Economics Work Package 11:
SRL1: The Urban Intervention Options Work Brief

Deliverable 2: Summary of life cycle costs for water supply infrastructure solutions

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Te Awarua-o-Porirua Collaborative Modelling Project

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Summary of life cycle costs for wastewater infrastructure solutions

Report prepared for Greater Wellington Regional Council.

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Disclaimer:

Whilst every effort has been made to ensure the integrity of the data collected and its application through the COSTnz Model, the author does not give any warranty as to the accuracy, completeness, currency or reliability of the information made available in this report and expressly disclaims (to the maximum extent permitted by law) all liability for any damage or loss resulting from the use of, or reliance on the LCC models or the information or graphs provided through them.

Costs presented in this report are based on current available information and should be read in the context of the assumptions presented in this report. Cost information has been gathered and modelled in order to gain an understanding of the relative difference in cost between different solutions, not the actual cost of each solution.

Any decision that is made after using this data must be based solely on the decision-makers own evaluation of the information available to them, their circumstances and objectives.

1 Introduction

1.1 Purpose and scope

The purpose of the project is to collaboratively generate information and knowledge to support the Te Awarua-o-Porirua Whaitua Committee make recommendations for land and water management in the Whaitua. The project will produce modelling outputs and knowledge describing the current environmental, social, cultural and economic conditions in TAoP Whaitua, as well as potential future outcomes that might result under urban and rural land and water management scenarios.

This work forms part of the Urban Intervention Work Brief and is one component of the overall economics work brief that addresses the decision making needs of the Whaitua Committee. This report follows-on from the Deliverable 1 Report "Summary of potential solutions available for stormwater, wastewater and water supply provision". The Deliverable 1 report documented potential solutions available to facilitate an operational focus towards water quality treatment, stormwater reuse and source control. Additionally, the report documented potential solutions available and currently being used to support water supply and wastewater infrastructure needs. Coupled with a decision-support matrix, a full range of solutions was presented, along with the applicability of their use and cost information, as documented in national and international literature.

Deliverable 2 of the Urban Intervention Work Brief requires the development of a cost 'reference library' for the different solutions. The costs need to be provided as estimates of the undiscounted life cycle costs in NZ$2017. This report provides a description of the modelling work that was undertaken and the life cycle costs for those water supply solutions where cost data is available.

1.2 Life cycle costing

A life cycle costing (LCC) approach has been previously used to assess costs associated with stormwater devices in Australia, the United States of America (USA) and the United Kingdom (UK) (Vesely *et al.*, 2006[1]). The Australian/New Zealand Standard 4536:1999[2] defines LCC as the process of assessing the cost of a product over its life cycle or portion thereof. The life cycle cost is the sum of the acquisition and ownership costs of an asset over its life cycle from design, manufacturing, usage, and maintenance through to disposal. The consideration of revenues is excluded from LCC. A cradle-to-grave time frame is warranted because future costs associated with the use and ownership of an asset are often greater than the initial acquisition cost and may vary significantly between alternative solutions to a given operational need (Australian National Audit Office, 2001[3]).

LCC has a number of benefits and supports a number of applications and analyses (Lampe *et al* 2005[4]):

- it allows for an improved understanding of long-term investment requirements;
- it helps decision-makers make more cost-effective choices at the project scoping phase;

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[1] Vesely, E-T., Arnold, G., Ira, S. and Krausse, M. (2006). *Costing of Stormwater Devices in the Auckland Region.* NZWWA Stormwater Conference.

[2] Australian/New Zealand Standard. (1999). Life Cycle Costing: An Application Guide, AS/NZ 4536:1999. Standards Australia, Homebush, NSW, Australia and Standards New Zealand, Wellington, NZ.

[3] Australian National Audit Office. (2001). Life Cycle Costing: Better Practice Guide. Canberra, Commonwealth of Australia.

[4] Lampe, L., Barrett, M., Woods-Ballard, B., Kellagher, R., Martin, P., Jefferies, C., Hollon, M. (2005). Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems. WERF Report Number 01-CTS-21T.

