WSUD Case Study: Kirimoko Park

Master-planned, pipeless residential subdivision with small sections but spacious feel due to lack of fences, integrated landscaping and protected mountain-view shafts that combined with comprehensive maintenance provides a regenerative, resilient residential subdivision for people and nature.

Selecting a WSUD approach was driven by the developer's vision, but it cost less and delivered increased values by Stages 2 and 3 partly due to:

- Lower earthworking costs and no pipes (permeable sub-soils, suitable slopes and low intensity rainfall)
- Smaller sections increasing section yields
- Narrower streets using swales and bioretention as traffic calming measures
- Cost efficient treatment of a range of stormwater contaminants exceeding 'code'
- Increased native biodiversity and connectivity of natural areas, quality green spaces enhance the aesthetic appearance and provide benefits for carbon sequestration and water quality treatment
- Resilient, long term infrastructure provided by multiple, distributed treatment trains

Features

- Five-star walking and cycling through road and landscape design
- Plants and soil used to reduce stormwater volume and remove contaminants
- Community sign-up to the '***Kirimoko Code'***; individuals choose from list of sustainable / ecological features for building and landscapes
- Maintained locally, funded by annual residents levy at no cost to Council
- Limited on and off-street parking and strict covenants not for everyone!

About Kirimoko Park

The Kirimoko Park subdivision is about 2km north of the Wanaka town centre and 1km east of Lake Wanaka.

The site was farmland with patches of kanuka remnants, about 30m above the shoreline of Lake Wanaka. The topography has undulating gradients, gently sloping at grades of between 2 and 18%. The localised geology of the site and surrounding environment is loess (wind-blown silt) and glacial till material. Soils throughout the site are dominated by sandy silts and silty sands, and infiltration rates across the site are, on average, about 50 mm per hour, much higher than rainfall. Water exfiltrates into permeable subsoils, reducing surface runoff.

Plant growth is limited by a relatively short growing season due to cold temperatures (many frosts and occasional snowfall) in winter and drought in summer. In many places deep, free-draining soils allow large trees to develop. The area was a farm dominated by non-native grasses, but with scattered kanuka (a small native tree) remnants.

Stage 1 of the development was completed between 2011 and 2013 in the south west corner of the site across approximately 4.15 hectares. Stage 2 was a similar size and completed in 2014 and 2015 (4.17 hectares); Stage 3 was completed in 2015 and 2016 (3.58 hectares).

Staging plan courtesy of AR and Associates

Stormwater management approach

The Kirimoko Park WSD Concept Plan (Pattle Delamore Partners Ltd, 2009) highlights that 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. Stormwater infrastructure in the existing urban areas downstream of the development had limited stormwater capacity. The ultimate receiving environment is Lake Wanaka – a high value mountain lake used for contact recreation and showing recent degradation from sediment, (human) faecal and nitrogen inputs. In view of the rapid growth that Wanaka is currently experiencing there is strong community interest in addressing how development can be managed to retain the high natural values of Lake Wanaka and the surrounding landscape[1].

More information about each of the development stages, including specifics about design, cost, maintenance and post-construction observations are presented in the following sections.

Stage 1

Stage 1 treats and infiltrates stormwater via rain gardens, permeable paving and infiltration basins.

What works well	Missed opportunities
Narrow roads reduce the overall impervious areas.	Raised concrete edges of raingardens on the road edges are prone to damage, especially from trucks, but prevent vehicle entry.
Landscaping was carefully researched to find plants that perform well in Wanaka's environment, both exotic and native plants are used.	Feature trees are generally deciduous non-native trees – where these are next to infiltration areas their leaves require seasonal removal. Some tussock and bidibid (*Acaena*) groundcovers may be relatively short lived, requiring replacement to maintain high aesthetics. Acaena are too short to exclude common weeds.
Raingarden sandy media used FAWB[2] 2009 specification (>3% w/w organic matter, <3% silt and clay), was locally sourced and installed at 600 mm depth. Raingarden design included specific exfiltration rate of 800 mm/hr at construction due to reliance on soakage.	Basalt cobbles were expensive and are inconsistent with local geology. Poured resin pervious paving was difficult to maintain (i.e. remove sediment) and accessible to heavy vehicles that can damage it.
Roads have reduced traffic speeds of 25 km/hr. Low speeds are reinforced by clever placement of trees, raingardens, and varying surfaces used for roads and parking areas; this encourages walking and cycling.	Raingardens with raised concrete edges and vertical sides placed immediately adjacent to the road (so requiring strong edges) are expensive to construct.
General absence of fences and use of hedges and creates sense of cohesion and flow across landscape.	Rain tanks are not included as part of the stormwater design.
Infiltration basin doubles as recreational facility by incorporating seating, local boulders and local gravels (petanque), but lacks plants, in contrast to the stage 3 basin.	The low cost housing area, whilst incorporating WSUD features has a "traditional" feel as the road and turning circle are very wide and landscaping is focussed at the back of properties. There are no places to sit and enjoy landscape and limited privacy as all are on the flat compared with other areas of Kirimoko.

