Memorandum

Date: 14/04/2022

Job No: 1457

No of Pages: 5

To: Queenstown Lakes District Council (QLDC) cc: Catriona Lamont

From: Matt Wilkins

Re: Stormwater Management Options – Ladies Mile

This memo supports the Three Waters Infrastructure Report prepared by Candor³ pertaining to the proposed Ladies Mile plan change. It serves to outline the different stormwater management options explored as a means of managing the primary and secondary stormwater flows for the plan change area (see Figure 1 below). Water quantity management had the greatest constraints and therefore was the primary consideration when looking at stormwater management options. Water quality can be managed in a variety of ways regardless of the quantity management chosen. These are explored in the Three Waters Infrastructure Report.

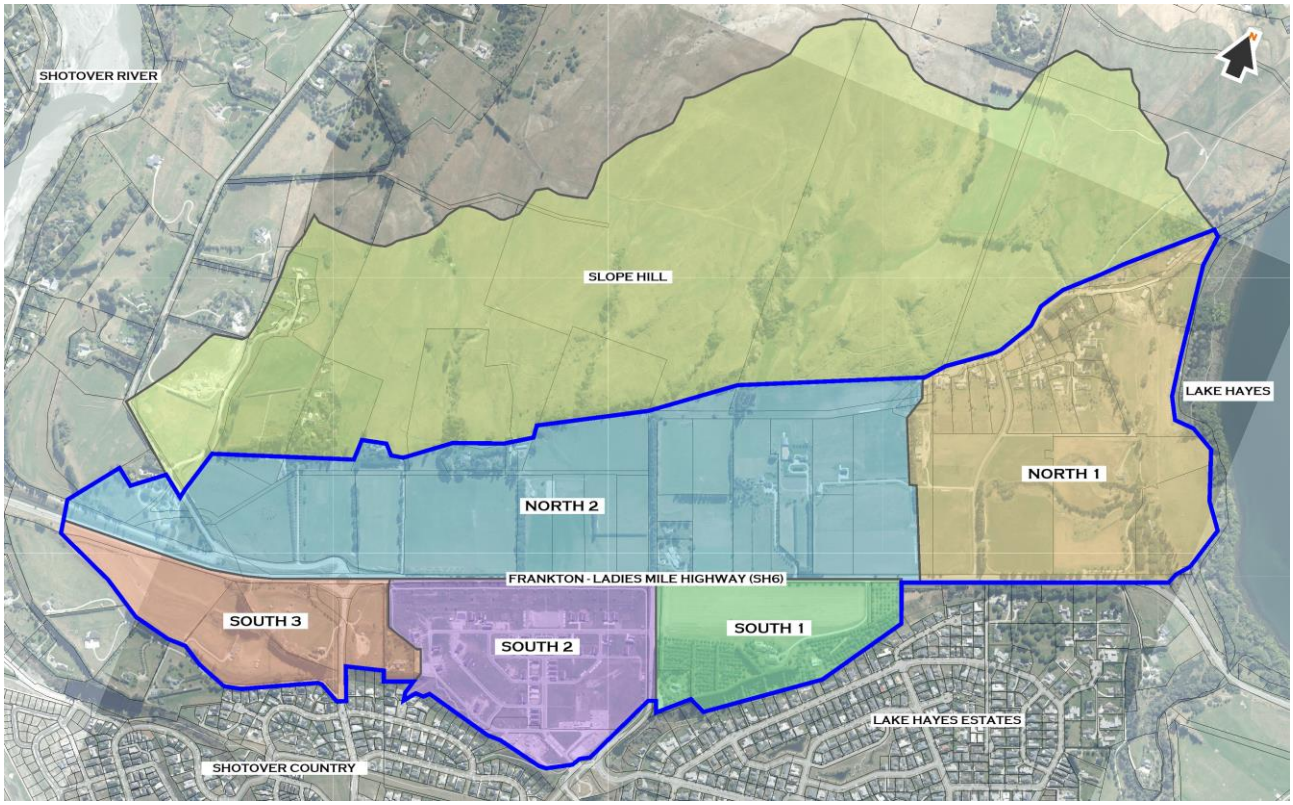


Figure 1: Plan change extents and catchments

Based on the existing site appraisal, the major constraints associated with stormwater management were identified as:

- Delivering a sufficient level of ground infiltration to ensure the ongoing replenishment of the Windemeer Aquifer.
- Managing the high peak flows and stormwater runoff volumes expected to flow into the masterplan area from Slope Hill. The total runoff for the 24-hour 100-year ARI rainfall event was estimated at approximately 97,000m³. The estimated peak flows from some of the individual Slope Hill gully features could be up to approximately 3.5m³/s.

- Providing discharge points for the primary stormwater systems. The existing primary stormwater system in the area, including the 1050mm diameter stormwater pipe located within Howards Drive, does not have the capacity to service the proposed masterplan area.
- Providing discharge points for the secondary stormwater systems. The management of surface water flows from area North 2 to the nearest water body is precluded by area North 1. The management of surface water flows from South 1, South 2, and South 3 are limited by the steep terrace slopes and the existing developments.
- Secondary stormwater flows which currently flow towards Lake Hayes cannot be redirected across State Highway 6. To redirect flows to the south of the highway would require them to be routed underneath the highway.
- Lake Hayes margins have been identified as a regionally significant wetland by the Otago Regional Council. In addition to this, Lake Hayes has been targeted for water quality rehabilitation as a part of the ORC long term plan, and subsequently as a part of the "Jobs for Nature" programme with funding from the Department of Conservation. The sensitive nature of these receiving waters will make it difficult to discharge to this location.
- There are a large number of different landowners within the plan change area. Coordination and alignment of development timelines will be required for large diversion options.

Based on these constraints and the principles outlined in the Three Waters Infrastructure Report, several water quantity management approach options were considered. These options are outlined below. It should be noted that the options were considered on a single management type approach i.e., not a combination of piping and soakage. This was done to clearly identify the benefits and constraints of each option. A combined approach and further options are explored further in the Three Waters Infrastructure Report.

Piped primary network

Creating a piped reticulation network to cater for the 20-year ARI rainfall event. This would have to tie into either the existing Howards Drive pipeline, or a new network. If the existing Howards Drive pipeline is to be utilized it will have to be upgraded to provide suitable capacity.

Benefits:

- Smaller device footprint. Water Quality treatment would still be required, but the detention area would be reduced compared to a soakage network.
- Ongoing maintenance costs are lower, however, at the end of the design life, the system will have to be fully replaced.

Limitations:

- Does not mimic the natural water cycle of the masterplan area.
- No allowance for soakage and therefore recharge of the Windemeer Aquifer.
- No opportunity for dual use (i.e. infrastructure does not provide any other function/benefit).
- No capacity in the existing infrastructure south of the highway, so any new network would have to be extended to the outlet location. Given this outlet location is unknown at this stage, there may be issues with property ownership and construction.

Soakage/infiltration for primary network

Create a soakage network to discharge the 20-year ARI rainfall event to the ground. Could be incorporated with the water quality treatment infrastructure.

Benefits:

- Mimics the natural water cycle for the area.
- Allows for recharge of the Windemeer Aquifer.
- Soakage areas can be dual use i.e. provide some recreation opportunity.
- Provide public amenity (greenspace).
- Provide habitat for native plant and animal species.
- Reduces the size and quantum of hard infrastructure (pipes).

Limitations:

- Soakage devices have a larger footprint compared to the piped system, and therefore reduce the available developable area.
- Potentially higher ongoing maintenance costs, however the replacement cost is less than the piped alternative.

Piped secondary flows (100 year ARI)

Create a piped network to convey the 100-year ARI flows. Could be incorporated with a primary (20-year) network as well.