- it provides for an explicit assessment of long-term risk;
- it reduces uncertainties and helps local authorities determine appropriate development contributions; and
- it assists local authorities in their budgeting, reporting and auditing processes.

Decision-making on the use and upgrade of water infrastructure needs quality data on the technical and financial performance of these devices. The financial performance will depend on the sum and distribution over the life cycle of the device of costs associated with design, construction, use, maintenance, and disposal. LCC can be used for structuring and analysing this financial information. A LCC approach has been used in this project to quantify, where possible, the cost implications of water supply infrastructure.

1.3 Caveat and limitations

Unlike the stormwater life cycle costing models, this is the first project which has attempted to collect cost data and quantify life cycle costs of water supply infrastructure. Very little cost data is available in New Zealand relating to water supply infrastructure. In many cases, the "site specific" nature of water dams and reservoirs means that obtaining standardized cost data which can be used in costing models is exceptionally challenging.

A study undertaken by the Water Environment Research Foundation (WERF - UK) and the AWWA Research Foundation (USA) (Lampe *et al*, 2005[4]) confirmed that both construction and maintenance cost data are notoriously difficult to obtain due to the 'financial sensitivity' of the information and the large number of variables involved in the construction and maintenance processes of water infrastructure. In addition, it is an exceptionally time consuming process to collect cost data and, in many instances, data collected is not comparable or suitable for use within a model. Whilst significant effort was placed on collecting water supply infrastructure cost data, no "actual" total acquisition cost data was received for many of the solutions, and no maintenance data was obtained from existing maintenance operations at all. Maintenance contractors were approached for cost information, but many refused to provide data. Their reasons ranged from financial sensitivities, to not having data in a meaningful form (many maintenance contracts are lump sums for maintenance based on areas rather than itemised maintenance), and variability of size making it too difficult to cost. Some contractors did assist by providing information around the likely maintenance activities that could occur, along with potential frequencies and costs. Due to the lack of total acquisition and maintenance cost data, and as shown in the table below, LCC models could not be developed for many of the water supply infrastructure solutions.

Solution	**Costing Approach**
Water supply dams/ reservoirs	Outside the catchment area. Insufficient cost information to develop a LCC model. Replacement cost provided.
Water treatment plants	Insufficient cost information to develop a LCC model. Replacement costs available along with a schedule of likely maintenance activities.
Pump stations	Insufficient cost information to develop a LCC model. Replacement costs available along with a schedule of likely maintenance activities.
Pressurized water supply pipes	Life cycle costs have been modelled.
Valves/ hydrants/ fittings	These costs have been included in the pressurized water supply pipe LCC models.

For those infrastructure solutions where LCC models could be developed, the data used to develop the models is based on the best available cost information at the time of writing this report and professional judgement. However, cost information is notoriously variable, and whilst every effort has been made to ensure the consistency and integrity of the data collected, reliance should not be placed on the actual costing figures. Significant work would be needed to collect additional cost and maintenance data in order to further refine the models. Decision-makers should rather use the life cycle costing information to understand the potential relative difference between the different management solutions.

2 Life cycle costing models and cost data

The Landcare Research COSTnz Model[5] has been used to determine life cycle cost information for the Porirua Whaitua. COSTnz is a site-specific model and requires a good understanding of the local site conditions, contaminant inputs and infrastructure solution design. In general, the life cycle costs are assessed using a unit-based approach. Whilst COSTnz is a LCC model which is focussed on stormwater infrastructure, it does include a "Generic" module which can be tailored to any type of "hard" infrastructure. The "Generic" module was modified and used to model water supply infrastructure life cycle costs for those solutions where sufficient maintenance data was available.

Cost data for the water supply models was obtained from a number of sources. Wellington Water provided some construction and installation cost data for the water supply infrastructure which they operate. In addition, cost information was obtained from Wellington Water and WaterCare Asset Management Plans (AMPs), as well as "on-the-ground" subdivisions undertaken in the Auckland Region and from water supply contractors.