[1] See the Wanaka Water Project at: https://www.uppercluthalakestrust.org/your-water/district/wanaka-water-project/
[2] Facility for Advancing Water Biofiltration, Monash University (Melbourne, Australia)

Photo 1: Stage 1 Rain gardens shortly after construction, before house construction showing raised edges.

Photo 2: Entrance with low-speed signs five years after construction.

Photo 3: Permeable (poured resin) car parking area around street tree with steel separation strip.

Photo 4: Permeable carpark (background) and detention area (foreground) which doubles as a petanque court with benching and boulders providing seating. The deciduous tree creates additional maintenance (leaf removal) in autumn.

Stages 2 and 3

Stages 2 and 3 treat and infiltrate stormwater via swales, rain gardens and infiltration basins. Stage 2 has no pipes. The cost of treatment is lowered by predominantly using swales which discharge to fewer, larger rain gardens with minimal use of concrete.

What works well	Missed opportunities
Stage 2 narrow roads reduce the overall impervious areas.	Standard road widths in Stage 3 were required by Council; these are inconsistent with Stage 2.
Reduced piping lowers construction and maintenance costs, and also creates a more resilient stormwater system as long as swales are not damaged by vehicles or filled in during buildout. Review of plans and supervision throughout build period reduces potential for such mistakes.	Council requirement for Stage 3 to have yellow lines on roads and signs lowers aesthetics and creates a disconnect with Stage 2 where these are absent (and aesthetics are higher).

What works well	Missed opportunities
Steep sided swales were established using browntop “ready-lawn” to avoid erosion during establishment. Browntop performs well in the Wanaka environment and under low-fertility conditions, it looks attractive even when allowed to flower and seed and stays dense – it can also tolerate relatively close-mowing.	The few ‘rain gardens’ have a significant pebble mulch surface with no plants to hide ugly metal domes; including native tussocks or taller, upright shrubs near the domes would mask them and complement landscaping.
Rain gardens and swales are used as traffic calming devices. The use of tussock planting on upper parts of some swales and steeper sides of swales protect them by discouraging driving across, or parking on, swales.	Some deciduous (non-native) trees, including large-leafed trees (English plane) create a seasonal maintenance requirement to keep swale pipes under driveways clear.
Landscaping was carefully planned and budgeted, and focusses on native plants, both groundcover and trees. More food for tui / bellbirds than when in farmland due to planted kowhai, flax and cabbage trees. More food for lizards by planting native berry-producing plants near remnant.	Some swales are particularly steep-sided to retain flood capacity. In places slopes could have been reduced by using more expensive (concrete) drive-way crossings
Native remnant kanuka has been retained and provides an amenity area for residents.	Residents have planted non-native bulbs under the kanuka canopy; such planting and any fertilisation does not assist the kanuka.
Many ‘iconic’ small trees are used in stages 2 and 3, including ribbonwood, lancewood, kowhai and cabbage trees, as well as totara – all are performing well. Most plantings have a variety of species, which increases resilience to drought or adverse events	Some tussocks have a relatively short life of 5 to 10 years without ‘grazing’ especially when stressed by irrigation (or being driven on); the ground-cover Coprosmas, Hebes and Pimelea probably have a longer life
Use of fords for overland flow paths reduces the need for large, expensive pipes. Fords also help traffic calming	
Driveway crossings use local stone to stabilise the pipe culverts and large boulders that act as bollards to protect corners from traffic.	Boulders need to be large enough not to move when hit by trucks (including rubbish trucks). Wooden bollards can be expensive to replace when broken (especially ‘frangible’ bollards);

Photo 5: Raingarden with unplanted stone mulch and exposed overflow dome.

