MAXIMISE THE LEVEL OF SERVICE USING CROSS ASSET PORTFOLIO RENEWALS MANAGEMENT

Michael Mason[1], Siri Rangamuwa[1], Theunis F. P Henning[2]

Corresponding Author:

Michael Mason

1. **Auckland Transport** www.aucklandtransport.govt.nz

Private Bag 92250, Auckland 1142, New Zealand

6 Henderson Valley Road, Henderson, Auckland 0612, New Zealand

2. **The University of Auckland**

Department of Civil and Environmental Engineering

The University of Auckland

Private Bag 92019

Auckland 1142 New Zealand

Michael Mason. Tel.: +64-9-447-4450; e-mail: michael.mason@aucklandtransport.govt.nz

ABSTRACT

Auckland Transport is tasked with managing its road and public transport assets in the most cost-efficient manner to deliver levels of service and manage risk across the asset portfolio.

The renewals approach outlined in this paper is part of an optimised decision-making methodology that is helping improve customer satisfaction through a more robust, consistent and equitable approach to the management of transport assets and their levels of service across the region.

Auckland Transport asset management has been developing a renewals optimisation model (ROM) to help optimise the condition profile of the portfolio and provide investment options to balance levels of service, cost and risk for each asset class.

It identifies the investment required to change the current condition profile of each asset class to a more cost-efficient state while having regard for funding constraints, levels of service, risk and whole of life cost. It uses accepted depreciation curves for each asset group, an interactive process of allocating investment for renewals by insuring the investment for each asset class achieves the desired level of service in a balanced manner.

The tool also enables the development of portfolio investment options for renewals scenario decision making based on the specific requirements of each asset class. It achieves this by identifying the consequences of trade-offs between:

- steady condition state to be achieved
- level of service required
- number of years allowed to achieve desired levels of service
- level of backlog that can be accepted – based on risk, criticality, movement and public perception considerations.

The outcome of this approach is a balanced long-term renewals programme that will help resolve inherited variations in the condition state of transport assets and their levels of service across the region.

KEYWORDS

Portfolio; Asset Management; Renewals optimisation; Levels of service; Risk management

INTRODUCTION

Modern society is highly dependent on its underpinning water, energy, transportation, communications and waste services infrastructure. Stakeholders and customers have every right to expect that their networks will continue to provide services reliably and safely every day, year after year.

Ongoing customer satisfaction is dependent upon the suitability, performance and condition of the assets that they use. These network characteristics need to be managed well to maintain public confidence in the network. Public infrastructure managers have several key responsibilities when identifying the work and funding required to maintain network service levels:

- to understand the levels of service required by the community and funding stakeholders
- to identify the most cost-efficient level of funding required to maintain network service and manage risk of failure
- to provide advice to decision makers on the trade-offs between the level of funding, service levels and risk.

Auckland Transport has been developing a renewals forecasting model to help optimise the condition profile of its portfolio and provide a common approach to balancing levels of service, cost and risk across all asset classes. In this three-way relationship, asset condition provides a first proxy for levels of service. While condition is not the only driver of renewals investment, it does underpin many of the levels of service and risk factors on the network. Condition, as ‘loss of service potential’, is also a primary variable in understanding the value of the current investment and state of the network.

The model is part of an optimised decision-making methodology that provides a robust, consistent and equitable approach to the management of transport infrastructure renewals cost, risk and levels of service across the region.

Michael Mason. Tel.: +64-9-447-4450; e-mail: michael.mason@aucklandtransport.govt.nz

BACKGROUND

Auckland Transport was formed as a council-controlled organisation as part of the Auckland local authorities' amalgamation in 2010. It is the single agency responsible for managing local transport networks for the Auckland region and is the second largest road controlling authority in New Zealand next to NZ Transport Agency.

The asset portfolio includes road pavement and bridges, footpaths, street lights, parking buildings, pay-and-display units and signal-controlled intersections. The public transport assets comprise train stations, rail carriage and motor units, ferry wharves and terminals, bus way stations, bus shelters and a multi-model fare system.

Transport assets were transferred from eight legacy authorities to the newly created Auckland Transport on 1 November 2010. This asset portfolio was built up by the previous Auckland councils and each developed and maintained their assets according to their own priorities and funding capabilities. The amalgamated portfolio of assets therefore has significant local variations in levels of service and asset condition and performance across the region. Analysis of current asset condition has identified long-term investment issues, needs, costs and risks. These include:

- current renewals investment deficit - historical deferred renewals with associated potential for increased whole of life costs
- renewals liabilities - increased expenditure within the planning period if levels of service are to be maintained
- areas of high risk - assets that represent unacceptable risk to the network and attract increased maintenance and whole of life costs.

The renewals model is designed to provide an investment path that addresses these issues over the long term.

THE RENEWALS MODEL

The model uses asset management policies based on the specific requirements of each asset class such as:

- condition profile to be achieved in the long term
- condition-based level of service required
- level of tolerance for backlog risk.

It uses these policies to identify the annual renewal needs for each asset class. It also provides the reverse process i.e. the input of annual budgets for each asset class to identify the condition and backlog consequences that result. This provides for direct testing of trade-offs between:

- funding availability
- level of service required
- level of backlog that can be accepted based on risk, criticality, movement and public perception considerations.

The model uses a range of input data for each asset class including base life, renewal cost rate, current condition and annual growth in the asset base. This data is applied at a level of granularity appropriate to the asset. Please note that data used within this paper was current at the time of writing.

The following sections describe the use of asset management policy settings and processes within the model. They are:

- condition and deterioration
- levels of service
- changing the condition profile
- risk and backlog management
- trade-offs
- maintenance
- outputs.

Condition and deterioration

Auckland Transport uses a condition grading system based on the 2011 International Infrastructure Management Manual (IIMM)[1] to monitor the condition state of the network. Assets are assessed against a 5 point condition scale from 1 (very good) through to 5 (very poor).