3 Life cycle costing assumptions

All models have the same life cycle costing assumptions, as follows:

- The base year for the COSTnz model is 2007. As a result, all costs were inflated to a base year of 2017 using a 2.8% inflation rate. Any other data received was also inflated to a base year of 2017 in order to ensure all data was comparable and had the same base date in the models.
- A life cycle analysis period and life span of 50 years was used for all model runs.
- A discount rate of 3.5% was used for the discounted life cycle costs (however, as required in the scope of works, only undiscounted life cycle costs are presented in this report).
- Decommissioning costs were not included in the models as none of the solutions would be decommissioned after 50 years.

4. Model assumptions for individual solutions

The following section describes the total acquisition cost (TAC) and maintenance cost (MC) assumptions, as well as any specific design assumptions or cost limitations, for each water supply solution.

It should be noted that, where possible, a range of costs (from low to high) has been provided. Providing a range of costs assists in addressing uncertainty in the cost estimates. In addition, this

[5] Ira, S. J. T., Vesely, E-T., McDowell, C and Krausse, M. 2009. *COSTnz – A Practical Life Cycle Costing Model for New Zealand*. NZWWA Conference, Auckland.

range helps to remind users that the value of these life cycle costs lies in their ability to provide a relative comparison of costs between different solutions, rather than the actual cost itself.

4.1 Water supply dams/ reservoirs

The regional water supply source for the Porirua Whaitua is outside the catchment area and is within the Lower Hutt Valley. The focus for the Porirua Whaitua is on the conveyance of water from this source.

Cost information for water supply dams was particularly difficult to source since they are not included as separately costed items in the AMPs. In addition, due to the large variation between sizes of dams (which relate to their particular function as well as available space), contractors were not willing to price elements of dam construction and maintenance. With respect to water supply reservoirs, the replacement cost[6] varies from $625,000 - $3,600,000 per reservoir (based on the Wellington Water and WaterCare AMPs).

Recommendations (to allow a LCC model to be built):
Specific cost information, based on the construction of a proposed water supply dam or reservoir would need to be obtained. It is noted that a reasonable amount of detail for the proposed facility would be needed in order to allow an engineer to cost the facility. Maintenance activity, frequency and cost data would also need to be collected. This could potentially be collected from the water supply facility in the Lower Hutt Valley (assuming the newly proposed water source is similar in nature) in order to develop a proposed maintenance schedule and costs.

4.2 Water Treatment Plants

No cost data was received on water treatment plants from Wellington Water. In addition, for the reasons discussed in 4.1 above, cost information could not be obtained from contractors. Based on the WaterCare AMP, the replacement cost of a water treatment plant is in the order of $26 million.

Maintenance activity, frequency and cost information for water treatment plants was obtained from one Auckland source and no maintenance cost data was provided by Wellington Water. The source provided information based on his professional judgement and made the assumption that it was for a large scale, high loading treatment plant. The table below summarises this information:

Maintenance Activity	Frequency	Unit	Cost
Routine Maintenance			
Automated Electronic	Once	per plant	approx $4000-$5000
Check pumps, lift lid, hose down walls (2 technicians, two	Weekly	per hour	$ 75.00
General maintenance for a plant handling 1000 cubic	Daily	per plant	$ 680.00
General maintenance for a plant handling 600 cubic	Daily	per plant	$ 85.00
Service for a plant handling 3 cubic metres a day	Every 3 months	per hour	$ 85.00
Corrective Maintenance			
Technician inspection	as required	per hour	$ 85.00
Waste water labourer	as required	per hour	$ 65.00

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6 Replacement cost is defined as the measured fair value of an asset less depreciation.
http://www.aucklandcouncil.govt.nz/Plans/LongTermPlan/VolumeThree/section_s1341978107152.html Accessed on 12/6/2017

Recommendations (to allow a LCC model to be built):
Specific cost information, based on the construction of a proposed water treatment facility would need to be obtained. It is noted that a reasonable amount of detail for the proposed facility would be needed in order to allow an engineer to cost the facility. Maintenance activity, frequency and cost data would also need to be collected. Costs provided in the table above are generally per hour, so an estimation of the number of hours needed to undertake the activity for a specific plant would be need to be estimated.