There are a range of routes available for a piped network. Heading east and discharging to the watercourse linking Lake Hayes and the Kawerau River most closely follows the natural water cycle. This could be laid in the SH6 road corridor minimising the landowners involved. This is explored in Section 5.2.6.3 of the Three Waters Infrastructure Report. Alternatives include:

- Heading west to the Shotover River, however this is going against the natural topography of the site and would introduce deep infrastructure.
- Splitting the catchment to run in both directions. This would reduce pipe sizes but would mean deeper infrastructure heading towards the Shotover River, and likely coordination with private landowners. It would also mean a greater length of pipe.
- Upgrading the existing Howards Road infrastructure. This would require works on the existing network within a developed area with significant cost and disruption. The construction of the upstream network to get flows to this location (network of either the east or west option above) would still be required.

Benefits:

- Smaller device footprint (roughly 4 ha less than a soakage system assuming centralized quality treatment and piping the 20-year ARI flows). There would have to be some area set aside as a means of getting the overland flows into the piped reticulation, however this would be significantly smaller than a soakage or swale system.
- No large land acquisition requirements
- Smaller ongoing maintenance costs than a soakage or swale system.

Limitations:

- Pipes would have to be circa 2400mm diameter in order to accommodate the large flows. There is a large capital cost associated with the construction of infrastructure of this size.
- Large replacement cost at the end of the design life.
- No opportunity for dual use.
- No recharge of the Windemeer Aquifer.
- Large number of independent landowners would require sequenced and coordinated development and buy in from all parties.
- Does not mimic the natural water cycle.

Secondary overland flow diversion (100 year ARI)

This could be via swales and/or the proposed road network to divert secondary flows to a discharge location (to be confirmed via further detailed design). Swales would have to intercept Slope Hill flows and secondary flows generated by the development.

Benefits:

- Reduced risk of blockage when compared with a piped network.
- Smaller footprint than the soakage option.
- Provides some green space amenity for the plan change area. Could be incorporated into a green corridor walking/cycling network.
- Cheaper construction cost than the piped network and soakage options.
- Much less end of design life cost than piped options.
- No large land acquisition requirements when compared with on-site disposal (soakage).

Limitations:

- Physical limitations in constructing swales to discharge location (cannot get to Lake Hayes or Shotover River without passing through private property). May have to implement a piped outlet.
- Does not provide as much amenity/dual use compared to a soakage option.
- If secondary flows are redirected down roads etc, increased risk to pedestrians/vehicles in large rainfall events.
- Does not provide recharge of the Windemeer Aquifer.
- Requires coordination with multiple landowners with different development timeframes.

Secondary network soakage (100 year ARI)

This could be via central soakage basins, or within each private development area. These would be dry soakage areas that will only be inundated during large rainfall events and can be utilized for recreation at all other times.

Benefits:

- Dual use benefit of soakage areas. These can be amenity greenspace or used for recreation.

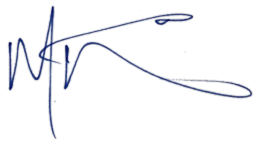
- Habitat for native flora and fauna.
- Lower risk of blockage.
- Recharge of the Windemeer Aquifer.
- Mimics the natural water cycle of the masterplan area.
- Less coordination of multiple landowners and development timeframes.
- No outlet requirements.

Limitations:

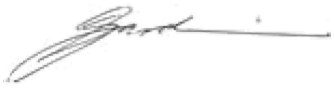
- Large device footprint. Less available development area.
- Land acquisition requirements.
- Larger ongoing maintenance costs.

The options presented above highlight the benefits and limitations of each management approach. Ultimately a combination of several approaches could be incorporated. We believe soakage of primary and secondary flows most closely mimics the natural water cycle and provides good outcomes in terms of the environment and social amenity. This is explored further in the Three Waters Infrastructure Report.

Included with this memo is a cost analysis of the proposed stormwater collection and treatment costs for both the decentralized and centralized approaches including allowances for land value and civil costs. It provides some context for the economic differences between the options considered.



Matt Wilkins
Civil Engineer



John Gardiner
Civil Engineer, Director

Candor³
ENGINEERING FOR LIFE

6 December 2021

Ladies Mile Proposed Stormwater Collection and Treatment Estimated Costs, Decentralised & Centralised Approaches

The proposed Ladies Mile Masterplan has the following main elements.