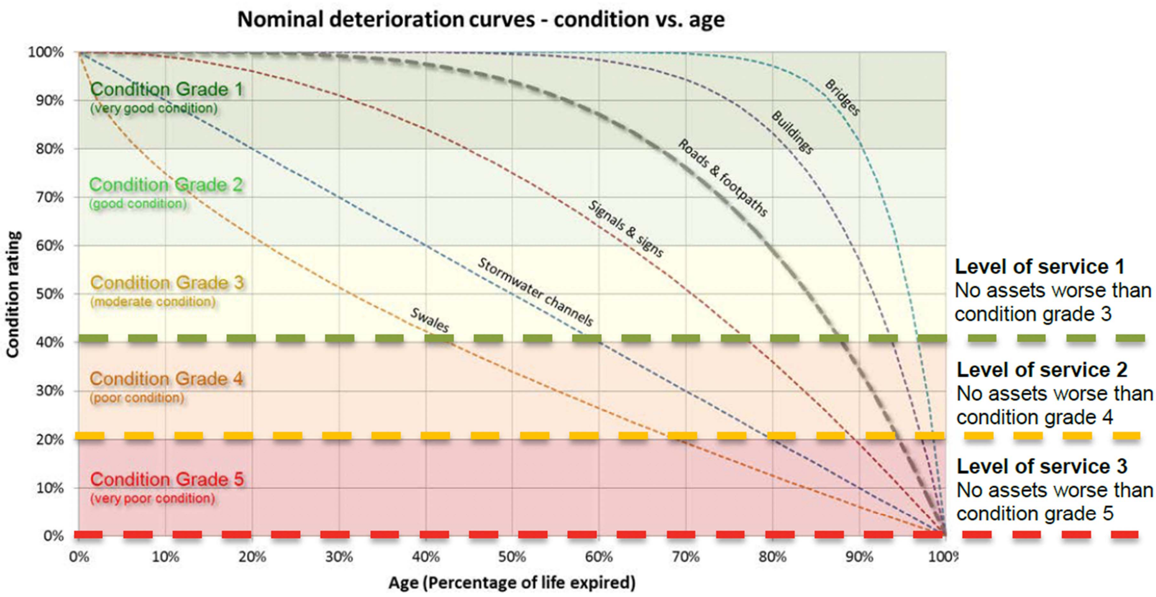


FIGURE 1 Condition grades, deterioration rates and condition-based levels of service.

Asset types such as road pavements, buildings, bridges and drainage all have different base lives and deteriorate at different rates. Several factors influence their rates of deterioration and useful lives including built specification, loading and environmental conditions. Examples of these are illustrated in Figure 1.

The model uses the above deterioration curves and asset base lives to calculate the annual deterioration of each asset. These curves are initial estimations for planning purposes and are based on earlier work done within the New Zealand infrastructure asset management sector. The accuracy of the curves and actual expected life for each asset type (and their significant variants) will be improved as asset knowledge is developed and the trends of renewal needs are better understood across the portfolio.

Levels of service

The predominant driver of renewals investment is the condition of network assets, although other factors must be considered to address specific levels of service or risk. This renewals model uses condition as a proxy for levels of service.

Figure 1 shows the general approach taken to renewals intervention, using three levels of service options for the management of asset condition. Each asset type has been assigned a condition-based level of service based on this approach. Currently, no asset types are set to be managed at level of service 3 because of the potential for higher levels of risk, maintenance costs and negative public perception. Level of service 2 is currently the default setting for the majority of the assets.

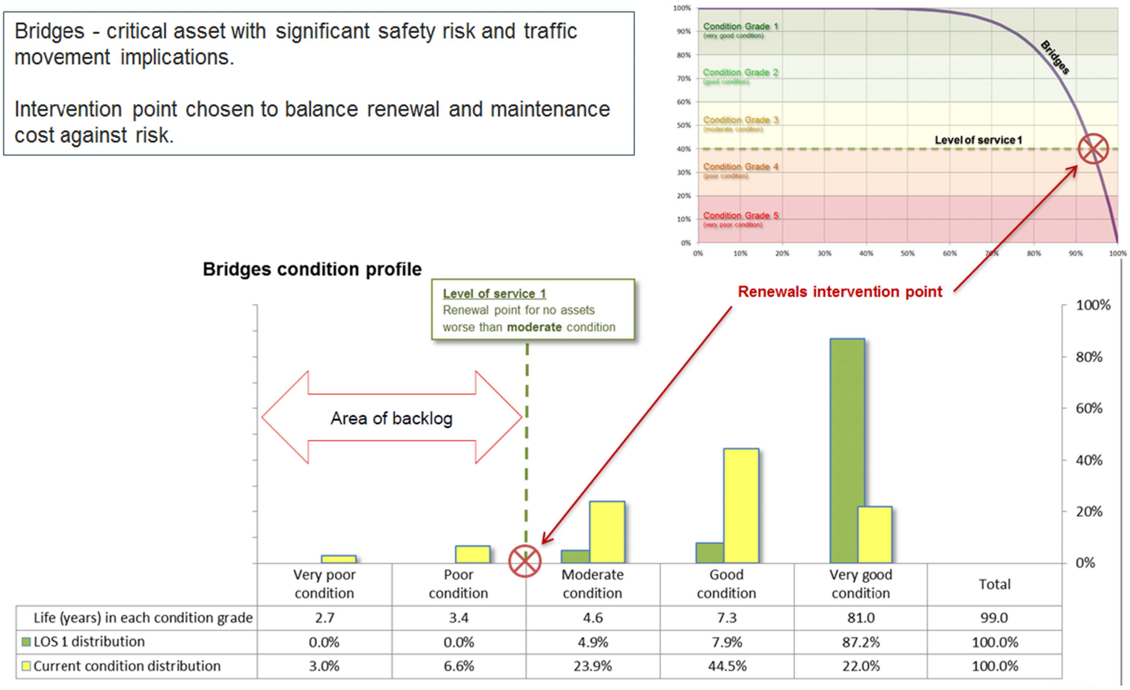
Some assets deemed critical such as bridges, traffic systems, wharves, and public transport front-of-house are managed to achieve level of service 1 because of significant risk, traffic movement or public perception implications. Assets that have deteriorated beyond condition grade 5 are deemed to have failed and generally carry too much health and safety risk for public use.

