REPORT

Network deterioration analysis 2009/10

Prepared for Invercargill City Council

MAY 2010

INVERCARGILL CITY COUNCIL

Network deterioration analysis 2009/10

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1 Executive Summary

1.1 Background

The use of dTIMS CT, a predictive modelling system, significantly contributes towards optimal maintenance planning on both the network and the project planning levels. It assists Council with better management information on a network level, including:

- Optimal maintenance expenditure / quantities in order to achieve the long-term customer levels of service for the network; and
- Prediction of the network condition as result of long-term maintenance regimes.

dTIMS CT has been implemented on the Invercargill City Council (ICC) network and several analyses have been executed during the last few years. The outputs are used to assist Council network maintenance budgeting and at a project level in the preparation of the forward works programme.

The analysis was based on inventory and condition data from the RAMM database. Missing data has been obtained by means of calculating and estimating using various methods as necessary.

The model has been customised for local conditions and these tables are listed in Appendix B:.

1.2 Purpose

This report is a summary of the current network condition, the pavement deterioration modelling outputs, and the predicted conditions for the network based on the analysis.

This report was compiled and written on behalf of Invercargill City Council by MWH, who has also performed a review on the analysis, which can be found at the end of this report.

The report should be used as a decision support tool in managing and maintaining the Invercargill City Council's road network. To reach the goal of delivering this report the following tasks were involved in the modelling process are:

- Ensure data validity and robustness;
- Confirm custom parameters to suit local conditions;
- Perform analysis, taking current practises into consideration;
- Predict annual maintenance quantities to maintain the level of service on the network; and
- Enhance the modelling setup for this network.

1.3 Fast Facts of the Network

(Length in km)	Rural		Urban		Total Length (km)
Hierarchy	Chipseal	AC	Chipseal	AC	
Local Roads	60.5	0.5	163.4	4.5	228.9
Minor arterial	65.2		12.5	39.7	117.4
Commercial			11.4	10.0	21.5
Distributor/Collector	48.2		37.2	7.6	93.0
Total Length (km)	**173.9**	**0.5**	**224.5**	**61.8**	**460.7**

1.4 dTIMS CT Modelling Achievements

A summary of the modelling achievements in terms of the suggested budgets, work quantities and predicted conditions are presented in Table 1.1. The current pavement and surface conditions are of an acceptable level, but the analysis with the given constrained budget was not able to maintain the average network condition levels. It is evident in the average roughness and pavement age increasing over the period of 10 years. The situation is similar for the rutting, surface age and surface integrity index.

Table 1.1: Trigger and Optimised Budget and Quantities summary

		Trigger	Very High	Normal	Very Low
Work Quantities (km/year)	**Current**	**Predicted 10yr Average**			
Resurfacing (Chipseal)	28.0	71.3	35.0	34.3	22.6
Resurfacing (AC)	4.0	4.2	4.5	1.9	0.5
Pavement Refurbishment	3.0	9.4	3.79	3.81	3.29
Agency Cost ('000) - 10 year annual average					
Programmed Maintenance		$9,161	$4,945	$3,764	$1,998
Routine Maintenance Variances		**-44%**	**-7%**	**0%**	**19%**
Condition	**Current**	**Predicted average condition after 10 years**			
NAASRA	93	90.2	98.4	99.6	104.0
SII	5.06	0.9	15.6	16.4	26.5
Rutting	6.96	6.1	6.9	6.9	7.1
Surface Age	8.24	3.6	7.9	8.4	11.2
Pavement Age	46.31	44.4	51.1	51.0	51.6

1.5 Recommendation from analysis

The Council's current investment level of $4 million for programmed maintenance on the network will not be sufficient to maintain the current integrity and condition of the network within the next 10 years.

AC resurfacing and pavement renewals are prominent in the analysis addressing various issues on the network. Despite active programmed maintenance, all conditions on the network, except the surface age and rutting, deteriorate gradually over ten years.

More effective programming and possible increased funding would be necessary for the current network condition to be sustained.

A data improvement plan should be established and implemented based on the data validation process and it findings. This would make future analyses more robust, and ensure that the council has updated data in RAMM.

The development of documentation describing the maintenance decision approach used would add value to the confirmation of alignment between network maintenance practices and the deterioration analysis.

Further development of the ICC setup is recommended for configuration to local conditions and practices.

2 Introduction

This report summarises the process and output from the 2009/10 dTIMS modelling process for the Invercargill City Council (ICC) network.

2.1 Objectives

The objective was to build a model that credibly correlates with the network maintenance practises, and represents the network deterioration specific to ICC. The aim was also to move towards a stable model without drastic changes between modelling rounds. In short the objectives were to:

- customise the model in terms of unit costs of the treatments, treatment quantities, maintenance drivers and current budget;
- validate analysis outputs to determine the credibility of the model; and
- determine the likely effects of budget variations on the network condition.

2.2 Processes Undertaken

The tasks undertaken to perform the modelling are as follows:

2.2.1 Tasks performed by ICC in-house:

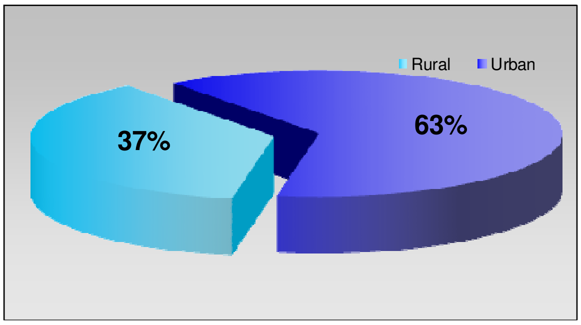
- Unloading of the data from the RAMM database.
- Building the dataset by means of validation and updating of the data to be used in the analysis.
- Importing the prepared dataset into the dTIMS CT Model Setup
- modify the standard NZ dTIMS setup to accommodate the changes to the optimal model
- Perform analyses with two analysis sets
- Trigger Model;
- Optimal Model
- Feedback to RAMM team regarding data improvements.