A 25m wide buffer with SH6, with a continuous cycleway and pedestrian access along the full length of SH6 which will provide for local access roads to properties, achieving high levels of informal surveillance.

Connection to SH 6 (Ladies Mile) will be via 3 additional roundabouts at Howards Dr, and the Eastern roundabout, and a new Lower Shotover Road roundabout, with a connection to Spence Road.

There are two stormwater proposals on the table, a Decentralised and a Centralised Scheme (as proposed in the adopted Ladies Mile Masterplan) -

Decentralised Scheme

Stormwater disposal schemes have been proposed where individual landowners deal with any runoff entering their developments from Slope Hill and convey it to an attenuation / soakage area within each property, via a swale that allows pre-treatment and soakage.

In this scenario the collection swale at the base of Slope Hill is significantly smaller than that proposed for the Centralised system, and the conveyance swale to the treatment area is used as a pre-treatment and infiltration device.

These devices have been sized for the catchments areas from Slope Hill, and the areas of the 8 different land holdings.

We have looked at two options;

A. The Slope Hill catchment is collected by a cut off drain, and piped from the cut off drain to the stormwater management area by pipe.

B. A cut off drain collects runoff from the Slope Hill catchment, and treatment swales conveying water from the cut off drain to the stormwater management areas. These swales are deep enough to accept piped drainage from the adjacent lots to be directed into this N-S swale.

The options considered result in stormwater management areas requiring a base area approximately 3.5 – 4.0m deep for the swale option and 4.5 - 5m depth below existing ground levels for the piped option. If a 1 in 4 side slope is adopted significant areas of land are required for stormwater management with the piped option requiring slightly less land but having higher construction costs. The large swale option is feasible and has lower construction costs but uses more land for the swale which has aesthetic and maintenance implications for the developments in future. The large swale does allow treatment / attenuation areas to be slightly shallower resulting in a lower use of land overall.

The piped option will be more expensive to construct but has certain advantages in terms of building the developments in the first instance and maintaining them in the longer term as an extensive network of swales imposes constraints on the connectivity of the developments throughout the Ladies Mile Masterplan area and is challenging to maintain over the longer term.

The costs for the two options investigated are set out as follows -

	Construction Costs	Option A Pipes to SMA	Option B Large swales to SMA
Section		**Cost**	**Cost**
100	Preliminary and General	$2,669,000	$2,338,000
200	Earthworks and Clearing	$9,233,000	$8,880,000
500	Swales (& pipework where required)	$9,275,000	$7,423,000
1200	Construction Contingency	$4,235,000	$3,728,000
	TOTAL CIVIL WORKS	$25,412,000	$22,369,000
	Land Area (m2)	162,000	163,328
	Land Costs ($300/m2)	48,621,000	48,998,000
	TOTAL LAND COSTS	48,621,000	48,998,000
	TOTAL COST – CIVILS & LAND	74,033,000	71,367,000

The land cost for either option is similar in aggregate although where individual land holdings are sited within the catchment does have a bearing with properties towards the west requiring less land and properties to the east requiring more land due to lengths of swale required. The construction costs for the piped option are considerably greater than for the swale option.

What might also be considered in this equation is the potential fragmentation and potential lack of connectivity of the overall development if a network of swales is installed throughout the masterplan area to manage stormwater.

An option also considered was to pipe the 100 year event along SH6 to the Lake Hayes outlet, however the cost of this is option circa $10-12m plus the cost of going under SH6. This option was not considered worthwhile as the reduction in storage area was circa 6000m^2 gross area (at $300/m2 = $1.8m).

Please see Appendix A for a plan of the Decentralised proposal (Option B).