Changing the condition profile

The condition profile is the amount of the asset in each condition grade (1 to 5) at any one time. The renewals forecasting model does not recycle the existing condition profile to a set timetable. Instead it identifies the investment required to change the current condition profile of each asset class to a more cost-efficient state over time while having regard for growth, funding constraints, levels of service, risk and whole of life cost.

Figure 2 shows an example existing condition profile (yellow columns) as the current measure of the asset within each condition grade. It shows:

- the condition-based level of service i.e. the renewals intervention point for this asset class
- the level of existing backlog i.e. the amount of asset below the intervention point in condition grades 4 and 5
- the level of future backlog liability i.e. the higher than optimal renewals expected at the intervention point within the next 12 years (from condition grades 3 and 2)
- a low level of asset in condition grade 1 means that more of the asset is either currently in backlog, or will need to be renewed soon.



	Very poor condition	Poor condition	Moderate condition	Good condition	Very good condition	Total
Life (years) in each condition grade	2.7	3.4	4.6	7.3	81.0	99.0
LOS 1 distribution	0.0%	0.0%	4.9%	7.9%	87.2%	100.0%
Current condition distribution	3.0%	6.6%	23.9%	44.5%	22.0%	100.0%

FIGURE 2 Condition profiles

The target condition profile (green columns) is based on the nominal deterioration profile and represents the most cost efficient condition state for the asset class (i.e. results in the least whole of life renewals cost). This is the condition profile that the model works towards over time. Figure 2 also identifies the time the asset spends in each condition grade. This shows that for some assets, the fast rate of deterioration near the end of their lives is a key risk consideration when setting condition-based levels of service and managing backlog.

Figure 3 is an example of output from the model showing how the current condition profile is changed over time from its current condition profile to its more optimal state. For this example (bridges) the level of service is 1 (no assets worse than moderate condition) therefore all orange is backlog. The policy settings in this example allow a small but reducing percentage of backlog in the long term.

The model identifies the annual renewals cost and the annual average for each decade. In figure 3 the model indicates a reducing renewals cost as the asset moves towards a more cost-efficient condition profile. Note that the examples in this paper reflect growth in the asset base which has been input into the model.

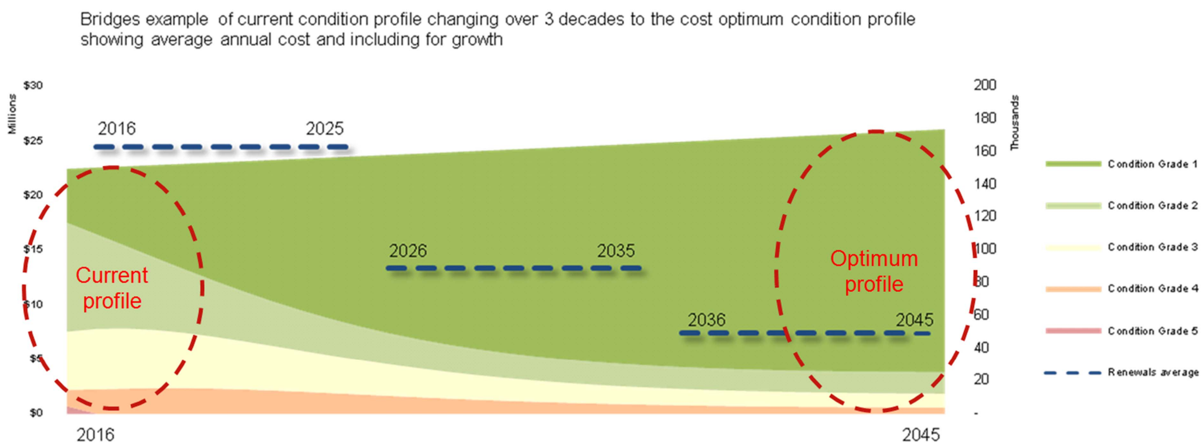


FIGURE 3 Condition profile change over time

Risk and backlog management

Risk is incorporated into the model in two ways:

- by setting the condition-based level of service (the renewals intervention point). This is a first response to risk and reflects the tolerance for risk for each asset and was discussed earlier.
- by setting the time to address current and annually accruing backlog. This reflects the tolerance for backlog risk over time for each asset. This has an impact on cost and condition.

The model incorporates a 'years to address backlog' variable that reduces all backlog to zero over a set number of years and maintains it at zero thereafter. Backlog in this context is anything that falls below the level of service intervention point in each year. The examples shown in figures 4 to 9 identify the cost and condition impacts of setting different amounts of time to address the existing backlog.

Trade-offs

The model enables setting of asset management policies based on the specific requirements of each asset class such as:

- condition profile to be achieved in the long term
- condition-based level of service required (renewals intervention point)
- number of years allowed to address backlog i.e. achieve desired levels of service (level of acceptance of backlog risk).

The model uses these policies to identify the annual renewal needs for each asset class. However, it also provides the reverse process i.e. the input of annual budgets for each asset class to identify the condition and backlog consequences that result. This provides for direct testing of trade-offs between:

- funding availability
- level of service required
- level of backlog that can be accepted based on risk criteria such as criticality, movement and public perception considerations.

