost to lot owners, there is a general recognition of the vastly superior urban amenity value offered by the subdivision and as such, this code has been well received by the residents and the remaining lots are proving very popular with real estate prospectors.

2.6 WSUD DESIGN ELEMENTS

The Kirimoko Park internal road networks and associated urban architecture, landscaping and stormwater WSUD elements were largely conceived at the onset of the Plan Change process, where a comprehensive Structure Plan was developed for the Kirimoko Block. Figure 3 below shows two typical views of the Kirimoko Park WSUD streetscape.

Figure 3. Kirimoko Park WSUD Streetscape

Figure 4. Kirimoko Park WSUD Concept Plan - From PDP (2009). Dark blue areas depict detention/soakage basins, red dashed lines are proposed swales and light blue symbols represent propose raingardens.



This Structure Plan outlined the main roading network for the area and, from that Structure Plan, a Master Plan for Kirimoko Park was developed which identified key stormwater design features including detention / infiltration basins, swales, raingardens and fords. The development of the Master Plan from the outset allowed the planning of the Kirimoko Park subdivision to progress systematically and in a coordinated fashion through a number of stages. Figure 4 shows the WSUD concept plan for Kirimoko Park.

The stormwater WSUD infrastructure was integrated into the roading and urban landscape design, such that the construction of underground piped infrastructure was avoided wherever possible. This was achieved through the introduction of the following key design criteria / elements:

- Earthworks in Kirimoko Park are mainly limited to road corridors only. Road alignments generally follow the contour in a curvilinear fashion and in keeping with the site topography.

- Road drainage is achieved through swales, removing the need for kerb and channel. Swales are capable of following the naturally-inspired curvature of the roading network, which is not something that can be easily achieved with piped systems (see Figure 5).

- Swales are primarily planted or grassed, and in some cases, rock lined.

- Runoff from swales and other primary drainage systems discharges to raingardens or detention / infiltration basins, with excess flows being ultimately conveyed via pipes to the existing public piped infrastructure downstream of the development.

- Subsoil drainage is virtually eliminated from the development in view of the highly permeable soils and the initiative to maximise infiltration of treated runoff to ground.

- A high level of runoff volume and flow mitigation is achieved through infiltration within the swales, raingardens and detention basins, due to the highly permeable underlying soils, and evapotranspiration within the planted WSUD practices.

- The swales, raingardens and detention basins also result in a high level of treatment of stormwater runoff and the retardation of flows thereby mimicking natural conditions.

- Sag points in roads drain through concrete fords which are provided with a small diameter low flow culvert for the passage of the smaller, more frequent flows.

- The fords in turn act as traffic calming measures in the form of an inverted speed humps.

- The management of stormwater through surface water WSUD features allows stormwater to become a visible part of the urban landscape and showcases the high quality urban environment and its interaction with water (see Figure 6).

If a conventional pipe system rather than a WSUD system had been constructed, the quantum of the post development flows resulting at the point of discharge (in this case the existing piped infrastructure immediately downstream of the development) would have been significantly higher than pre-development conditions, in terms of both peak flow rates and volumes, unless substantial attenuation structures were constructed.

Figure 5. Kirimoko Park Stage 2 Proposed Stormwater Layout Plan as submitted for Engineering Approval (AR Civil Consultants Ltd, 2014)