2.2.2 Task performed by MWH

- Reporting of results

3 Current network statistics

3.1 Background



The input data is the most important part of the predictive modelling process. To obtain reliable results from the analysis, the data used should be robust. Hence, a review of the Invercargill City Council (ICC) RAMM database relevant to predictive modelling was carried out. The objectives of the review were:

- Data checks of RAMM database to determine completeness and soundness of values;
- Highlight issues related to data refinement;
- Understand the existing pavement and inventory characteristics for customisation of NZ dTIMS; and
- Prepare data improvement plan.

The following sections describe the characteristic of the network, based on the data from RAMM. All lengths specified are in centreline kilometres.

3.2 Surface distribution

The surface distribution across the ICC network is shown in Figure 3.1. Chipseal is the most predominant surface type covering around 87% (398 km) of the network. The network has a rural/urban split of 38%/62% respectively.

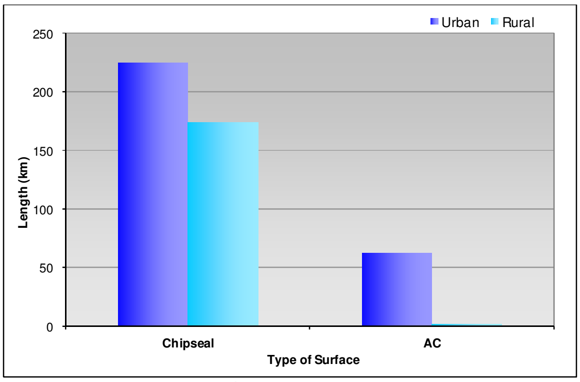


Figure 3.1 Surface distribution

3.3 Treatment lengths

The Council has 1822 treatment lengths on the network, varying from 50 to 3.9 km. The total length is 462.7 km of which 460.8 km is modelled. Figure 3.2 presents the length distribution of the treatment lengths across the network, also indicating the percentage of the network in each length category. From the figure, it is seen that 74% (1354 in number) of the treatment lengths are less than 250 m, representing 41% of the total network length. This high number of short treatment lengths can be expected from a predominantly urban network.

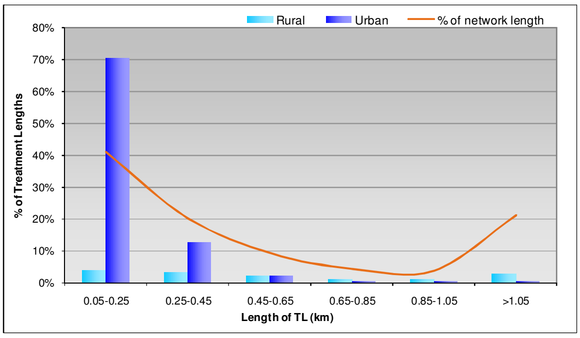


Figure 3.2 Treatmentlength distribution

3.4 Network surface age

Various expressions are sensitive to the network surface age as a variable. Figure 3.3 shows the surface age distribution of the network. From the figure it can be seen that 56% (257 km) of surfaces are less than 8 years old. Almost 10% (45 km) of surfaces on the network which are older than 15 years. these older surfaces must be closely monitored for failures (or checked to confirm the accuracy of the surface information).

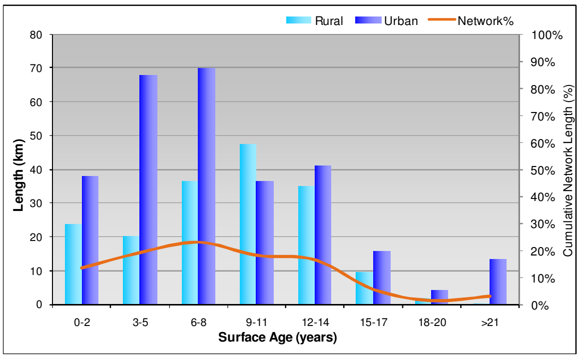


Figure 3.3 Surface age distribution

Figure 3.4 represents the history of surface construction with the data as it currently appears in RAMM. The line in the chart shows the cumulative growth trend of the surfacing history on the network. There was a gradual increase in surface renewals from 1998 onwards (this might also be that the data was recorded from then onwards. For the last ten years the average surface renewal rate was approximately 32 km per year, resulting in an average expected surface life of almost 14 years.

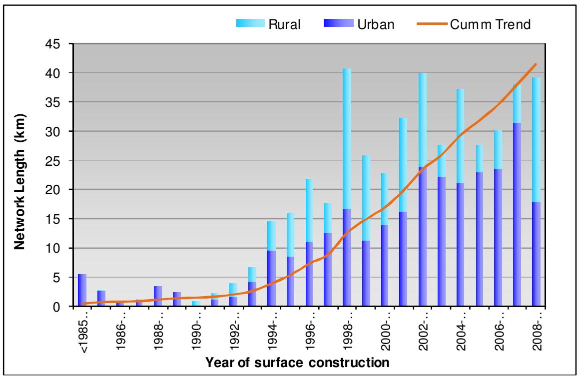


Figure 3.4 Surface construction history since 1990

3.5 Remaining surface life

Apart from the surface age profiling, the remaining surface life serves as a guide in respect of the surface life capacity in the network. With varying expected lives from different surfaces, it can be misleading to observe the age distribution only. In Figure 3.5 the remaining surface life distribution for the network is shown. Only 10% of the network has exceeded their estimated design life, now having less than zero years of remaining life. Around 61% of the network surfaces has between 0 and 11 years of remaining life left. Caution should be taken towards the almost 20% with zero to two years of remaining life, if not attended to, they might become surfaces with high risk to failure. The surface remaining life is used to evaluate the age condition of the network and is calculated using the age of the surface and it relevant expected life. It is therefore important that the expected life data be updated when surfaces exceed their original expected lives and there is still service life remaining.