This function can provide decision-makers with a better understanding of the relationship between cost, level of service and risk for each asset class and across the portfolio as whole. An example of the input of specific annual budgets and the consequential cost and condition is shown in Figure 10.

Maintenance

In practice there is a strong correlation between renewals and maintenance. Maintenance strategies can have positive or negative impacts upon deterioration profiles, useful lifes and whole of life costs.

Conversely, the impact of deferred renewals on maintenance needs may not be immediate but will become apparent over the medium to long term. In particular:

- assets in very poor condition tend to require enhanced maintenance if renewals are deferred
- structural maintenance is most affected by deferred renewals.

These relationships are not yet fully understood and quantified and are therefore not used in this version of the model. This is an important area for future development.

Outputs

Typical outputs from the model are shown in figures 4 to 11. These show condition and renewals cost outputs and are used to inform decision making on policy settings at the asset level. Figure 11 shows an example summary of 30 year expenditure ($m). These outputs are used by decision makers in several ways:

- to understand the cost of condition-based levels of service
- to understand future renewals liability
- to assess the risks associated with current and future backlog
- to understand the condition and risk consequences of different budget scenarios
- to provide a consistent basis for trade-offs of cost, condition and risk across the asset portfolio

FURTHER IMPROVEMENTS

The renewals model has been reviewed by Auckland University for its general approach and has received a very positive assessment.[2] Their report states that 'significant value has already been achieved by the development of the renewal model, and this approach could well become best practice not only in New Zealand but also internationally'.

The model has also been tested for its detailed functioning by an external specialist. Nevertheless it is still a work in progress and a programme of refinements and improvements is on-going. Planned improvements include:

- refinement of current and future condition profiles including stochastic analysis
- refinement of the deterioration modelling process
- increased granularity of analysis
- inclusion of maintenance impacts upon deterioration profile and useful life
- multi-criteria analysis of a broader asset significance factor to inform levels of service and renewals intervention, rather than just asset condition. This includes variables against each asset type such as loading, risk, criticality, location and customer satisfaction.

The model is currently maintained as a Microsoft Excel spread sheet but it is intended that it be developed as a stand-alone application on another platform.

CONCLUSION

The Auckland Transport portfolio renewals model is an integrated approach to understanding the relationship between condition-based levels of service, cost and condition-based risk across all classes of assets in the transport portfolio. It provides a long-term baseline of renewals needs and a consistent basis for renewals decision-making.

It is not intended to replicate other detailed and specialised analyses undertaken for individual assets in the network. What it does provide is:

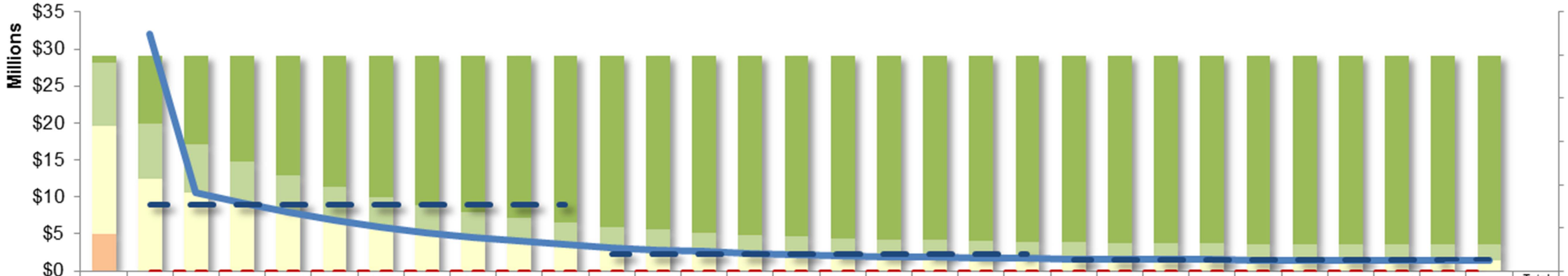
- an investment path for changing the condition of the assets to a lower cost steady state condition profile over the long-term. This normalises existing variations in condition-based levels of service and backlog across the network.
- an understanding of long-term renewals cost pressures between asset classes across the portfolio
- visibility of condition-based risk resulting from existing and future backlog
- a mechanism for direct testing of trade-offs between funding, level of service and level of backlog risk.

The asset management assumptions and policy settings used in the model are set by consensus among Auckland Transport asset specialists and local managers. These will continue to be improved to give decision-makers confidence that the underlying asset management assumptions and policies reflect the high level and long term behaviour and requirements of the network.

The model is currently providing executive decision makers with the long term baseline costs of managing renewals on the Auckland Transport network.

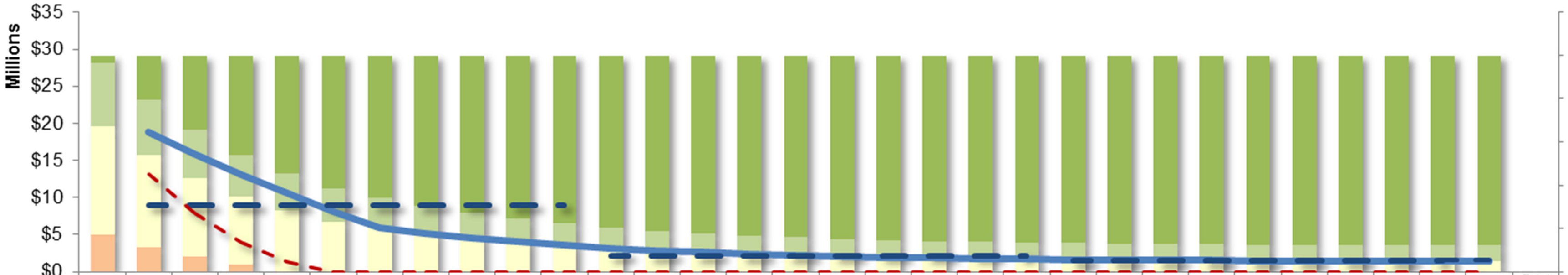
REFERENCES

1. International Infrastructure Management Manual (IIMM) International Edition; New Zealand Asset Management Support (NAMS), 2011.
2. Henning, T.; Integrated Transport Plan Version 2 – Asset Management Model Review; UNIServices centre for infrastructure research, 2013.