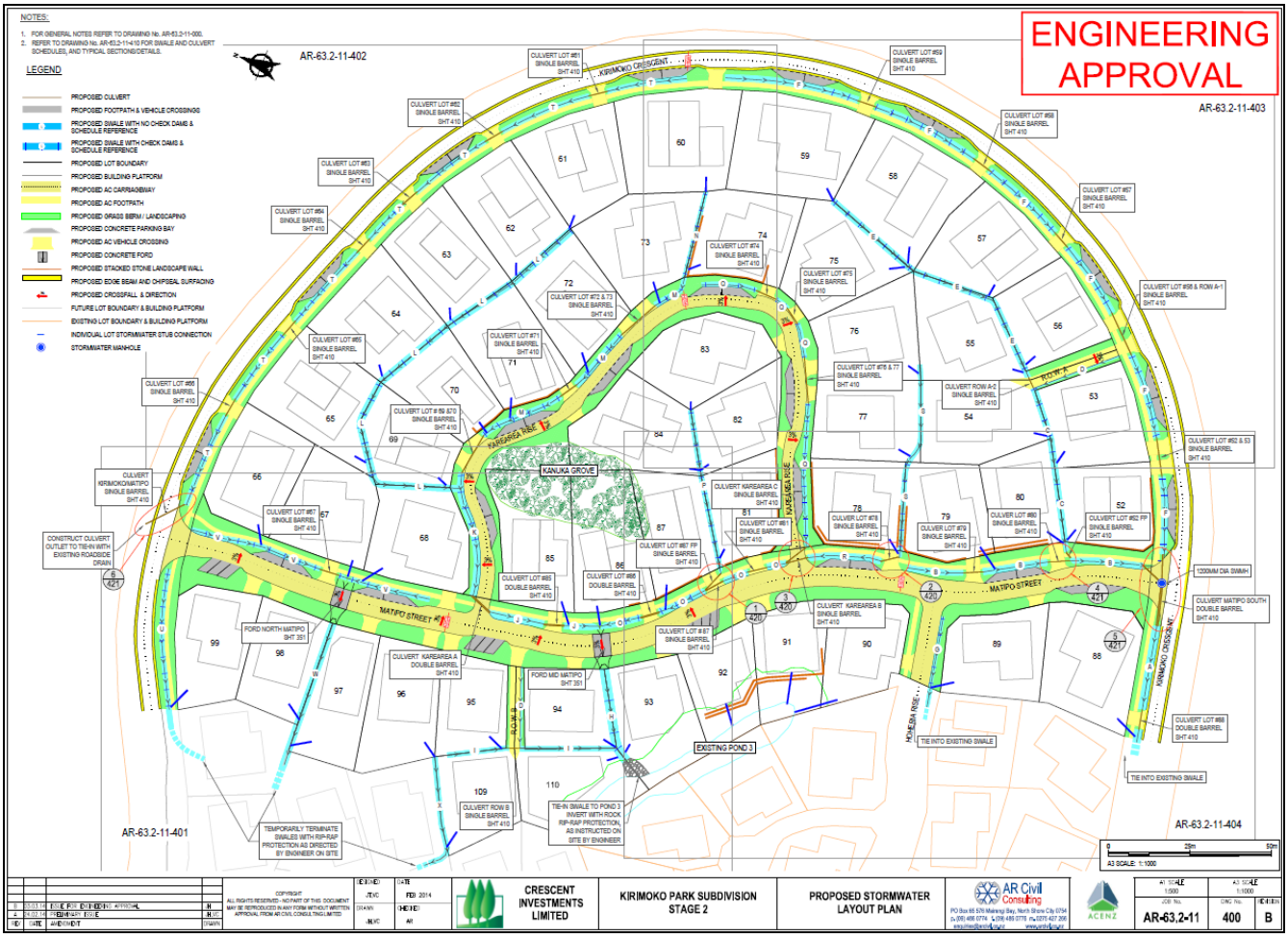


Figure 6. Kirimoko Park WSUD Design Elements (on left is a raingarden and swale and on the right, a swale-to-ford footpath and road crossing)

The Kirimoko stormwater WSUD system has instead resulted in significantly reduced overall stormwater volumes and peak flow rates, even when compared with pre-

development conditions with a much reduced need for such structures. This has translated to a positive effect on the downstream infrastructure due to decreased loads and reduced peak flows, and is in line with QLDC's requirement that residential subdivisions be stormwater neutral.