Photo 6: Local stone used for retaining wall with flattened dome (from vehicle damage) despite protection provided by planted tussock and light stand.

Photo 7: Relatively steep swale with base of dense Browntop turf grass edged with local boulders, native tussocks and shrubs that together provide resilient, stable site and separation of sites without fences.

Photo 8: Fords for overland flow paths reduce need for pipes and are traffic calming features.

Photo 9: Local boulders used to protect swales from vehicles.

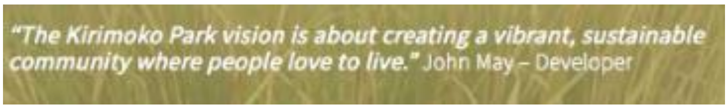
Photo 10: A native kanuka shrubland remnant has been retained.

The Kirimoko Code

Owners of the lots have to abide by Kirimoko Code (KC) and be part of the residents' association. Within the KC there are requirements around passive solar design, solar heating, composting, worm farms, use of native materials, incentives, and other environmental requirements. Understanding the importance of creating green, sustainable cities and the importance of landscaping, the developer gifted a native planting package for the lot owners to use. Houses are individually designed to maintain view shafts to the lake and ensure compliance with the KC.

Consent notice conditions and covenants underpin the KC and residents are required to pay a fee which is then used for maintenance of the green infrastructure.

The resulting effect of the KC is that there is a price premium on the lots over and above conventional subdivision lots.



Costs and benefits – "*More than Water*"

"*More than Water*" Assessment Tool

Using the newly developed "More than Water" Assessment Tool[3], the costs and benefits of the WSUD Kirimoko subdivision can be assessed and compared with a traditional (business as usual – BAU) approach to development. The tool allows the user to select the level of each benefit or cost criteria (from low to high), level of importance of a particular criteria, and reliability of the information used to make the assessment. Detailed guidelines are available to guide the user as they make their assessment. The range of assessment criteria are shown in the two tables below.

"*More than Water*": benefits assessment criteria

		Benefit	Level	Importance	Reliability
Water	Environmental	Hydrology	High	High	High
		Water quality	High	High	High
		Aquatic habitat quality	N/A	High	High
		Drainage network and aquatic ecosystem connectivity	N/A	High	High
		Natural character (water bodies)	N/A	High	High
	Social	Supplementary water supply	Low	High	High
		Reduced wastewater/CSO loading	Low	High	Low
		Drainage & flood management	High	High	High
		Climate change adaptation	Med	High	High
		Recreation	N/A	High	High
		Provisioning (e.g. fishing)	N/A	High	High
		Connectedness with nature (water bodies)	N/A	High	High
Non-water	Environmental	Preservation of natural soils	Med	High	High
		Microclimate management (UV, temperature, air quality)	Med	High	Low
		Carbon sequestration and mitigation	Med	High	High
		Terrestrial habitat quality	Med	High	High
		Terrestrial ecosystem connectivity	Med	High	High
		Natural character (land)	Med	High	Low
	Social	Reduced building material consumption	Med	High	Low
		Infrastructure resilience	High	High	High
		Food & fibre production	Med	High	Low
		Public safety	High	High	Low
		Connectedness with nature (land)	Med	High	Low
		Community health and wellbeing	Med	High	Low
		Property values	High	High	Low