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	3%	32%	41%	49%	56%	61%	66%	70%	73%	75%	78%	79%	81%	82%	83%	84%	85%	85%	86%	86%	86%	87%	87%	87%	87%	87%	87%	88%	88%	88%	88%	
Condition Grade 2	30%	25%	22%	20%	17%	16%	14%	13%	12%	11%	10%	10%	9%	9%	9%	9%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	18%	15%	14%	12%	11%	10%	9%	8%	7%	7%	7%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	
Condition Grade 4	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Condition Grade 5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Renewals cost	4.6	32.0	10.6	9.1	7.9	6.9	6.0	5.2	4.6	4.0	3.6	3.2	2.9	2.6	2.4	2.2	2.1	1.9	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	127.3
Renewals average	.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	127.3
Backlog liability	19.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

FIGURE 4 Setting 1 year to address backlog



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	3%	20%	35%	46%	55%	61%	66%	70%	73%	76%	78%	80%	81%	82%	83%	84%	85%	85%	86%	86%	86%	87%	87%	87%	87%	87%	87%	88%	88%	88%	88%	
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Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	18%	15%	13%	12%	11%	10%	9%	8%	7%	7%	6%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	
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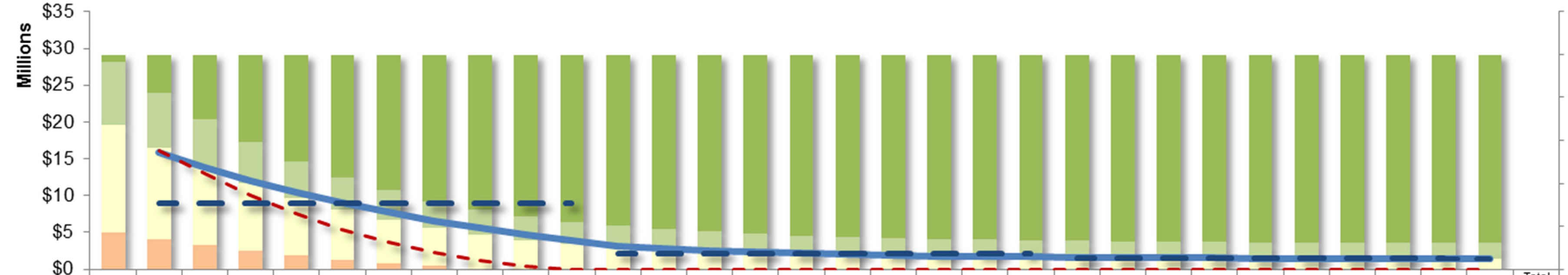
Condition Grade 5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	17%	12%	7%	3%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Renewals cost	4.6	18.8	15.8	13.1	10.5	8.2	5.9	5.2	4.5	4.0	3.6	3.2	2.9	2.6	2.4	2.2	2.0	1.9	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	127.1
Renewals average	.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	127.1
Backlog liability	19.7	13.1	7.9	3.9	1.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

FIGURE 5 Setting 5 years to address backlog



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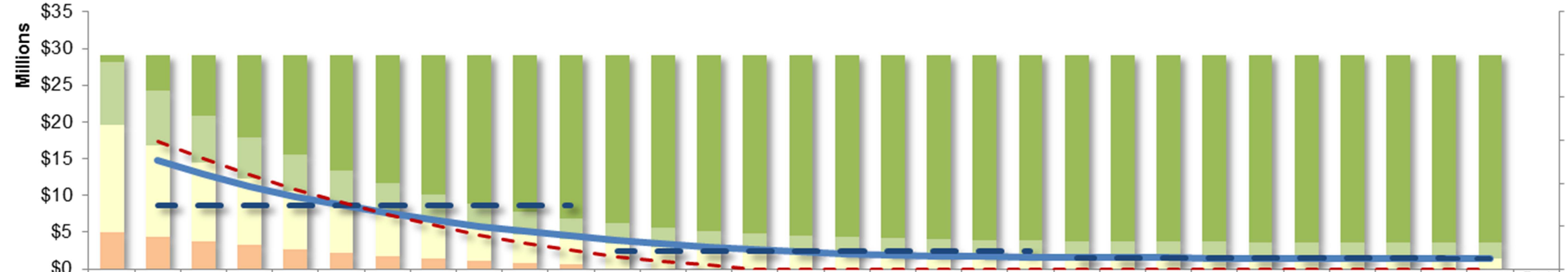
Condition Grade 1	3%	18%	30%	41%	50%	57%	63%	68%	72%	76%	78%	80%	81%	82%	83%
Condition Grade 2	30%	25%	22%	19%	17%	15%	14%	13%	12%	11%	10%	10%	9%	9%	9%
Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	17%	15%	13%	12%	11%	10%	9%	8%
Condition Grade 4	16%	14%	11%	9%	6%	5%	3%	2%	1%	0%	0%	0%	0%	0%	0%
Condition Grade 5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Percentage backlog	17%	14%	11%	9%	6%	5%	3%	2%	1%	0%	0%	0%	0%	0%	0%
Renewals cost	4.6	15.9	13.8	12.0	10.4	9.0	7.7	6.6	5.6	4.7	3.9	3.1	2.8	2.6	2.4
Renewals average	.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	2.2	2.2	2.2	2.2
Backlog liability	19.7	16.1	12.9	10.0	7.5	5.4	3.6	2.1	1.1	.4	.0	.0	.0	.0	.0