4.3 Water Supply Pump Stations

No cost data was received on water supply pump stations from Wellington Water. In addition, for the reasons discussed in 4.1 above, cost information could not be obtained from contractors. Based on the Wellington Water and WaterCare AMPs, the replacement cost of a water pump stations vary from $75,000 to $300,000.

Maintenance activity, frequency and cost information for water supply pump stations was obtained from one Auckland source and no maintenance cost data was provided by Wellington Water. The source provided information based on his professional judgement and made the assumption that it was for a large scale, high loading pump station. The maintenance contractor stated that, over the course of 10 years, the amount spent on repairs to the pump station each year would likely equate to the total pump value. The table below summarises this information, and it is noted that this table is the same as that provided for the maintenance of wastewater pump stations.

Maintenance Activity	Frequency	Unit	Cost
Routine Maintenance			
Chamber lid replacement	Within 25 years	per lid	$ 3,000.00
General maintenance/inspections of pumps	Every 10 years, although possibly every 6 years if close to a daycare, school or	per pump	total replacement cost of pump
Pump station inspection (usually 4 hours per month)	weekly-fortnightly	per hour	$ 85.00
Moving pumps for closer inspection	Every three months	per station	$ 850.00
Corrective Maintenance			
Chamber repairs	Every 25 years	per chamber	Inspection fees ($65-85 per hour), possible repairs needed

Recommendation (to allow a LCC model to be built):
Total Acquisition Costs: specific cost information, based on the construction of a series of proposed water supply pump stations would need to be obtained. Potentially the data obtained for wastewater pump stations can be used and extrapolated for water supply (since the data primarily relates to the size of the pumps used).

Maintenance Costs: Additional maintenance activity, frequency and cost data should be collected from existing Porirua pump stations in order to refine the proposed maintenance schedule and costs above. Potentially a monthly maintenance schedule with associated costs could then be developed, which could then be used in a life cycle costing model. Corrective maintenance costs could be identified through historic records for the pump stations, or based on total pump replacement every 10 years, along with a sum for other minor repairs. These costs could then be modelled and converted to a L/s pumping rate to complement the existing TAC information.

4.4 Water Supply Pipes

The COSTnz "generic" model was used to develop life cycle costs for pressurized water supply pipes, and it is based on a similar approach to the stormwater pipe models. Data from Wellington Water has shown that they service a total pipe length of approximately 547km, with an associated "other fittings" (i.e. hydrants, valves and meters) of approximately 17983.

Based on the recommendations of the Regional Standard for Water Services in the Wellington Region (November 2012), the following design assumptions are recommended to inform the TAC:

Pipes >200mm in diameter	Pipes 100mm – 200mm in diameter	Pipes >100mm in diameter
750m x relevant pipe	750m x relevant pipe	750m x relevant pipe
2 x Combination Air Valves	2 x Combination Air Valves	2 x Combination Air Valves
2 x Air Release Valves	2 x Air Release Valves	2 x Air Release Valves
4 x Air/ Vacuum Valves	4 x Air/ Vacuum Valves	4 x Air/ Vacuum Valves
4 x Scour Valves	3 x Fire Hydrants	4 x Scour Valves
3 x Fire Hydrants	5 x Connection/ Service Fittings	5 x Connection/ Service Fittings
1 x Backflow Preventers		
5 x Connection/ Service Fittings		

Costs of the differing valves are reasonably similar, and given the resolution of the model, the difference between the valve costs could reasonably fall within the low and high values limits of the model. As a result, and to simplify the modelling process, 150m sections of pipe were costed, and the following assumptions were used in the LCC model:

Table A Water supply pipe network assumptions

Pipes >200mm in diameter	Pipes 100mm – 200mm in diameter	Pipes 100mm in diameter	Pipes >100mm in diameter
150m x relevant pipe	150m x relevant pipe	150m x relevant pipe	150m x relevant pipe
3 x valves	3 x Valves	2 x Valves	2 x Valves
1 x Fire Hydrant	1 x Fire Hydrant	1 x Fire Hydrant	1 x Connection/ Service Fitting
2 x Connection/ Service Fitting	1 x Connection/ Service Fitting	1 x Connection/ Service Fitting	

Pressurised water supply LCC models could only be costed to a pipe size of 200mm in diameter. Cost information on PE water supply pipes >200mm was difficult to obtain and, in some instances, contradictory in nature. As a result, the models do not include costs of bulk or trunk main supplies.