"*More than Water*": costs assessment criteria

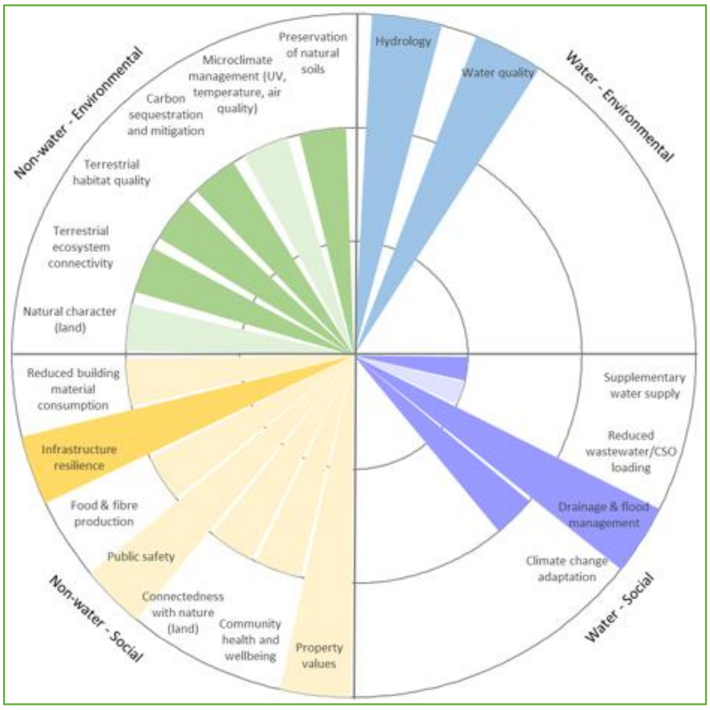
		Cost	Level	Importance	Reliability
PROJECT	Cost effectiveness	Housing affordability	Low	High	High
		Private development yield	High	High	High
		Public infrastructure delivery	High	High	High
		Health and wellness affordability	Low	High	Low
	Avoided costs	Avoided earthworking costs	Low	High	High
		Avoided hard infrastructure/ pipes costs	High	High	High
		Reduced impervious area costs	Low	High	High
		Avoided landscaping costs	Low	High	Low
		Avoided property operation costs	Low	High	Low
ENVIRONMENT	Cost effectiveness	Water quality cost effectiveness	High	High	High
		Hydrology cost effectiveness	High	High	High
		Aquatic habitat quality cost effectivenss	N/A	High	High
		Terrestrial habitat quality cost effectivenss	Med	High	Low
	Avoided costs	Avoided environmental remediation costs	High	High	Low
		Avoided property remediation and storm damage costs (flc	High	High	Low
		Avoided costs of future proofing (climate change; resilienc	High	High	Low

The assessment was undertaken via a workshop approach comprising the research team, project information provided by consultants involved in the development of Kirimoko Park, a site visit and discussions with the relevant development consultants. Detailed cost information was available for certain aspects of the development and this has been used in the assessment.

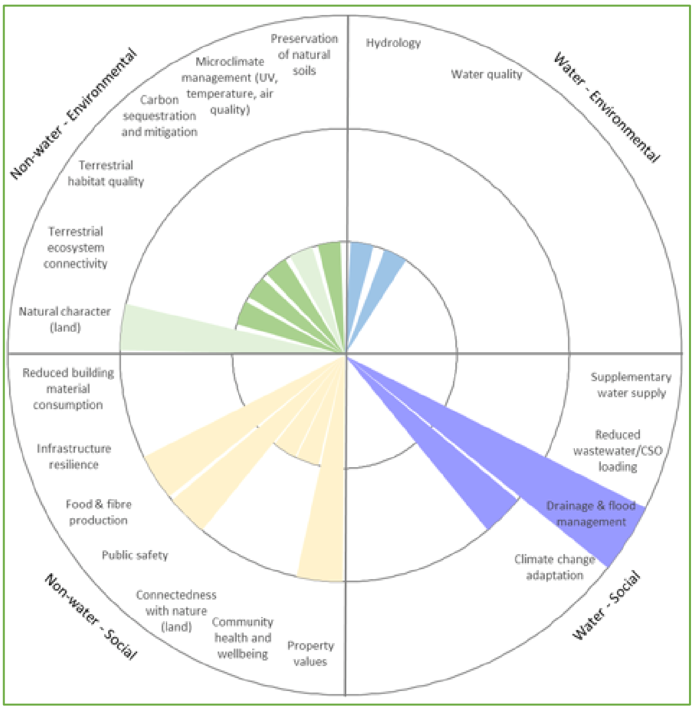
[3] More than Water Assessment Tool: https://www.landcareresearch.co.nz/science/living/cities,-settlements-and-communities/water-sensitive-urban-design