2.7 SUSTAINABILITY

Kirimoko Park has been designed with a committed focus on sustainability. This is reflected in the design of the WSUD stormwater systems and roading and infrastructure at subdivision stage, and carried through to the design and construction of the individual dwellings. Experience in Kirimoko Park indicates that the additional cost of building these features into the design at an early stage is not excessive and often results in long term cost savings.

During subdivision development phase, there was an overarching objective to maintain the natural landform. This resulted in the avoidance of significant earthworks and a very low level of intervention for the formation of roads and infrastructure, translating to a reduced need for transportation of soils, less generation of sediment and overall lower environmental impacts.

Additionally, the development has introduced unique roading and transportation design, including walkways, cycleways and shared use spaces. The undulating topography together with the curvilinear nature of the roading network and its integration with bespoke urban landscape and WSUD features has created attractive, community focused pedestrian amenity features within a low speed environment.

Other elements that contribute to the sustainability of Kirimoko Park at subdivision stage include the avoidance of the commonly used H4 treated timber in all construction work and street furniture (for environmental reasons), the use of locally sourced rocks and materials, the use of recyclable asphalt, the use of organic fertilizers in replacement of synthetic products, strict controls around the use of pesticides, and the use of natural hessian fibres for erosion protection and weed control in replacement of synthetic materials.

As already mentioned, the Kirimoko Park sustainability initiative translates through to responsibility by each individual lot owner and the design of each dwelling within the development. The Kirimoko Park Landscape, Building and Design Code provides guidance on the design and approval process to lot owners, including the employment of sustainability initiatives. As an example, each residential dwelling within Kirimoko Park is required to consider the incorporation of the following sustainable features into the design:

- Passive solar design
- Natural light and natural ventilation to all rooms – excluding storage areas and toilets
- Double glazing throughout the building (as required by the Building Code)
- Solar ready hot water cylinders
- Roof insulation to a minimum of R3.6
- Wall insulation to a minimum of R2.8
- Under slab/floor insulation to a minimum of R2.0
- Insulation of party walls and internal walls between heated and non-heated rooms i.e. garage to a minimum of R2.8
- Insulated or solid core external doors

- Permeable surface treatment to at least 50% of otherwise sealed areas (not including building foot print) or independent on-site soakage sufficient to reduce run off from impermeable surfaces by at least 50%.

In addition to the sustainable features listed above, there is a requirement for each dwelling within Kirimoko Park to include a minimum of three of the following elective sustainable features:

- Permeable surface treatment to 80-100% of otherwise sealed areas (not including building footprint) or independent on-site soakage sufficient to reduce run off from impermeable surfaces by 80-100%
- Heat sink walls and/or floors
- Light wells in 2 storey buildings
- Energy efficient heating
- Energy efficient lighting system and appliances
- Water efficient systems and appliances (WELS rating of 3 or higher) thermally broken external window and door joinery
- Water conservation measures such as roof water collector tanks, grey water systems
- Solar powered lighting, pumps etc. in garden design
- Full solar hot water system
- Compost or worm farm
- External air vented fires
- The use of materials with low embodied energy content such as local and raw materials rather than highly processed and imported materials
- Any other specific sustainable feature introduced as part of the building and/or landscape proposal.

Feedback from the developer and first inhabitants has indicated a general acceptance of this code by residents buying into this development, which shows a willingness to live in a truly sustainable community and take part in its ownership and care.

3 CONVENTIONAL VERSUS WSUD COST COMPARISON

As mentioned previously, a key challenge facing the development community and Councils is the difficulty of accurately determining costs associated with WSUD, both at the time of implementation and in the long term, and how this translates to asset capitalization, development contributions and maintenance costs.

Given that WSUD is still a relatively new concept and many of the projects that form part of current research represent 'pilot' projects, there is little data on the long term maintenance aspects and costs of WSUD (Koru Environmental Consultants Ltd, 2009) and therefore, the information offered in this paper focuses primarily on capital construction costs rather than maintenance costs.