	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	84%	85%	85%	86%	86%	87%	87%	87%	87%	87%	87%	88%	88%	88%	88%	88%	
Condition Grade 2	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Condition Grade 3	7%	7%	6%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	
Condition Grade 4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Condition Grade 5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Renewals cost	2.2	2.0	1.9	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	126.7
Renewals average	2.2	2.2	2.2	2.2	2.2	2.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	126.7
Backlog liability	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

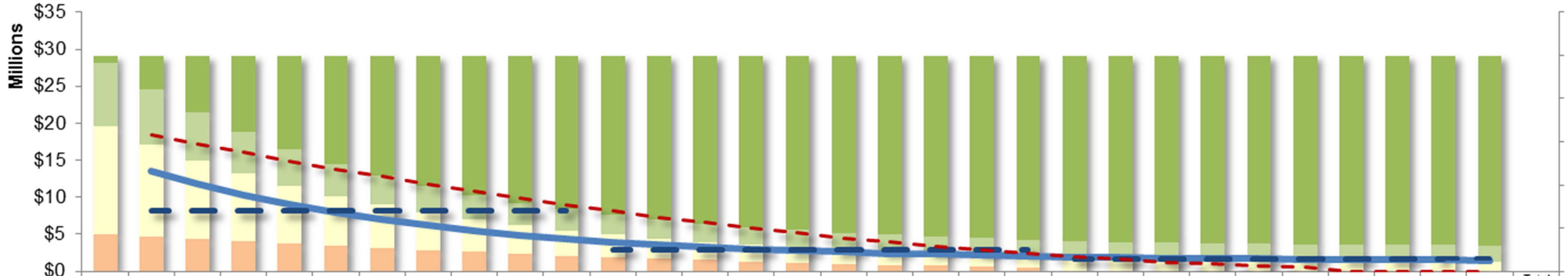
FIGURE 6 Setting 10 years to address backlog



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Condition Grade 1	3%	17%	28%	38%	47%	54%	60%	65%	70%	73%	76%	79%	81%	82%	83%
Condition Grade 2	30%	25%	22%	19%	17%	15%	14%	12%	11%	11%	10%	10%	9%	9%	9%
Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	17%	15%	13%	12%	11%	9%	9%	8%
Condition Grade 4	16%	15%	13%	11%	9%	8%	6%	5%	4%	3%	2%	1%	1%	0%	0%
Condition Grade 5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Percentage backlog	17%	15%	13%	11%	9%	8%	6%	5%	4%	3%	2%	1%	1%	0%	0%
Renewals cost	4.6	14.7	12.9	11.3	9.9	8.6	7.6	6.6	5.8	5.1	4.5	4.0	3.5	3.0	2.7
Renewals average	.0	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	2.4	2.4	2.4	2.4
Backlog liability	19.7	17.2	14.9	12.8	10.8	9.0	7.4	5.9	4.6	3.4	2.5	1.6	1.0	.5	.2

	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	84%	85%	86%	86%	86%	87%	87%	87%	87%	87%	87%	88%	88%	88%	88%	88%	
Condition Grade 2	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	
Condition Grade 3	7%	7%	6%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	
Condition Grade 4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Condition Grade 5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Renewals cost	2.3	2.0	1.9	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	126.4
Renewals average	2.4	2.4	2.4	2.4	2.4	2.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	126.4
Backlog liability	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

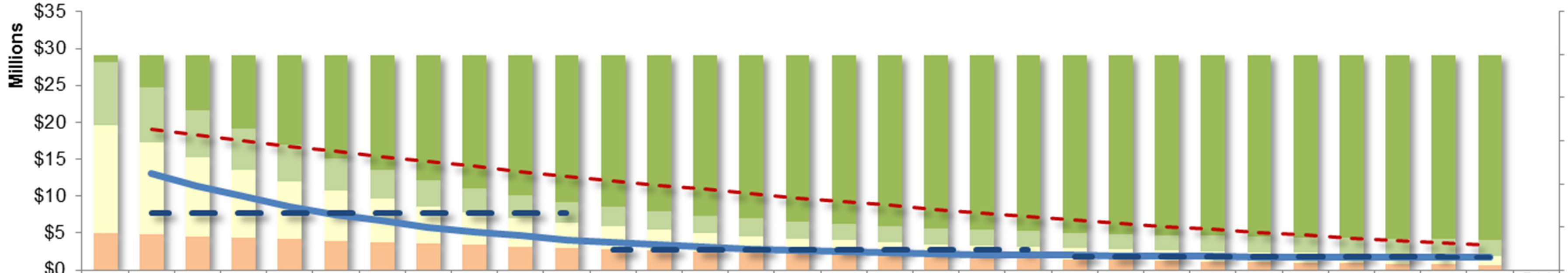
FIGURE 7 Setting 15 years to address backlog



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Condition Grade 1	3%	16%	27%	36%	43%	50%	56%	61%	65%	68%	71%	74%	76%	78%	79%
Condition Grade 2	30%	25%	22%	19%	17%	15%	13%	12%	11%	10%	10%	9%	9%	8%	8%
Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	17%	15%	13%	12%	10%	9%	8%	8%
Condition Grade 4	16%	16%	15%	14%	13%	12%	11%	10%	9%	8%	7%	7%	6%	5%	5%
Condition Grade 5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Percentage backlog	17%	16%	15%	14%	13%	12%	11%	10%	9%	8%	7%	7%	6%	5%	5%
Renewals cost	4.6	13.5	11.8	10.3	9.0	7.9	7.0	6.2	5.5	4.9	4.4	4.0	3.6	3.3	3.0
Renewals average	.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	2.8	2.8	2.8	2.8
Backlog liability	19.7	18.4	17.2	16.0	14.9	13.8	12.7	11.7	10.7	9.8	8.9	8.0	7.2	6.5	5.8