Although not tested in detail we have looked conceptually whether locating the stormwater treatment and detention areas adjacent to the east-west collector road would make a material difference to our estimates. Such a scenario would result in deeper pipe networks to the SW treatment and retention areas due to the ground falling slightly away from Slope Hill towards SH6. This would therefore make the treatment detention areas larger due the longer batters generated by the increased depth. Overall, it is anticipated that locating decentralised stormwater devices adjacent to the east-west collector road would in all likelihood result in slightly increased construction costs and slightly more land area being utilised if this solution was selected.

Centralised System. (as indicated in the adopted Ladies Mile Masterplan)

Option C is to install a centralised system, using a continuous collection swale at the base of Slope Hill, and two stormwater treatment and storage basins to cater for the 100 year event, with an outlet under SH 6 to the existing pipe in Howards Drive being utilised to help drain water from the western most of the two proposed stormwater management areas.

The cost of this option is set out as follows.

	Construction Costs	Centralised system to SMA
Section		**Cost**
100	Preliminary and General	$1,886,000
200	Earthworks and Clearing	$2,830,000
500	Swales (& pipework where required) & Treatment areas incl. planting	$7,854,000
1200	Construction Contingency	$2,514,060
	TOTAL CIVIL WORKS	$15,084,000
	Land Area (m2) [1]	81,382
	Land Costs ($300/m2)	$24,415,000
	Total Cost - Civils and Land	**$39,499,000**

[1] *This land area includes circa 8,800m^2 of unformed legal road that is utilised for swales and treatment/detention areas*

Refer to Appendix B for a plan of the Centralised stormwater management proposal

Land Opportunity Cost

QLDC have provided an indicative land value of $300/m2 for the raw undeveloped land. This has been used as a basis of comparison of all options. The Decentralised scheme we have estimated would use approximately double the land area of the Centralised scheme under any scenario, and be more expensive to construct and maintain, as there are more devices, and they are less efficient.

For clarity the cost of the options considered are compared in the following table -

Option	Land area (m2)	Land Cost (assumes $300/m2)	Civils Cost ($)	Total Cost of Civils, land cost ($)
A) Pipes to SMA	162,071	48,621,000	25,413,171	**74,034,351**
B) Large swales to SMA	163,328	48,998,000	22,370,357	**71,368,637**
C) Centralised	81,382	24,416,000	15,084,000	**39,499,000**

It can be seen that the centralised option is significantly cheaper than the decentralised options.

What is not clear from the above tables is the additional positive financial impact of a centralised system for the developers. If a centralised system is installed using approximately 8.1ha of land it frees up a similar amount of land that can be developed and sold. In our opinion this opportunity cost needs to be recognised in the calculations as follows -

Based on a rough analysis of recent sales in the Shotover Country subdivision we estimate that the higher density of Ladies Mile will sell for approx. $1000/m^2. If it is assumed that 20% of the land freed up in a centralised system will go to roads etc. approximately 6.0ha will be delivered as finished sections that can be sold. This land has been accounted for at $300/m^2 in the calculations within the above tables and, in our opinion, an adjustment should be made to recognise the increased value of the land available for sale. Assuming that construction costs to develop the additional land will be in the order of $500/m^2 the additional value that can be realised by