As recommended by Wellington Water, an "on-cost factor" of 1.13 (approximately 50% of the installation cost) was added to the installation cost to account for costs incurred through the design, planning and consenting phase, and to account for compliance and management fees during construction. This percentage is relatively consistent with the recommendations Table 6.2 of Chapter 6 of an unnamed/ undated EPA report[7].

Total Acquisition Costs:

The following formula was used to determine the TAC for each scenario:

[7] Chapter 6 of an unnamed/ undated US EPA Report: https://www3.epa.gov/npdes/pubs/usw_d.pdf

TAC Cost for 150m of pipe = [(Pipe Installation Cost x 150) + (cost of fittings in Table A)] 50% design, planning, supervision & contingency cost*

Pipe installation costs (from Wellington Water, Rawlinsons[8] and AR & Associates)

Pipe Diameter (mm)/ Infrastructure*	Low (NZ$) (greenfield rate) ($/m)	Mid (NZ$) (suburban rate) ($/m)	High (NZ$) (CBD rate) ($/m)
20 - 60mm	196	280	336
100mm	228	360	432
150mm	268	380	456
200mm	348	510	612
Valves (<100 dia pipes)**	1,340	2,170	3,000
Valves (>100 dia pipes)	2,160	3,395	4,630
Fire Hydrants	1,850	2,355	2,860
Connection/ Service Fitting	1,750	2,315	2,880
Initial Testing	1,150	1,868	2,586

* PE80B SDR 11 PN 12.5 pipes. Cover depth of approximately 1m or less.
** Valve life span = 25 years

Maintenance costs:
Since no addition maintenance data was available for water supply pipes, maintenance activities, frequencies and costs for the low, mid and high scenarios incorporate the same activities as for stormwater pipes. The modelled maintenance spreadsheets are shown below. An increase from 1 to 2 hours for CCTV inspection has been allowed for the larger pipe sizes. The water supply pipes are likely to be flushed rather than vacuumed, so this cost has been included. The model also makes an allowance for the replacement of valves every 25 years. Finally, a sum was estimated for minor repairs to fittings and hydrants (where applicable) every 10 years. Since no cost data was available to assist in estimating this cost, the minor repairs were assumed to equate to half of the connection/ fitting installation cost.

8 Rawlinsons New Zealand Construction Handbook (2007)

Low costs

MAINTENANCE COSTS

Routine Maintenance	Frequency (Per Year)	Unit	Costs		Total Cost
	User Defined		Model/ Default	User Defined	
Routine testing (including leaks, flow tests, pressure tests, valve/ hydrant checks)	1	per device		$500.00	$500.00
Annual Service (inspection of operating unit and clearing debris from inlets; outlets; replacement of filters/ cartridges/ bags, etc)	1	per device			$0.00
Minor repairs	1	per device		$450.00	$450.00
Make good following vandalism		per device			$0.00
Other Activities *{please specify}*					$0.00
Traffic Management	2	per device			$0.00
					$0.00
					$0.00
					$0.00
					$0.00
TOTAL ROUTINE MAINTENANCE COSTS [Annual]					**$950.00**