	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	81%	82%	83%	84%	85%	85%	86%	86%	87%	87%	87%	87%	88%	88%	88%	88%	
Condition Grade 2	8%	8%	8%	8%	8%	8%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%	
Condition Grade 3	7%	7%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	
Condition Grade 4	4%	3%	3%	3%	2%	2%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	
Condition Grade 5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	4%	3%	3%	3%	2%	2%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	
Renewals cost	2.8	2.6	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.5	125.5
Renewals average	2.8	2.8	2.8	2.8	2.8	2.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	125.5
Backlog liability	5.1	4.4	3.9	3.3	2.8	2.3	1.9	1.5	1.2	.9	.6	.4	.3	.1	.0	.0	.0

FIGURE 8 Setting 30 years to address backlog

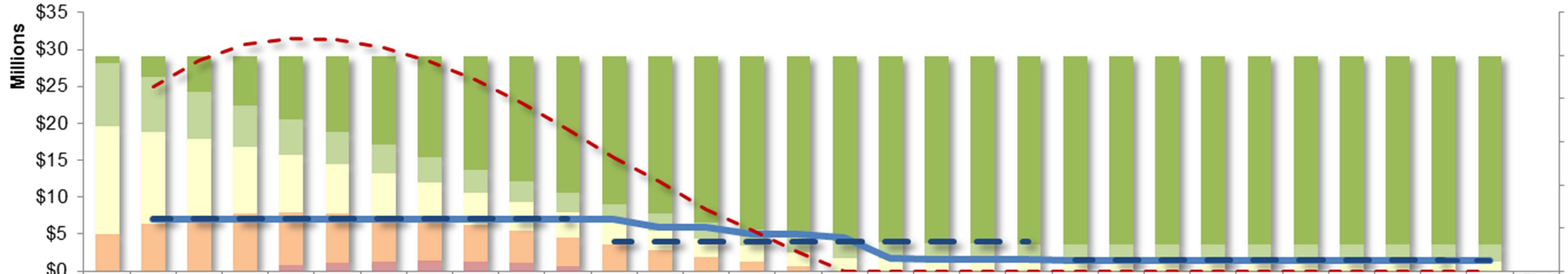


	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Condition Grade 1	3%	15%	26%	34%	42%	48%	54%	58%	62%	65%	68%	71%	73%	75%	76%
Condition Grade 2	30%	25%	22%	19%	17%	15%	13%	12%	11%	10%	10%	9%	9%	8%	8%
Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	17%	15%	13%	12%	10%	9%	8%	8%
Condition Grade 4	16%	17%	16%	15%	14%	14%	13%	12%	12%	11%	10%	10%	9%	8%	8%
Condition Grade 5	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Percentage backlog	17%	17%	16%	15%	14%	14%	13%	12%	12%	11%	10%	10%	9%	9%	8%
Renewals cost	4.6	13.0	11.4	9.9	8.6	7.6	6.6	5.8	5.2	4.6	4.1	3.7	3.4	3.1	2.8
Renewals average	.0	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	2.7	2.7	2.7	2.7
Backlog liability	19.7	18.9	18.2	17.4	16.7	16.0	15.3	14.6	13.9	13.3	12.7	12.0	11.4	10.9	10.3

	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	77%	79%	80%	81%	81%	82%	83%	83%	84%	84%	84%	85%	85%	85%	86%	86%	
Condition Grade 2	8%	8%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	
Condition Grade 3	7%	7%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	4%	4%	4%	
Condition Grade 4	7%	6%	6%	5%	5%	5%	4%	4%	4%	4%	4%	3%	3%	3%	3%	2%	
Condition Grade 5	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	8%	7%	7%	6%	6%	5%	5%	5%	4%	4%	4%	3%	3%	3%	3%	2%	
Renewals cost	2.6	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	121.6
Renewals average	2.7	2.7	2.7	2.7	2.7	2.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	121.6
Backlog liability	9.7	9.2	8.7	8.2	7.7	7.2	6.7	6.3	5.8	5.4	5.0	4.6	4.3	3.9	3.6	3.2	.0

FIGURE 9 Setting 50 years to address backlog

Headings	2016 result	2017 result	2018 result	2019 result	2020 result	2021 result	2022 result	2023 result	2024 result	2025 result	2026 result	2027 result	2028 result	2029 result	2030 result	2031 result	2032 result	2033 result
Renewals cost	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	6,000,000	6,000,000	5,000,000	5,000,000	4,495,712	1,734,561	1,641,390
Backlog liability	24,960,731	28,557,186	30,705,860	31,608,896	31,442,687	30,360,961	28,497,534	25,968,763	22,875,722	19,306,128	15,336,037	12,031,335	8,449,058	5,638,531	2,642,014	-	-	-
Percentage outside LOS	21.90%	24.87%	26.54%	27.12%	26.77%	25.66%	23.90%	21.62%	18.90%	15.84%	12.49%	9.72%	6.78%	4.49%	2.09%	0.00%	0.00%	0.00%
Renewals actual	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	6,000,000	6,000,000	5,000,000	5,000,000			



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Condition Grade 1	3%	10%	17%	23%	29%	36%	42%	47%	53%	58%	64%	69%	73%	77%	81%	84%
Condition Grade 2	30%	25%	22%	19%	17%	15%	13%	12%	10%	10%	9%	8%	8%	8%	8%	8%
Condition Grade 3	50%	43%	37%	31%	27%	23%	20%	17%	15%	13%	11%	10%	9%	8%	7%	7%
Condition Grade 4	16%	22%	25%	25%	24%	23%	21%	19%	17%	15%	13%	12%	10%	7%	4%	2%
Condition Grade 5	1%	0%	0%	1%	3%	4%	5%	5%	5%	4%	2%	1%	0%	0%	0%	0%
Percentage backlog	17%	22%	25%	27%	27%	27%	26%	24%	22%	19%	16%	12%	10%	7%	4%	2%
Renewals cost	4.6	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.0	6.0	5.0	5.0
Renewals average	.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	4.0	4.0	4.0	4.0	4.0
Backlog liability	19.7	25.0	28.6	30.7	31.6	31.4	30.4	28.5	26.0	22.9	19.3	15.3	12.0	8.4	5.6	2.6