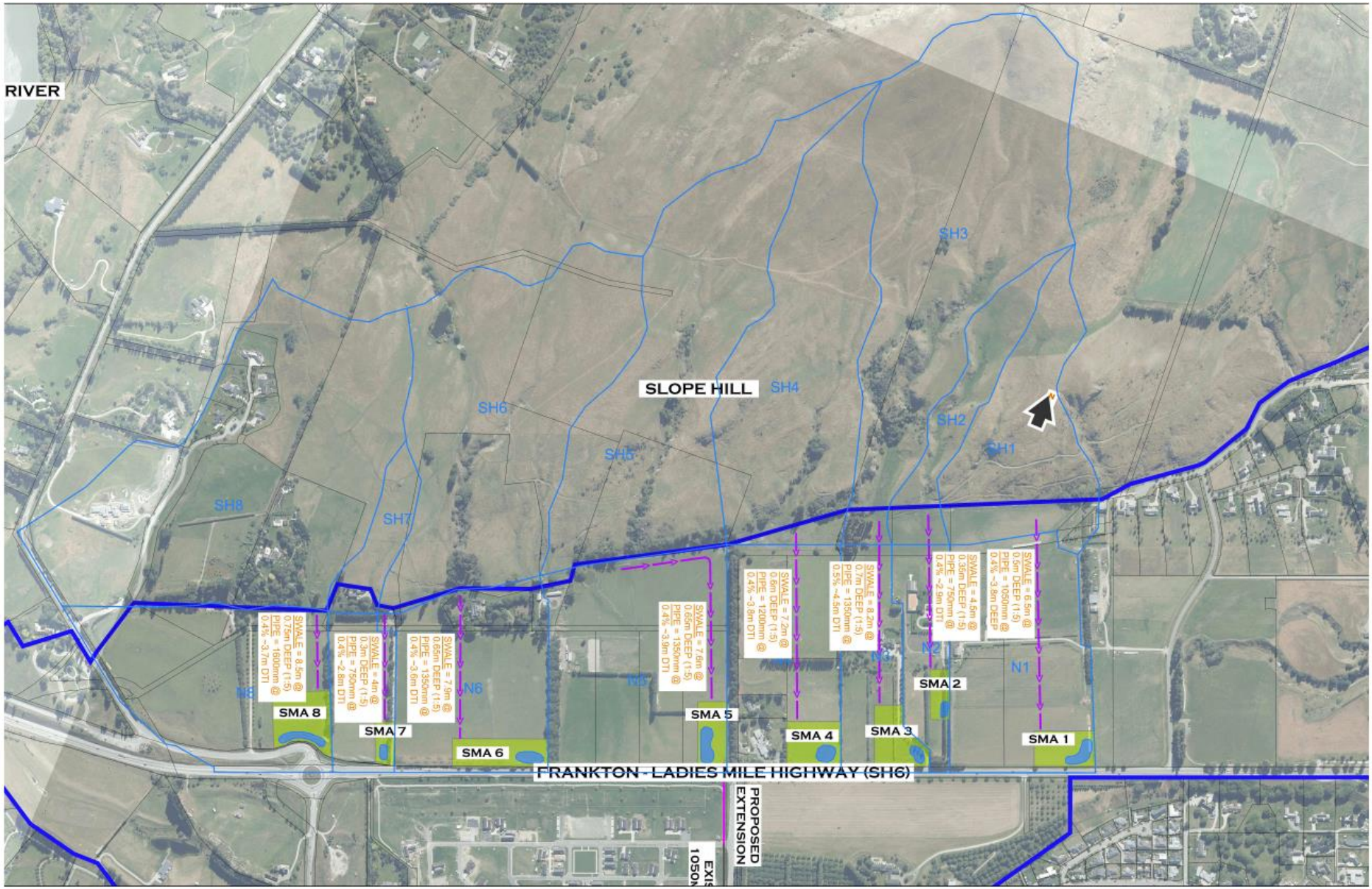
developers will be in the order of $12.0m (60,000m^2 @ $200/m^2). We display this in the following table as a lost opportunity cost for options A and B.

Option	Land area (m2)	Land Cost (assumes $300/m2)	Lost Opportunity Cost ($)	Civils Cost ($)	Total Cost of Civils, land cost ($)
A) Pipes to SMA	162,071	48,621,000	12,000,000	25,413,000	**86,034,000**
B) Large swales to SMA	163,328	48,998,000	12,000,000	22,370,000	**83,369,000**
C) Centralised	81,382	24,415,000	Nil	15,084,000	**39,499,000**

Conclusion

Overall, the cost comparison of the Decentralised and Centralised stormwater schemes show that the centralised scheme is considerably cheaper by circa $43.8m to $46.5m including the lost opportunity cost of the additional land required for the decentralised option. This price differential is driven by additional land areas required, the opportunity cost of not being able to sell developed land and higher civil costs.

Appendix A Decentralised System Plan (Option B)



Appendix B Centralised System Plan (Option C)