Some of the cost benefits arising from WSUD are summarised as follows:

- The use of 'soft' or 'green' WSUD stormwater practices maximizes infiltration and evapotranspiration, thereby reducing the volume and discharge rate of runoff, reducing or removing altogether the need for piped infrastructure and decreasing the load to downstream infrastructure and receiving environments. This translates to reduced construction costs to the developer and reduced operation & maintenance and depreciation costs to the network operator.

- The elimination of piped stormwater infrastructure also removes the risk of cross-connections with wastewater systems, which often translate to detrimental environmental impacts and costly maintenance and remediation works.

- While land area requirements associated with the construction of WSUD practices may in some cases be greater than conventional developments, in other instances WSUD practices can be located partly or wholly within private land thereby optimizing land development yield and improving landscape amenity in lots. This can represent savings with regard to the use of land.

- WSUD practices can be also integrated into the streetscape in such a way that the additional area requirements (such as areas dedicated to treatment and detention practices, for example) are minimized or eliminated and the use of land rationalized. In some instances, the reduction of impervious areas is generally offset by the increase in land used for green infrastructure. Again, this can translate to savings in terms of land costs, in addition to reduced pavement costs.

- WSUD also investigates opportunities for clustering of groups of dwellings, which can result in greater lot yields to the developer and superior open spaces and amenities to the community. The clustering of lots is also an opportunity to rationalize and reduce overall roading and utility service infrastructure requirements, resulting in measurable cost savings.

- In addition, one of the key drivers for design is maintaining the land form, where earthworks are primarily confined to the formation of road corridors. In Kirimoko Park, the internal roading system follows the contour of the land thereby eliminating significant cuts and fills and comprehensive site-wide earthworks operations and associated costs.

- The contoured road configuration lends itself well to the construction of roadside swales, which can follow the curvilinear horizontal and vertical geometry. This translates to significant cost efficiencies when compared to pipes, as a piped system in this context would result in an excessive number of manholes to avoid interference with other services, the road carriageway and/or private land.

- The type and nature of the ground cover planting at Kirimoko Park is such that, from a landscape maintenance perspective, it is more economical to maintain than conventional, mown lawn grasses.

- Additionally swales remove the need for kerb and channel, again offering savings to the project.

Table 1 provides a summary of cost comparisons of WSUD versus conventional piped solutions, for projects in the US and New Zealand, respectively. It should be noted that the New Zealand cost data has been modified from its original source to exclude construction of wastewater, water supply and utility services.

At this stage the costs of construction for Kirimoko Park are considered commercially sensitive. Therefore the costs for Kirimoko Park Stage 2 in Table 1 are given in percentages (100% being the cost of conventional infrastructure).

The US Examples are indicative only and include the full costs of development, whereas, as mentioned above, the NZ examples do not include wastewater and water supply or utility services costs.

Table 1: Cost Comparison between WSUD and Conventional Stormwater Management Systems

COST COMPARISONS - CONVENTIONAL PIPED vs WSUD

US Examples

Project	Conventional [US$]	WSUD [US$]	Cost Difference [US$]	Percent Difference (%)
Boulder Hills	$299,600	$250,600	$49,000	16%
Chapel Run	$2,460,200	$888,735	$1,571,465	64%
Buckingham Green	$541,400	$199,692	$341,708	63%
Tharp Knoll	$561,650	$339,715	$221,935	40%
Pleasant Hill Farm	$1,284,100	$728,035	$556,065	43%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills Subdivision	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Donovan Park	$52,800	$12,800	$40,000	76%
Garden Valley	$324,400	$260,700	$63,700	20%
Kensington Estates	$765,700	$1,502,900	-$737,200	-96%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek	$12,510	$9,099	$3,411	27%
Prairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus	$3,162,160	$2,700,650	$461,510	15%

NZ Examples

Project	Conventional [NZ$]	WSUD [NZ$]	Cost Difference [NZ$]	Percent Difference (%)
Heron Point	$1,476,000	$1,180,000	$296,000	20%
Palm Heights	$5,538,000	$3,973,000	$1,565,000	28%
Wainoni Downs	$4,915,000	$3,430,000	$1,485,000	30%
Kirimoko Park (Stage 2)	100%	77%	-	23%

Sources: Auckland Regional Council (2010); USEPA (2007); University of New Hampshire (2011), Meridian Land Development Consultants (2015).