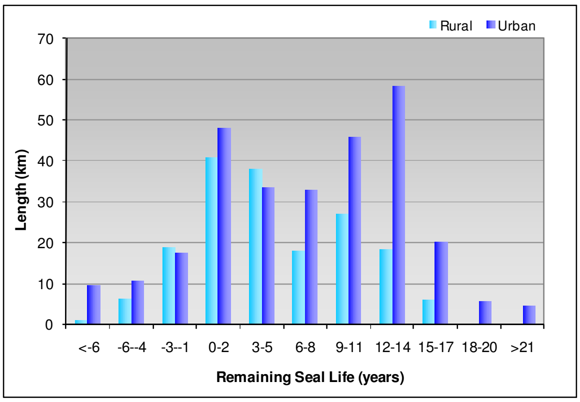


Figure 3.5 Surface remaining life on the network

3.6 Network pavement age

The pavement age distribution is shown in Figure 3.6. Nearly 72% of the pavements are more than 40 years old. These pavements may pose a risk of sudden unexpected failures on the network. As pavement deterioration occurs with age, traffic and climatic conditions, the structural capacity of the network may decrease.

It is clear from Figure 3.6 that an average SNP has been adopted for most of the network. This indicates that only a small portion of the network has been surveyed to determine the remaining structural capacity of the pavement. It is expected that with more accurate data, a decline in SNP might be observed for the older pavements. An understanding of the structural capacity across the network is a critical element and improvements in the available data should be a priority.

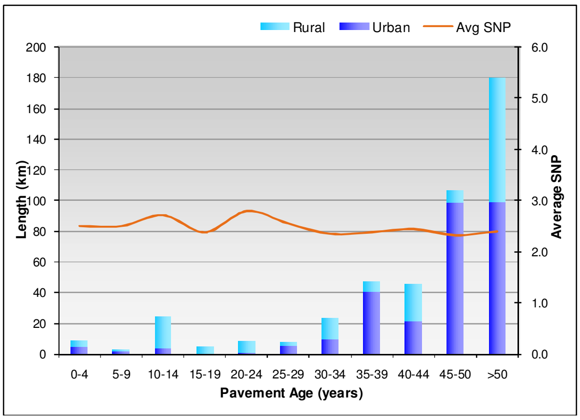


Figure 3.6 Pavement age distribution on the network

The pavement construction history of the current pavement inventory is graphed in Figure 3.7, with the trend of the cumulative pavement length indicated. It is shown that most of the pavement development happened in the years 1950 to 1975. Thereafter was a significant reduction in annual pavement construction and renewals.

For the past ten years, the average renewal rate was 3 km per year, resulting in an expected pavement life of 153 years and indicates that a potential is created that at some time, the potential is created that in the future, a high number of renewals would be necessary to maintain network integrity.

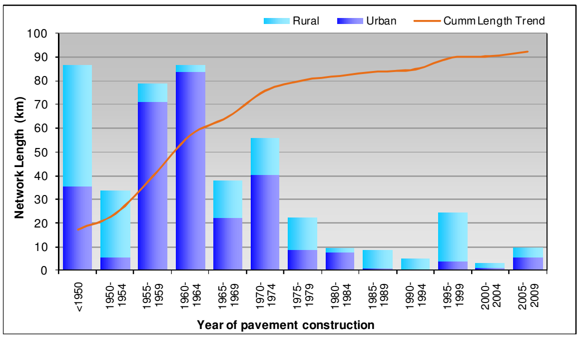


Figure 3.7 Pavement construction history since 1950

4 Current network condition

4.1 Surface integrity index (SII)

In Figure 4.1 the average SII for the network is represented in SII groups. The network surfaces seem to be in a good condition judging by the SII. Most of the surfaces have SII values below two, which is a very good condition. There is only 47 km of the network with SII values greater than 10. These can also be a result of those surfaces exceeding their expected lives (depending on the status of the data in RAMM).

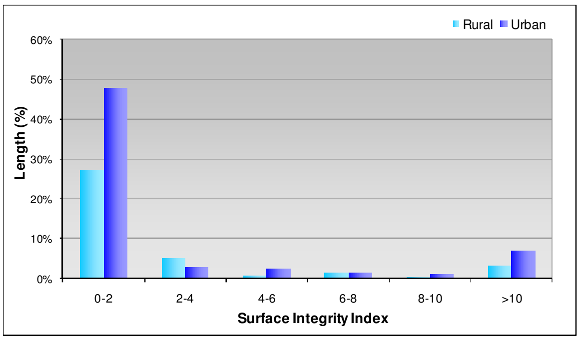


Figure 4.1 Surface Integrity Index distribution for the network

4.2 Structural number (SNP)

The SNP values for a road network can be used as a good indication of the structural soundness of the pavement structures. The pavement strength is one of the important inputs for the dTIMS analysis and is calculated predominantly using the results of Falling Weight Deflectometer measurements.

Most of the SNP values have been estimated for the network based on local knowledge network knowledge and some measurements. Figure 4.2 shows the resulting distribution of SNP values on the network. It will add much value to the understanding of the structural capacity of the pavements to have FWD measurements on more substantial portion of the network.

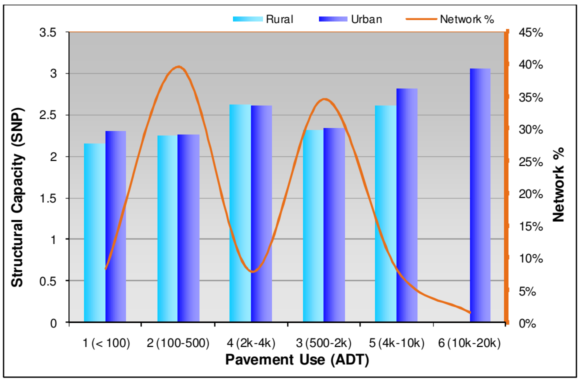


Figure 4.2 structural capacity (SNP) on the network

The SNP varies between 2.1 and 2.6. It is evident that the values have been approximated being within such a small range. It is also appropriate to have higher SNP values for the higher trafficked roads, as indicated in the figure, as the sections with heavier traffic and traffic volumes are designed to have greater structural capacity.

4.3 Roughness on the network

Roughness is also used as an indicator of pavement deterioration on the network. In the model setup, roughness can only be improved by introducing a pavement renewal treatment, implying that roughness is one of the triggers of pavement renewals in the analysis.