No) no

Cost of Additional Service

Corrective Maintenance	Frequency (Number of Years)	Unit	Costs		Total Cost
	User Defined		Model/ Default	User Defined	
Replacement of valves	25	per valve		$2,680.00	$2,680.00
Replacement of parts (fire hydrants; fittings, etc - half the TAC of connections/ fittings)	10	per device		$875.00	$875.00
Cleanout of Sediment*	10	m^3			$0.00
Disposal of Sediment	10	m^3			$0.00
Other activities *{please specify}*					
CCTV	25	per hour		$240.00	$240.00
Traffic Management	10	per pipe		$450.00	$450.00
Vacuuming / flushing of Pipes	10	per service		$260.00	$260.00
Disposal of Sediment	10	m3			$0.00
TOTAL CORRECTIVE MAINTENANCE COSTS					**$4,505.00**

Mid costs

MAINTENANCE COSTS

Routine Maintenance	Frequency (Per Year)	Unit	Costs		Total Cost
	User Defined		Model/ Default	User Defined	
Routine testing (including leaks, flow tests, pressure tests, valve/ hydrant checks)	1	per device		$750.00	$750.00
Six Monthly Service (inspection of operating unit and clearing debris from inlets; outlets; replacement of filters/ cartridges/ bags, etc)	2	per device			$0.00
Annual Service (inspection of operating unit and clearing debris from inlets; outlets; replacement of filters/ cartridges/ bags, etc)	1	per device			$0.00
Minor repairs	1	per device		$715.00	$715.00
Make good following vandalism		per device			$0.00
Other Activities *{please specify}*					$0.00
Traffic Management	2	per device			$0.00
					$0.00
					$0.00
					$0.00
					$0.00
TOTAL ROUTINE MAINTENANCE COSTS [Annual]					**$1,465.00**

No) no

Cost of Additional Service

Corrective Maintenance	Frequency (Number of Years)	Unit	Costs		Total Cost
	User Defined		Model/ Default	User Defined	
Replacement of valves	25	per device		$4,340.00	$4,340.00
Replacement of parts (fire hydrants; fittings, etc - half the TAC of connections/ fittings)	10	per device		$1,157.50	$1,157.50
Cleanout of Sediment*	10	m^3			$0.00
Disposal of Sediment	10	m^3			$0.00
Other activities *{please specify}*					
CCTV	25	per hour		$305.00	$305.00
Traffic Management	10	per pipe		$517.00	$517.00
Vacuuming of Pipes	10	per service		$350.00	$350.00
Disposal of Sediment	10	m3			$0.00
TOTAL CORRECTIVE MAINTENANCE COSTS					**$6,669.50**

High costs

MAINTENANCE COSTS

Routine Maintenance	Frequency (Per Year) User Defined	Unit	Costs Model/ Default	Costs User Defined	Total Cost
Routine testing (including leaks, flow tests, pressure tests, valve/ hydrant checks)	1	per device		$750.00	$750.00
Six Monthly Service (inspection of operating unit and clearing debris from inlets; outlets; replacement of filters/ cartridges/ bags, etc)	2	per device			$0.00
Annual Service (inspection of operating unit and clearing debris from inlets; outlets; replacement of filters/ cartridges/ bags, etc)	1	per device			$0.00
Minor repairs	1	per device		$715.00	$715.00
Make good following vandalism		per device			$0.00
Other Activities *{please specify}*					$0.00
Traffic Management	2	per device			$0.00
					$0.00
					$0.00
					$0.00
					$0.00
TOTAL ROUTINE MAINTENANCE COSTS [Annual]					$1,465.00

No) no

Cost of Additional Service

Corrective Maintenance	Frequency (Number of Years) User Defined	Unit	Costs Model/ Default	Costs User Defined	Total Cost
Replacement of valves	25	per device		$6,000.00	$6,000.00
Replacement of parts (fire hydrants; fittings, etc - half the TAC of connections/ fittings)	10	per device		$2,880.00	$2,880.00
Cleanout of Sediment*	10	m^3			$0.00
Disposal of Sediment	10	m^3			$0.00
Other activities *{please specify}*					
CCTV	25	per hour		$370.00	$370.00
Traffic Management	10	per pipe		$585.00	$585.00
Vacuuming of Pipes	10	per service		$440.00	$440.00
Disposal of Sediment	10	m3			$0.00
TOTAL CORRECTIVE MAINTENANCE COSTS					$10,275.00