"*More than Water*" Benefits Assessment

Kirimoko Stage 2: As constructed

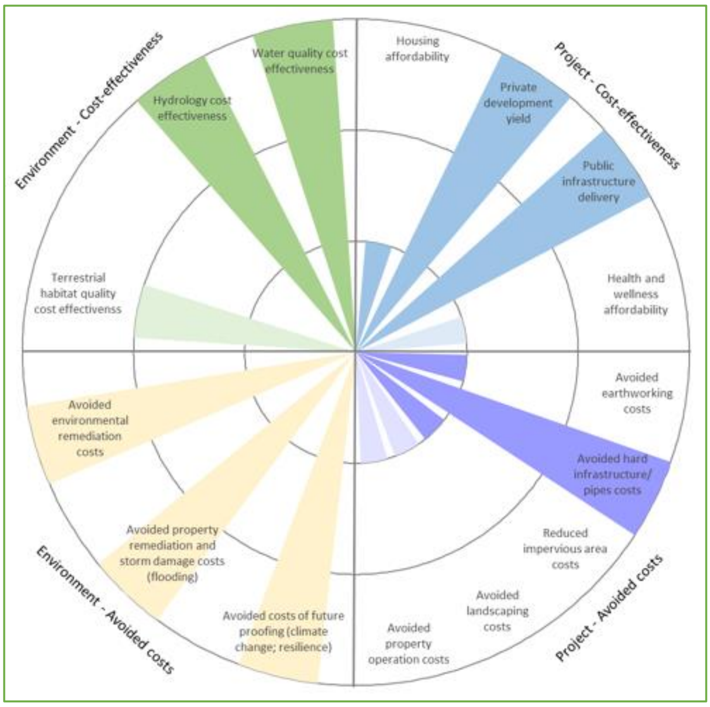


KIrimoko Stage 2: BAU

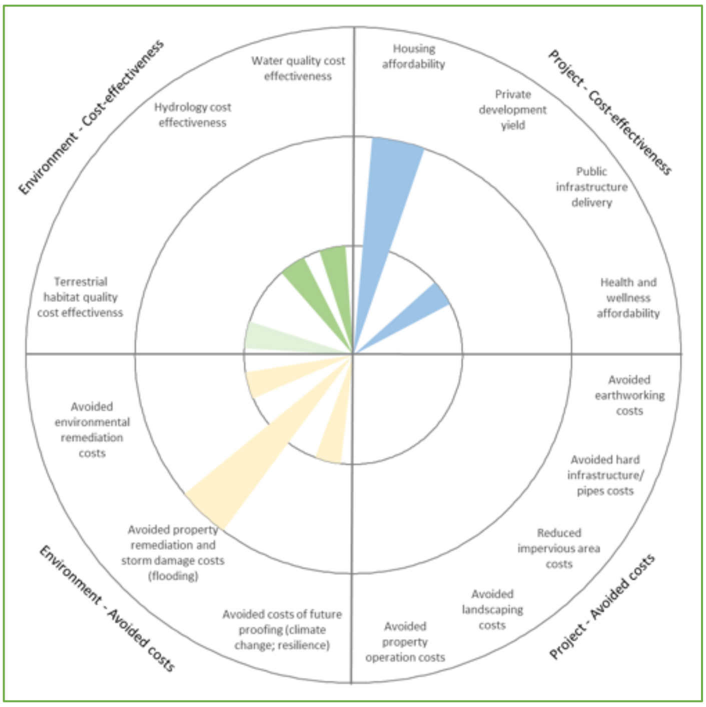


"*More than Water*" Costs Assessment

Kirimoko Stage 2: As constructed



Kirimoko Stage 2: BAU

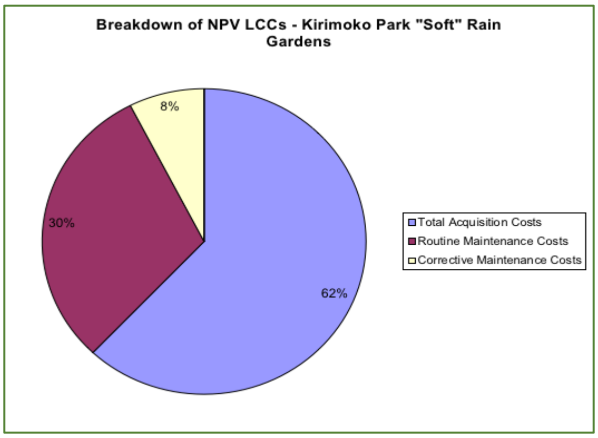


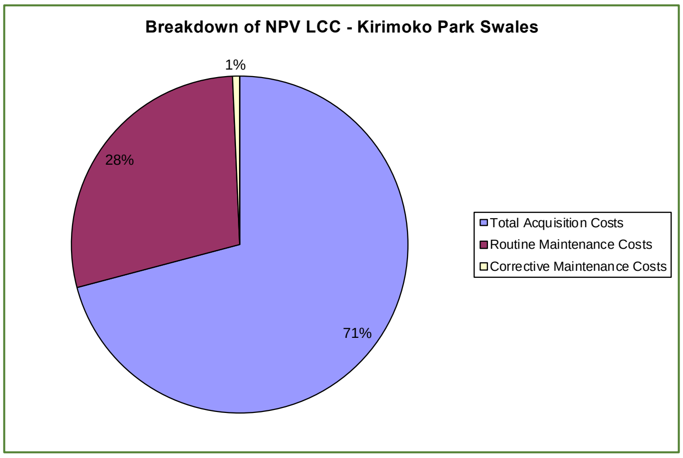
Learnings on costs of WSUD

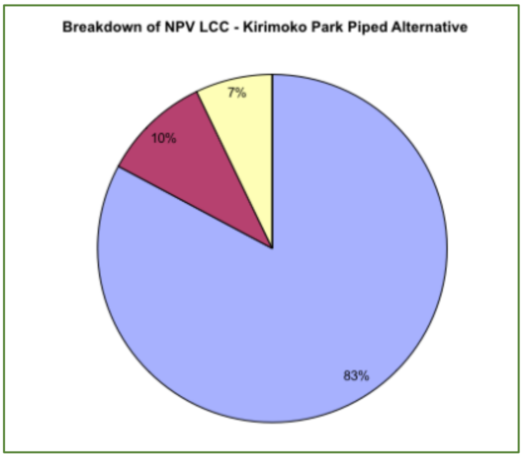
LIFE CYCLE COSTS

Kirimoko Park includes a number of different types of green infrastructure. The indicative estimate life cycle costs are shown below for some of the practices. These estimates are net present value estimates over a life span of 50 years.

Stormwater Practice	LCC $/unit/year
Stage 1 "concrete" edge rain gardens	$44/ m^2
Stage 2 and 3 "soft" infiltration rain gardens	$12/ m^2
Swales	$9/ linear m
Pipes	$11/ linear m