The 2008/09 National Land Transport Programme (NLTP) Guidelines have performance indicators for roughness and categorises them for urban and rural networks. The rural and urban conditions have different targets and thresholds for different traffic categories. A summary of the NLTP guidelines:

Traffic Group (vpd)	Average target		Threshold value	
	Urban	Rural	Urban	Rural
A (>10k)	90		120	
B (5k-10k)	100	90	130	110
C (1k-5k)	110	100	140	120
D (200-1k)	120	110	150	130
E (50-200)	140	120	170	150
F (<50)		140		180

- The average target is defined by Maximum average roughness on sealed roads and the requirement is that the average NAASRA roughness all sealed roads in group shall not exceed the target.
- The threshold value should ideally not be exceeded by the roughness of the roughest sealed road in a traffic group and tolerance is allowed that no more than 5% by length of roads in any group shall exceed roughness limit (the threshold value).

The results of the benchmarking against the NLTP guidelines are discussed for the rural and urban networks in sections 4.3.1 and 4.3.2 respectively.

4.3.1 Rural Network

Figure 4.3 shows the current rural network roughness compared with the NZTA targets and thresholds. As seen from the figure, the roughness condition for all the traffic categories is well below the target roughness. The roughness at these levels indicates good road smoothness and fairly stable pavement conditions can be assumed for the roads categorised here.

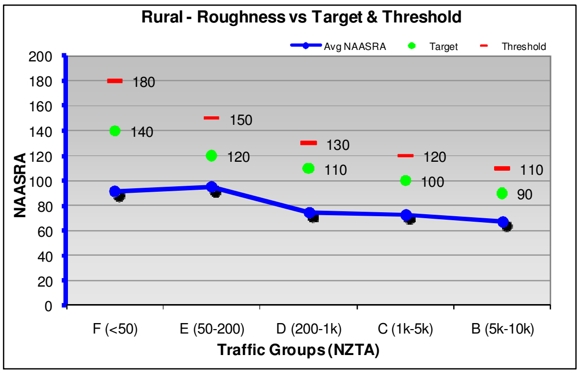


Figure 4.3 Rural roughness compared to NZTA guidelines

The thresholds suggested by NZTA are not to be exceeded by more than five percent of the length of road in a traffic category.

Figure 4.4 represents the length of road in percentage of each category exceeding the threshold. It is important to note that the rural network is approximately 38% total network length, but the guidelines evaluate the roughness for each traffic category individually. There are some sections that exceed the threshold with a total length of 2.1 km. No category has sections that exceeds the 5% limit.

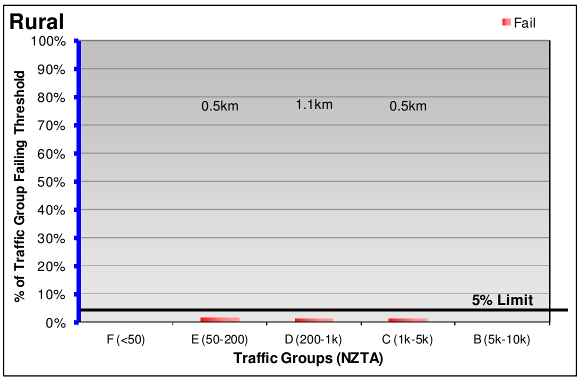


Figure 4.4 Rural network percentage exceeding NZTA guidelines

4.3.2 Urban network

The urban part of the network represents 62% (286 km) of the total network. Observing Figure 4.5, it is evident none of the traffic categories exceed the roughness targets as suggested by NZTA. Urban networks usually have higher roughness averages than rural networks, which can also been seen by comparing Figure 4.3 and Figure 4.5.

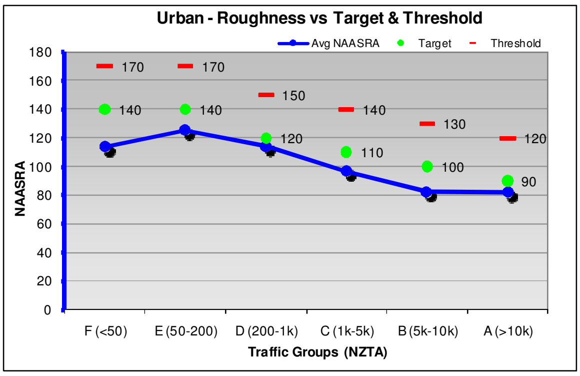


Figure 4.5 Urban roughness compared with NZTA guidelines

Figure 4.6 shows the percentage of road length in each traffic category that exceeds the suggested roughness threshold values. All categories have sections exceeding the threshold limits. Categories D and E also exceed the 5% tolerance on the threshold limits.

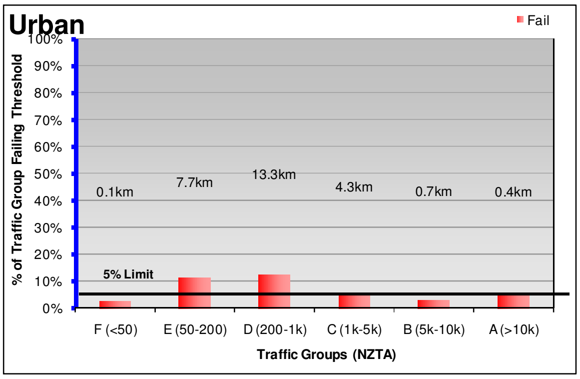


Figure 4.6 Urban network percentage exceeding the NZTA guidelines

5 dTIMS analysis preparation

5.1 Data preparation

The input file of dTIMS CT is built using RAMM data primarily extracted from the following tables:

- Roadnames;
- Treatment Lengths;
- Maintenance Costs; and
- Forward Works Programme

During the data preparation, missing or incorrect data are also sourced by using additional tables from RAMM. These tables may include the following:

- Carriageway;
- Surface and Pavement Structure;
- Rating;
- HSD Roughness;
- HSD Rutting; and
- Falling Weight Deflectometer.

5.2 Deleted records

For the dTIMS CT analysis there were some treatment lengths deleted from the data set, and therefore not modelled. The two predominant reasons are performance and functional considerations.