4.5 General water supply cost/ model exclusions and notes

The following general notes and exclusions apply to the water supply cost information and pipe LCC model assumptions discussed in this report:

- Consistent pipe material assumed (PE80B SDR 11 PN 12.5 pipes. Cover depth of approximately 1m or less).
- The models do not include connections to private lots/ houses (i.e. plumbing to house, etc)
- The models do not include monitoring of flows or metering.
- All costs are a mix of engineers estimates, quotes and guesstimates, and are based on the assumptions detailed in this document.
- Maintenance costs and schedules are rough estimates/ guesstimates based on "best available data" at this time.
- Local cost information has been used where it is available.

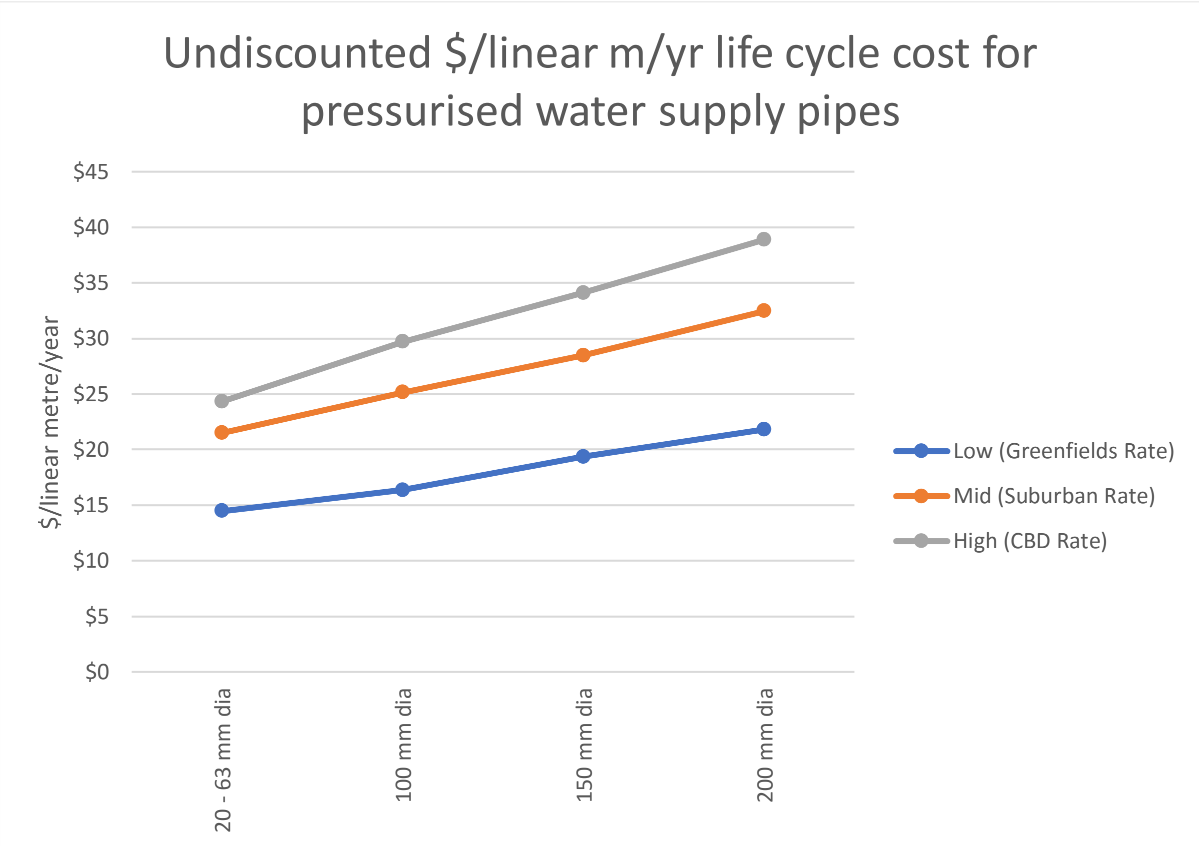
5. Summary of undiscounted life cycle costs

5.1 Results

The table and graph below provide a summary of the undiscounted $/year (2017) life cycle costs (based on a 50 year analysis period) for the pressurized water supply piped systems.