It is worth noting that while there is a significant range in cost from the above projects, the results consistently show that WSUD has a lower construction cost compared to conventional design.

The only exception is Kensington Estates where the cost of WSUD was significantly lower than conventional systems due to an expensive permeable paving product used in the construction of carparks.

In summary, our findings show that through the implementation of WUSD principles and thoughtful design, the scope for meaningful capital cost savings can be significant.

4 LEARNINGS

A number of learnings have derived from the Kirimoko Park Development, ranging from planning and engineering related learnings to those focused on philosophical acceptance of WSUD practice. The key learnings are outlined below:

- The Kirimoko subdivision is non-complying due to the range of lot sizes, yet this development has been accepted, and in some instances celebrated by Council planners and engineers. If a non-complying development proposal such as this one can be justified on good design, and this is communicated well to Council staff, it is possible to overcome Council or community resistance to approve such a development.

- The responsibility for maintenance remains an area where further development is needed, particularly with regard to the allocation of maintenance operations to either private or public management.

- Notwithstanding this, in the case of Kirimoko Park, the feedback to date has been that there is general acceptance from the residents to assume maintenance levies, in return for a high quality streetscape, landscape and amenity environment. This has resulted in a sense of pride and ownership having been attained by Kirimoko Park residents.

- The Kirimoko Park development was landscape driven, as are most WSUD developments, which meant that the topography dictated where WSUD devices were to be located. The location of the WSUD practices in the context of the site's topography needs to be factored into the development staging and costs.

- Councils wanting to incentivise WSUD need to consider including some WSUD features as offset against reserve land contributions. The integrated WSUD, landscape design and urban design approach of Kirimoko Park provided significant amenity within the road corridor however there was little if any compensation regarding reserve land contributions.

- The Kirimoko Park development resulted in less earthworks than a standard development as the road system is able to follow the contour in a curvilinear fashion, reducing significant cuts and fills for the formation of road corridors.

- Clustering development at Kirimoko Park resulted in decreased requirements for roading and infrastructure and maximization / rationalization of open spaces, which assisted in achieving greater yields.

- Infiltration within swales and raingardens at Kirimoko Park resulted in a reduction or elimination of dedicated detention systems. This in turn translated to reduced space requirements and costs for dedicated detention devices.

- Overall, the experience at Kirimoko Park indicates that WSUD is considerably more economical to construct when compared to conventional systems. This is in agreement with findings from overseas and local research (as outlined in Table 1).

5 CONCLUSIONS

There are many conclusions that are derived from the Kirimoko Park development. The main conclusions are as follows:

- WSUD is a more resilient design than the piped system. It is superior in terms of durability, earthworks extent, cost to repair / replace, susceptibility to blockage (i.e. more robust), resilience (e.g. in an earthquake), passive surveillance / inspection and health and safety (i.e. no need for confined space entry).

- Upskilling and possibly certification in WSUD practices could assist in providing Councils with a better understanding and acceptance of WSUD. Perhaps the introduction of a professional institute in New Zealand, similar to those in the USA and Australia, which will facilitate upskilling in WSUD across New Zealand and would assist in putting WSUD on a better footing.

- Developing a national standard set of agreed objectives/ policies/ rules/ methods for Councils to use, rather than attempting to do this at a local level, could also reduce lengthy regulatory processes which place a burden on Councils and applicants alike.