Regarding the performance, there are treatment lengths where the environment or characteristics do not correspond with network level treatment lengths, and therefore have different performance curves. As the models are developed on typical types of road and surfaces, one must accept that there are some treatment length sections that fall outside of this scope. This would typically include access roads or lanes, roundabouts and parking areas. Traffic and loading patterns on these are not comparable to typical network level sections and cannot yet be modelled with the available models. The same reason exists for sections with concrete block surfacing or concrete slab surfacing, as the performance of these surfaces has not yet been captured in a local deterioration model.

Treatment lengths deleted due to functional reasons include sections with the following characteristics:

- where the owner is not Invercargill City Council
- all sections shorter than 50m
- where the pavement type was "Unseal", "Bridge" or "Concrete"
- treatment lengths with widths of less than 4 m

5.3 Missing/incorrect records

There were a number of records from the RAMM data tables that did not contain the necessary data. Table 5.1 shows a summary of the missing data in the data set and the criticality of the types of faults. The criticality is in terms of dTIMS usage and may be different than the data needs of the Council.

The criticality is used to indicate the importance of the data to the analysis. The most significant issues found were the lack of structural capacity data, pavement thickness data and pavement construction dates. A lesser number of errors were found with surface thicknesses, high speed data and traffic data. These data types are used in the models and have an important role in the deterioration modelling.

Table 5.1 Summary of data errors

Importance	Number of fields (not records)
Low Priority	11951
Required	649
Required if HSD present	4463
Required if NO HSD present	44
Required if RAMM SurfLife is to be used in Model	15
Required if Rating Data Present	18

To complete the missing records from the data set a combination of four methods was used:

- using additional data tables for information
- estimating values from similar sections based on various relevant criteria
- sourcing information from the Council

5.4 Customisation of the dTIMS model

The purpose of the customisation of the standard NZ dTIMS CT model is to suit the local environment of Invercargill City Council, and also to reflect the current maintenance regime.

The model setup for the Council will continually be improved to be appropriate to the Council's environment. The current and historical conditions of the network should be used to determine the calibration of the deterioration models in model setup.

Some of the customisations are discussed here and all the details are listed in Appendix B:

5.4.1 Local settings

The local settings include items such as the Council's own values regarding the roughness achieved after a surface or pavement renewal, the policy regarding the level of traffic when an AC must be applied and the traffic growth factor.

Also included in the local settings are the extent of preseal repairs to be applied before a treatment change will occur, when a two-coat seal should be applied and the wait times for the second coats.

5.4.2 Customised groups

The Council has chosen to make use of customised groups to apply different levels of service to different roads on the network. The predominant factor for determining the groups was the hierarchy. The defined groups are listed in Table 5.2.

Table 5.2 Defined custom groups

RAMM Name	FGroup
LOCAL	1
MINOR ARTERIAL	2
DISTRIBUTOR/COLLECTOR	3
COMMERCIAL	4

The use of FGroups provides the opportunity to specify different condition trigger levels for the different groups, as opposed to using traffic as a determining factor for different LOS. It is therefore possible to target strategic routes and set local roads to have less priority.

The utilisation of FGroups provided the opportunity to differentiate tolerable conditions between different hierarchy roads. Local roads (FGroup 1) were let to deteriorate more than commercial roads (FGroup 4). The purpose was to target maintenance on routes that were of public, social or political significance. If this is not done, it could happen that a local road have the same priority as an arterial road with much higher importance. When using traffic only as a criterion, a lower volume arterial or strategic route might be assigned a lower level of service, which was aimed at a local road.

The levels of service are translated in to conditions where treatments must be triggered. These triggers exist for various conditions and do not necessarily represent the worst tolerable condition or the average conditions, but are determined in the end by what the Council can afford to apply. The triggers may start out at the desirable level from the Council's point of view, but in light of the existing network condition, these levels are often shown as too high to be realistic and adjustments are necessary during the analysis.

6 dTIMS analysis results

6.1 Introduction

For an analysis to be successful there are a few factors that need consideration. Some of these are:

- robust network condition data and information
- realistic representation of the network performance
- appropriate levels of intervention
- keeping to the 2 GB file size limit

The latter two of these three items can be adjusted after each analysis and the analysis can be executed again, which introduces an iterative process in purpose of mimicking the network as realistically as possible.

This chapter provides a network level summary of the quantity of work and predicted condition resulting from the Trigger and Optimal Analyses.

Type of Model	Analysis Description
Trigger model	The treatments are triggered when condition variables reach pre-defined values representing the levels of service. There are no budget constraints for this model. The objective is to evaluate the cost of maintaining a set level of service and predict the resulting condition of the maintenance actions. This budget also repair the network backlog in the shortest possible time period.
Optimal model	Rather than treatments triggered by defined levels, the system generates strategies that conform to base LoS *ranges relating to the trigger levels set for the trigger model* and funding criteria. From these strategies it selects the 'optimum' strategy for each section. The selected strategies represent the optimal combination of economic investment and the performance condition index. The performance condition index (PCI) is a composite index with contributions from various condition variables that are modelled within the system.

The analysis is focused on the two main issues in asset management, being:

- Determination of a cost effective life-cycle strategy for the network (i.e. are we targeting the optimal maintenance quantities for the network?); and
- Investigation into the implication of the strategies on the long-term level of service of the network (i.e. are we achieving the desired outcome from the strategy in terms of network condition?)

6.2 Budgets

The initial budgets used for the analysis setup were based on current and previous expenditure on road pavement and surface maintenance by ICC. Five budgets are considered, with the normal budget being the closest to the current budget of the Council. The budget levels are named from Very Low to Very High. Table 6.1 shows the different budgets used and the variations to the Normal Budget. The variations are 25% and 50% below and up to 75% above the current budget. The object is to determine the effect of the different investment levels on the long-term performance of the network.

From the table it can be seen that the Trigger Model requires more than twice the investment of the current (normal) budget to maintain the network at the required levels of service.