	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	Total 2016-45
Condition Grade 1	86%	87%	87%	87%	87%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
Condition Grade 2	8%	7%	7%	7%	7%	7%	7%	7%	7%	8%	8%	8%	8%	8%	8%	
Condition Grade 3	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	
Condition Grade 4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Condition Grade 5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Percentage backlog	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Renewals cost	4.5	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	124.1
Renewals average	4.0	4.0	4.0	4.0	4.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	124.1
Backlog liability	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

FIGURE 10 Constrained budget trade-off - showing cost vs. condition

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2016-45 total
⊟ **Road**	Carriageway	110.0	124.0	130.0	127.0	124.7	120.9	125.3	120.0	124.0	128.0	123.4	125.4	124.1	126.0	126.3	127.3	137.1	133.7	132.6	132.6	133.0	133.6	134.3	135.1	135.9	136.7	137.6	138.6	139.6	140.7	3,887.5
	Bridges	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.4	26.3	26.5	26.2	25.5	24.6	23.6	21.1	17.6	15.1	13.2	11.9	10.9	10.1	9.6	9.2	8.8	8.6	8.4	8.2	8.1	8.0	8.0	541.5
	Footpath	10.4	6.8	9.0	11.1	13.1	14.9	16.7	18.3	19.8	21.2	22.4	23.6	24.6	25.5	26.4	27.2	27.9	28.5	29.1	29.7	30.2	30.7	31.2	31.6	32.0	32.4	32.8	33.2	33.6	34.0	728.0
	Retaining walls	8.5	16.0	18.0	25.0	23.0	20.0	18.0	17.8	6.6	5.1	4.0	3.3	2.9	2.7	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	211.2
	Parking	10.5	9.5	11.4	10.2	9.1	8.1	7.3	6.7	6.2	5.9	5.8	5.7	5.7	5.8	5.9	6.0	6.2	6.3	6.4	6.6	6.7	6.8	6.9	7.0	7.1	7.3	7.4	7.5	7.6	7.7	217.4
	Signs	0.7	1.7	4.0	5.5	6.1	6.2	5.9	5.6	5.4	5.3	5.3	5.3	5.4	5.5	5.6	5.8	5.9	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	169.8
	Drainage	9.6	13.9	20.8	26.4	30.5	33.6	35.8	37.4	38.4	39.1	39.4	39.4	39.3	39.0	38.6	38.2	37.7	37.2	36.6	36.1	35.6	35.1	34.7	34.3	33.9	33.6	33.4	33.2	33.0	33.0	1,006.8
	Traffic systems	13.0	9.6	8.2	7.2	6.6	6.3	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.3	8.4	8.5	8.6	8.8	8.9	231.9
	Sea walls	7.6	12.2	11.7	9.5	7.2	5.3	3.9	2.9	2.2	1.7	1.4	1.2	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	83.0
	Cycle	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	16.6
	Corridor structures	0.0	0.7	4.4	6.5	6.9	6.3	5.3	4.3	3.5	3.0	2.6	2.4	2.3	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.9	2.9	2.9	3.0	93.3
	Streetlighting	12.7	13.6	18.3	19.8	19.5	18.5	17.1	15.9	14.8	14.0	13.4	13.1	12.9	12.8	12.9	13.1	13.3	13.6	13.9	14.3	14.7	15.1	15.5	15.9	16.3	16.7	17.2	17.6	18.0	18.5	462.9
Road Total		**209**	**235**	**262**	**275**	**273**	**267**	**268**	**262**	**254**	**257**	**251**	**252**	**250**	**252**	**250**	**249**	**257**	**252**	**251**	**251**	**251**	**252**	**253**	**254**	**256**	**257**	**259**	**261**	**263**	**265**	**7,650**
⊟ **Public transport**	Rail	7.2	7.9	12.1	14.5	14.4	13.6	14.3	15.0	15.4	15.7	15.8	15.9	15.9	15.9	15.8	15.8	15.8	15.8	15.8	15.8	45.8	45.8	45.8	45.8	45.9	45.9	45.9	46.0	46.0	46.1	747.2
	Bus	1.2	2.5	2.9	2.6	2.3	2.0	1.9	1.9	1.9	1.9	2.0	2.1	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.9	70.7
	Ferry	10.7	13.4	7.0	4.6	2.5	2.7	2.6	2.5	2.4	2.4	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	95.7
	All PT	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.0	5.0
Public transport Total		**20**	**24**	**22**	**22**	**19**	**18**	**19**	**19**	**20**	**20**	**20**	**20**	**21**	**20**	**20**	**21**	**20**	**20**	**21**	**20**	**50**	**51**	**51**	**51**	**51**	**51**	**51**	**52**	**51**	**51**	**919**
Grand Total		**229**	**259**	**284**	**297**	**293**	**285**	**288**	**281**	**274**	**277**	**271**	**272**	**271**	**272**	**271**	**269**	**277**	**273**	**272**	**271**	**302**	**303**	**304**	**305**	**307**	**308**	**310**	**313**	**314**	**317**	**8,568**

FIGURE 11 Example draft summary output of 30 year expenditure ($m)

Michael Mason. Tel.: +64-9-447-4450; e-mail: michael.mason@aucklandtransport.govt.nz