Summary of undiscounted life cycle costs ($/ linear metre/ year):

$/m/yr	Low (Greenfields Rate)	Mid (Suburban Rate)	High (CBD Rate)
20 - 63 mm dia	$14	$21	$24
100 mm dia	$16	$25	$30
150 mm dia	$19	$28	$34
200 mm dia	$22	$32	$39



5.2 Other costs

5.2.1 Land costs

COSTnz does not include land costs in the total life cycle analysis. Therefore, in order to generate an accurate catchment-scale LCC, land costs need to be accounted for. Modelling work was undertaken as part of the UPSW stormwater cost model in an attempt to determine whether or not a land cost factor could be used to account for land costs in the different types of development scenarios (i.e.

greenfield vs retrofit development). This information was presented in the report entitled "*Deliverable 2: Summary of life cycle costs for stormwater infrastructure solutions*". The land cost factors are applied through the UPSW stormwater cost model relate to $/ha/ yr life cycle costs and therefore cannot be directly applied to the water supply pipe model costs. In the absence of further research and guidance, and given that the pipes are underground, it is recommended that the pipe models do not include a factor for land costs.

Further work is needed to validate this assumption and to determine what the land cost may be for other water supply solutions such as dams, treatment plants and pump stations.

5.2.2 Construction costs

A list of itemised construction costs (relating to earthworking and concreting) is provided in the report entitled "*Deliverable 2: Summary of life cycle costs for stormwater infrastructure solutions*".

5.2.2 Network fittings

To further supplement the "library" of water supply infrastructure costs, a list of costs obtained through the data collection process is provided below. Where necessary the costs have been inflated to a base date of 2017. The costs only encompass construction and installation costs, and do not include design, planning, preliminary and general or site supervision costs.

Network Fittings

Asset Type	2017 Cost	
	Unit Rate ($)	Life (yrs)
Back Flow Preventer	982	25
Bend Preformed	1855	70
Cross	3055	70
Dead End	2946	70
FLEXIBLE COUPLER	2946	70
Joint	1855	70
MECH FLANGE ADAPTER	2291	70
PIPE CONNECTION	3055	70
Reducer	1855	70
SADDLE	2291	70
Special	2291	70
Tapping Band	1746	100
Tee	1855	70

Service Fittings

Asset Type	2017 Cost	
	Unit Rate ($)	Life (yrs)
Back Flow Preventer	982	25
Bend Preformed	1855	70
Cross	1855	70
Dead End	2946	70
Joint	1855	70
Reducer	1855	70
Special	2291	70
Tapping Band	1746	70
Tee	1855	70

6 Conclusions

This report has provided an overview of the method and assumptions used in the life cycle costing process, along with the results of this analysis. Only full LCC models could be developed for pressurized water supply piped systems. This is mainly due to the fact that, whilst significant effort was placed on collecting water supply infrastructure cost data, no “actual” TAC data was received for many of the solutions, and no maintenance data was obtained from existing maintenance operations at all. The report presents LCC for piped water supply networks, and also provides a series of replacement costs for other water supply solutions. Where available, maintenance cost information has also been provided.

Significant further work would be needed to collect additional TAC and maintenance cost data in order to create LCC models for water treatment plants, water pump stations, potentially even water reservoirs, and to further refine the water pipe models.

It is recommended that, with respect to maintenance costs, the maintenance cost data collection protocols provided in this report be expanded and used to accurately and consistently capture maintenance cost data. Additional maintenance activity, frequency and cost data could then be collected from existing Porirua water supply networks in order to refine the proposed maintenance schedules and costs. Potentially a monthly maintenance cost schedule could then be developed, which could then be used in a life cycle costing model. Corrective maintenance costs could be identified through historic maintenance records.