Table 6.1 Budget setup summary

All costs in $'000	Trigger	Very High	High	Normal	Low	Very Low
Input Budgets	$ Unlimited	$7,000	$6,500	$4,000	$3,000	$2,000
% Variation to Normal		75.0%	62.5%	0.0%	-25.0%	-50.0%
10yr avg from analysis	$9,161	$4,945	$4,525	$3,764	$2,931	$1,998
% Variation to Normal	143.4%	31.4%	20.2%	0.0%	-22.1%	-46.9%

6.3 Modelling achievements

The modelling achievements from the analysis are of interest to understand the future funding and treatment requirements, and the predicted conditions as a result of these investments and treatment strategies.

The modelling achievements are summarised in Table 6.2. The details of the summary are discussed in the sections to follow.

Table 6.2 Modelling achievement summary

		Trigger	Very High	Normal	Very Low
Work Quantities (km/year)	**Current**	**Predicted 10yr Average**			
Resurfacing (Chipseal)	28.0	71.3	35.0	34.3	22.6
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Pavement Refurbishment	3.0	9.4	3.79	3.81	3.29
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Condition	**Current**	**Predicted average condition after 10 years**			
NAASRA	93	90.2	98.4	99.6	104.0
SII	5.06	0.9	15.6	16.4	26.5
Rutting	6.96	6.1	6.9	6.9	7.1
Surface Age	8.24	3.6	7.9	8.4	11.2
Pavement Age	46.31	44.4	51.1	51.0	51.6

Considering the comparison between the different budget scenarios, it is important to note the variance of the routine maintenance among the different budgets. The very low budget requires 19% more routine maintenance than the normal budget. this increase in routine maintenance is required to maintain the network to the extent possible with routine maintenance. It is noticeable that the Condition values after 10 years are not significantly different due to the applied routine maintenance. The very high budget requires 7% less maintenance than the normal budget and the trigger model would require 44% less maintenance.

6.3.1 Cost and quantity comparisons

The comparative 10 year average cost and quantities are shown in Figure 6.1 and Figure 6.2 respectively. The high level of pavement renewal investment required by the Trigger Model is clearly visible (also refer to Figure 6.5 and Figure 6.6). Pavement renewal costs are a significant portion of each of the budget scenarios, as it is the most expensive treatment, and a large apparent pavement renewal backlog exists on the network.

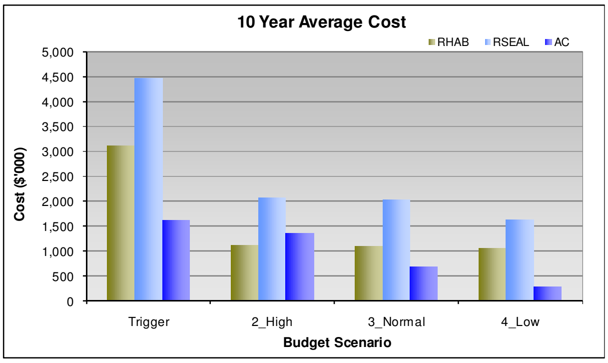


Figure 6.1 10 year average cost comparison

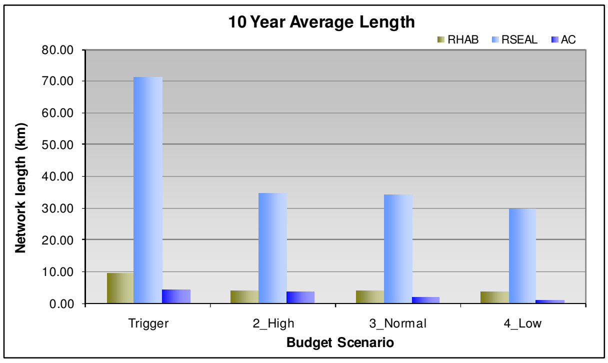


Figure 6.2 10 year average length comparison

Although substantial portions of the budgets are allocated to pavement renewals, the network length affected by resurfacing is much more, especially chipseal surfacing, as can be seen from the comparative lengths in Figure 6.2. Table 6.3 shows the predicted quantities and the associated expected lives if these quantities were implemented. The current pavement renewal practise of 3 km per year, yield an expected average pavement age of 154 years. The trigger model suggests an average pavement renewal of 9.4 km that will yield an average pavement age of 49 years. Similar comparisons are shown for reseal and AC for the trigger, very high and normal budgets.

Table 6.3 Length achievements and expected ages

		Current		Trigger		Very High		Normal	
Treatment	Network Length	Length (km)	Expected Life	Length (km)	Expected Life	Length (km)	Expected Life	Length (km)	Expected Life
RESEAL	398.4	28	14.2	71.3	5.6	34.7	11.5	34.3	11.6
AC	62.3	4	15.6	4.2	14.8	3.5	17.9	1.9	32.2
REHAB	460.7	3	153.6	9.4	49.3	3.8	121.0	3.8	121

It is evident that with the low quantity of annual pavement renewals, the performance expectations of the pavements are very high and the renewal strategy might need to be reviewed. The surface life expectations are not too far beyond the typical eight to 12 years of life.

6.3.2 Optimal Model predicted 10-year cost & quantities

The allocation of funds among the different treatments for the normal budget is shown in Figure 6.3. The cost allocation between the treatments is fairly consistent throughout most of the analysis period. Towards the end of the 20 year analysis period the more expensive treatments (Rehab and AC) tend to become less. The budget limit is $4 million for the optimal normal budget and within this budget the model addressed various aspects on the network during the initial years of the analysis. Consequently a trough in expenditure appears during years 5-7, which disappears again in year 8 as the network stabilises after the initial investment. The initial investment causes the network to have 'additional' capacity in terms of condition, which is 'utilised in years 5-7 of the analysis.

During the 20 year analysis period, there is an average expenditure of $2.4m on reseals, $519k on AC resurfacing and $983k on rehabilitation treatments.