- The available national and international data and experience in New Zealand contradicts any notion that WSUD is always more expensive than conventional design during the construction phase of a development. Experience at Kirimoko Park supports research that WSUD is considerably more economical to construct than conventional systems.

- Developments incorporating WSUD principles are popular real estate.

- The benefits of WSUD are far reaching and include environmental, land value, amenity, and social among others.

- WSUD doesn't stop at stormwater design. Successful developments like Kirimoko Park require a multi-disciplinary approach from Landscape Architects, Urban Designers, Planners, Civil Engineers, Council staff and the land developer.

- Incentives should be provided to WSUD developers and those who wish to buy into these types of developments. Stormwater rates reductions for WSUD property owners and discounted reserve land contributions for the developer are just two examples.

- Some councils are accepting (sometimes encouraging) of WSUD developments, but the vesting of WSUD infrastructure to council remains a problem due to the uncertainty surrounding long term maintenance costs and responsibilities.

ACKNOWLEDGEMENTS

Many thanks to John May for his vision and perseverance in getting the Kirimoko Park development off the ground, his assistance in providing the history of Kirimoko Park and input into the paper.

Thanks to John Carter of Meridian Land Development Consultants for his review of paper drafts and general input.

Many thanks to Scott Edgar of Southern Land for the providing some of the planning history behind the Kirimoko Park project.

Thanks to Sue Ira of Koru Environmental Consultants for her review of the paper and valuable overall contribution, particularly the costs section.

Thanks to Priya Kumar, Andrew Nell, Vera Cheung and Lucy Underwood for their contribution to the cost comparison section.

REFERENCES

AR Civil Consultants Ltd (2014) Kirimoko Park Subdivision Engineering Design Report – Stage 2. *Report Prepared for Crescent Investments Ltd.*

Auckland Regional Council (2010) Low Impact Design Versus Conventional Development – Literature Review of Developer-related Costs and Profit Margins. Technical Report TR 2009/045

Kirimoko Park Residents Association Inc. (Undated) Kirimoko Park Landscape, Building and Design Code. Retrieved February 15, 2015, from http://www.kirimokopark.co.nz/kpdocs/KP%20stage%202%20code%20HR1.pdf

Koru Environmental Consultants Ltd (2009) Quantifying the Costs of Low Impact Design in New Zealand. *Report prepared by Koru Environmental Consultants Ltd for Aqua Terra International Ltd and Tauranga City Council.*

Lauenstein, N., Kruger, R., and Pennington, M. (2010) Integration of Urban Design and Landscape Architecture into a Low Impact Stormwater Design. *Paper published in the Water New Zealand 2010 Stormwater Conference compendium.*

Meridian Land Development Consultants (2015), Schedule of Costs, Kirimoko Park Stage 2, *Prepared for Crescent Investments Ltd*.

Pattle Delamore Partners Ltd (2009) Kirimoko Crescent: Proposed Stormwater Concept. *Report Prepared for Crescent Investments Ltd*

United States Environmental Protection Authority (USEPA) (2007) Fact Sheet: Reducing Stormwater Costs through Low Impact Developments (LID) Strategies and Practices. EPA Publication Number 841-F-07-006. Retrieved March 10, 2015, from http://water.epa.gov/polwaste/green/upload/2008_01_02_NPS_lid_costs07uments_reducingstormwatercosts-2.pdf

MacMullan, E. & Reich S. (2007) The Economics of Low-Impact Development: A Literature Review. Retrieved March 12, 2015, from http://www.econw.com/media/ap_files/ECONorthwest-Economics-of-LID-Literature-Review_2007.pdf

University of New Hampshire (2011) Forging the Link: The Economic Benefits of Low Impact Development and Community Decisions, Millerworks, Portsmouth, Chapter 3, pp 4-8

Victoria Environmental Protection Authority (2005) Water Sensitive Urban Design – Factsheet. Publication 989. Retrieved March 12, 2015 from http://www.epa.vic.gov.au/~/media/Publications/989.pdf