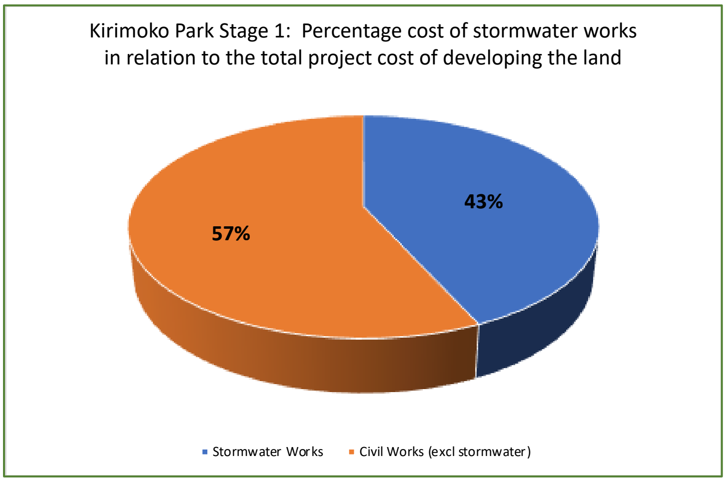


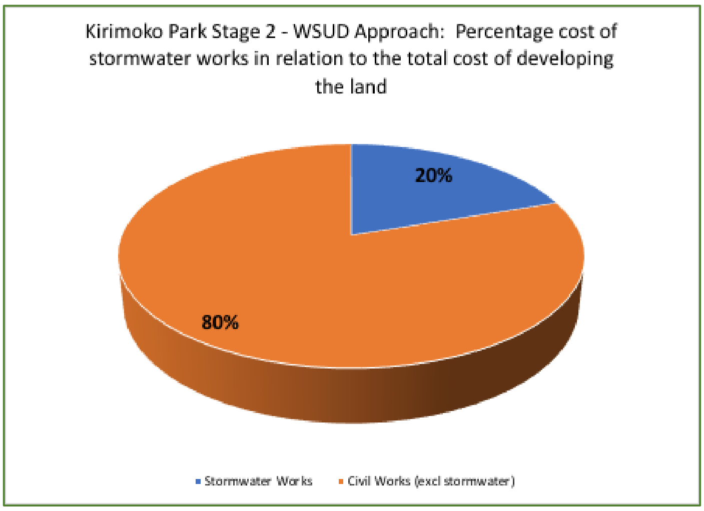




DEVELOPMENT RELATED COSTS

Overall, the water sensitive design approach of using swales over pipes, reducing the amount of earthworking needed and using narrower road widths resulted in an average saving of 22% over a traditional piped, kerb and channel approach to development. Landscaping features are integrated into the green infrastructure practices rather than being additional to it. No savings were realised through Stage 1 due to the use of expensive imported basalt materials, concrete edged rain gardens and pipes.





The two pie charts show that a WSUD approach can also reduce the total proportion that stormwater infrastructure contributes to the overall development cost.

Learnings on landscaping and maintenance

Most maintenance of swales, soakage/detention basins and rain gardens is integrated into general landscaping maintenance. Most devices are on public road reserves, maintained by the community organization through an annual rate. This means one or two people maintain the whole c.15 ha area, delivering cost-efficiencies and capturing of local knowledge. The Kirimoko 'stormwater systems and operation plan' (OMP) (AR Civil Consulting, 2012) clearly explains how the different components operate, who owns and is responsible for the different components, the maintenance practices (and how they relate to stormwater performance) and frequency. It includes a checklist that serves as a record of specific maintenance activities. The plan includes Appendices with the concept design drawings and raingarden media specification. With 'as built' plans appended and a list of landscape plant species this becomes a valuable resource to guide ongoing maintenance. Trees are maintained on a separate contract to an arborist, approximately 2-yearly while the young trees are developing. This includes removing lower branches to maintain 'clear zones' along roads. The OMP does not cover permeable paving (only used in stage 1).

Clever landscaping uses design elements to protect swales and overland flow paths from the most usual threats, being vehicle invasion and lawn-mower scalping or over-spraying. Protection is provided by corner boulders, wood bollards, tree placement (with protective staking/bollards or under-planting) and use of gravel mulching where vehicles can cut corners.

The most frequent maintenance activity is mowing grassed swales and removal of any debris in the swale systems (including slotted weir controls , pipes and cesspit inlets), approximately two-monthly, followed by trimming of hedges (although most hedges in the road reserve are maintained by adjacent owners) ; mowing frequency is likely increased where adjacent owners use irrigation (and fertiliser). At least annually (or after significant rain events) the following occurs:

- swales are checked for channelized erosion , sediment buildup and oil spills,
- raingardens are checked for infiltration (and if ponding remains 24 hours after rain),
- the condition of the top of overland flow bunds is checked,
- detention ponds spillways, freeboard, embankments, overflows are checked.

Raingardens and infiltration basins are maintained every 6- and 2-months respectively:

- Removing debris, floatable material or trash
- Removing weeds, maintaining plant cover

Acknowledgements

Several people assisted the Activating WSUD research partners in compiling this case study. Special thanks to Andrés Roa at AR and Associates for providing our team with information, support, expertise and assistance.

Our warmest thanks also go to Meridian Land Development Consultants, Southern Land Consultants and Southern Ventures for permission to use Kirimoko Park as a case study and for all your assistance.