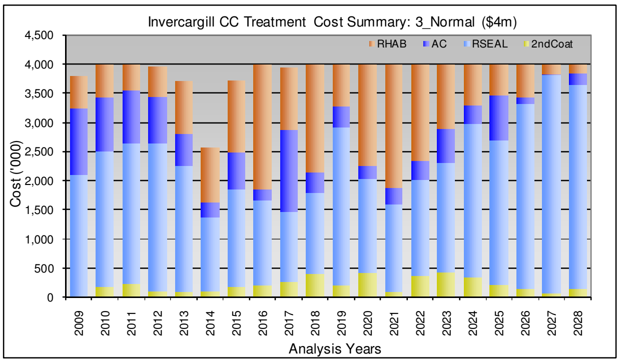


Figure 6.3 Optimal – 10 year average cost comparison

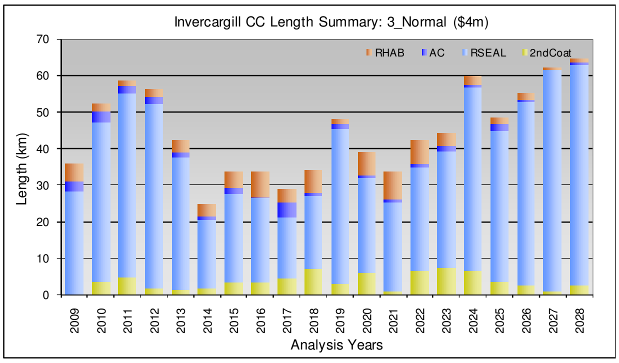


Figure 6.4 Optimal – 10 year average length comparison

The predicted lengths of the various treatments for the analysis period are shown in Figure 6.4. Reseal treatments make up a large portion of the treatments with a healthy average of 40 km per year. As the length of rehab treatments increase, the length of reseal treatments decrease significantly, due to the unit cost ratio. Substantial rehabilitation treatments happen through years 7-14 of the analysis.

6.3.3 Trigger Model predicted 10-year cost & quantities

The unlimited budget of the Trigger Model allows this model to introduce treatments necessary to address all conditions exceeding the worst allowable conditions on the network as set up in the model (via the trigger limits set). In Figure 6.5 the high investment in rehab, AC resurfacing and reseals in year two of the analysis is clearly visible. The total spending for the trigger model in year two is $36m that is used to address all conditions worse than the trigger limits. In subsequent years the investment stabilises in order to maintain the network at the required condition levels. This is an indication of the level of investment which would be required to hold the network, with no backlog being created or remaining. This budget average is around $6.6 million for the analysis period from year three onwards. It is evident that the pavement renewals are consistently addressed throughout the analysis period at an average rate of 6 km per annum.

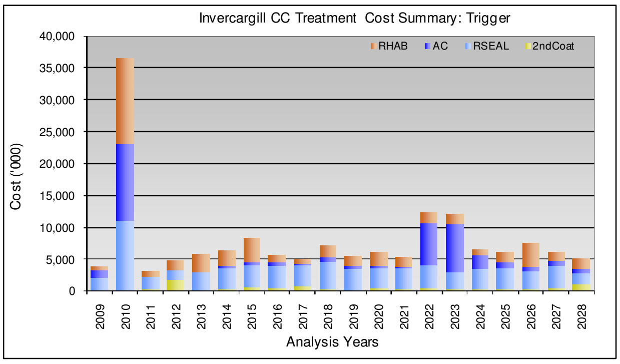


Figure 6.5 Trigger – 10 year average cost comparison

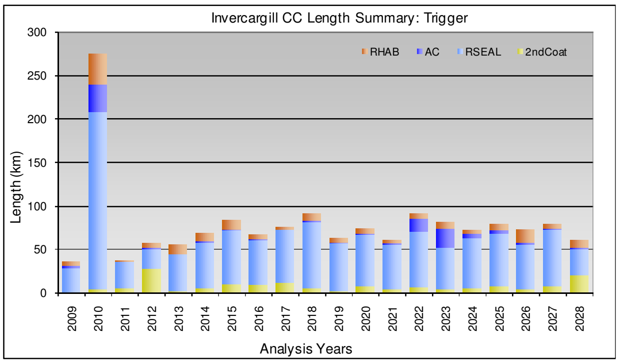


Figure 6.6 Trigger – 10 year average length comparison

The huge length of pavement renewals in year two results is significant second coat seals in year four, as seen in Figure 6.6. Onwards from year three of the analysis, the average reseal and AC resurfacing quantities are 40.6 km and 6.6 km respectively. The model perceives the network to be in a new or near new condition from year three onwards and therefore suggests lower renewal quantities to maintain the network condition. These quantities should be the target toward which the Council should aim to maintain the network.

6.4 Network condition predictions

The condition predictions for the network over the analysis period are based on renewal strategies within budget constraints, levels of acceptable service and the deterioration of the network. The major condition indicators on the network are discussed in the following sections.

6.4.1 Roughness

As mentioned in section 4.3, roughness was used as one of the indicators for pavement integrity. By renewing 34 km of pavements in the second year, the Trigger Model improves the average roughness condition of the network significantly, and maintains it at around 90 NAASRA for the analysis period. The very high budget maintains the current roughness condition of the network for about four years after which the roughness increases steadily. The normal budget not is able to maintain current condition and the average of the network deteriorates from 93 to 100 NAASRA over 10 years. The limited budgets are not able to maintain the network within 5 NAASRA of the current condition.

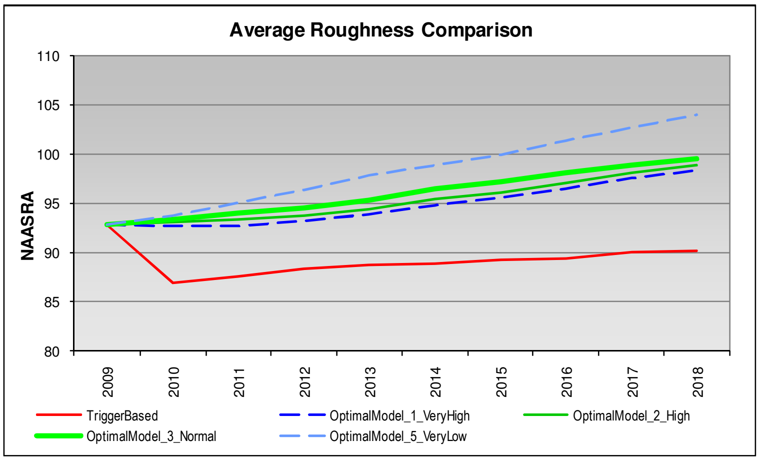


Figure 6.7 Predicted roughness average for 10 years

6.4.2 Surface integrity

The surface integrity is an indication of the visual condition of the surface and is also sensitive to the aging of the network. The Trigger Model improves the average SII from 5 to around 1 and maintains that condition for the rest of the analysis period. Referring to the cost and length of treatment charts (Figure 6.5 and Figure 6.6), the resurfacing average of 56 km per year (AC and Reseal) maintains the network surfaces in a very good condition with an average expected surface life of seven years.

Considering Figure 6.8, the budgets provided and the optimal strategies chosen could not result in maintaining the average surface integrity of the network. The normal budget, with a resurfacing average of 37 km per year (AC and Reseal), lets the network average SII deteriorate form 5 to 16 index points over 10 years. At the end of the 20 year analysis period, the SII is recovered to 13 SII. Considering Figure 6.10, it can be seen that the predicted average surface ages are not high, but there are a number surfaces not receiving any treatment throughout the analysis period. These surfaces advance well past their expected lives (the maximum age predicted is 45 years), and will influence the SII significantly, as can be see in this figure.

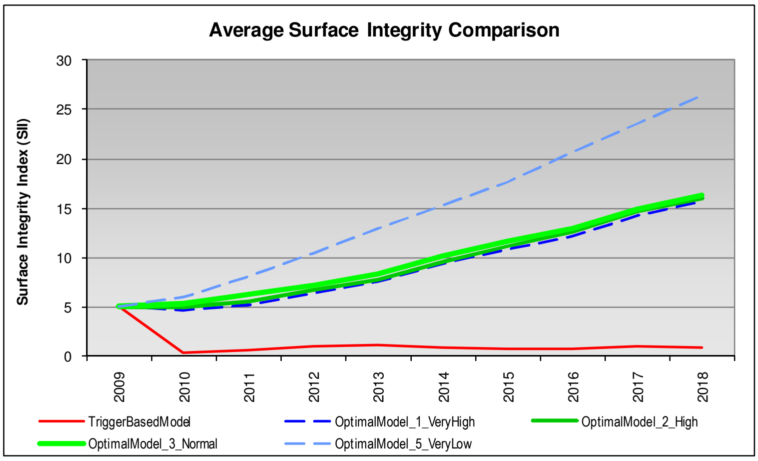
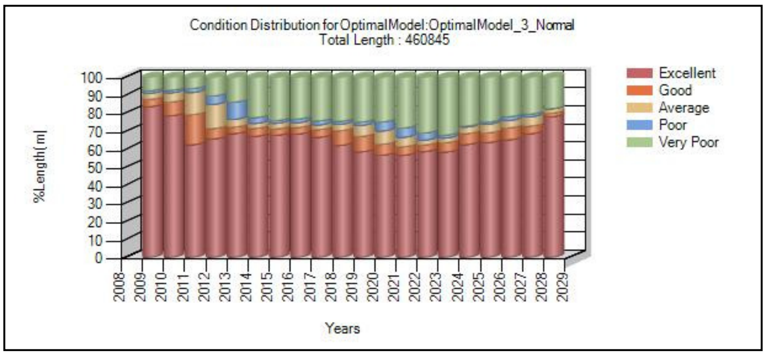


Figure 6.8 Predicted surface integrity index average for 10 years



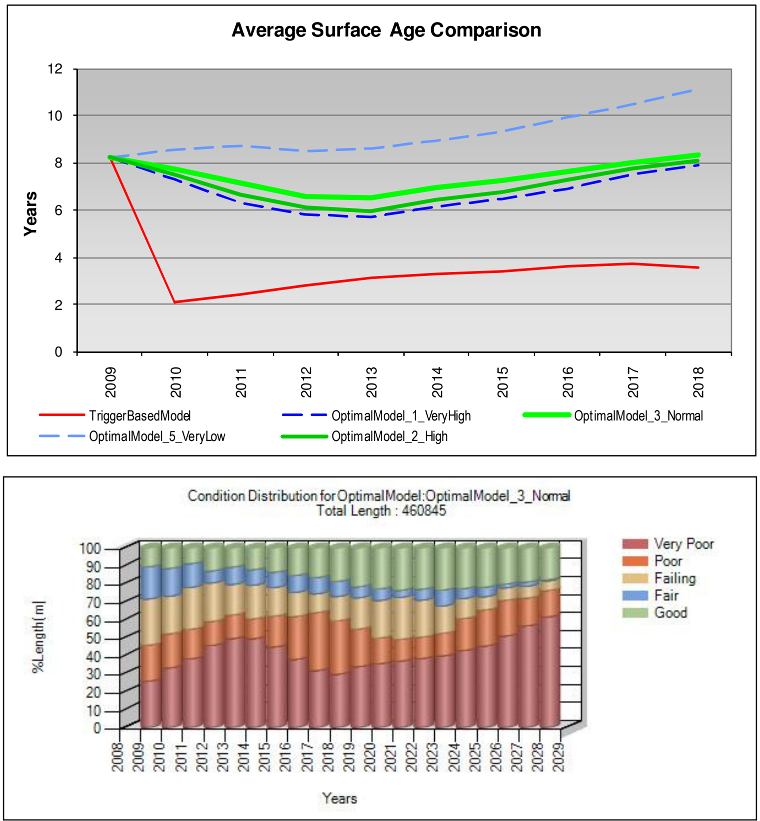
Category	Excellent	Good	Average	Poor	Very Poor
Range (SII)	0-4	4-8	8-15	15-20	>20

Figure 6.9 SII distribution on the network

Figure 6.9 shows the distribution of the SII on the network. It is shown that after the general deterioration of the SII during the initial mid stages of the analysis period, the network condition improves towards the end of the analysis period. In lieu of pavement renewals during the middle section of the analysis period, the surface condition might appear to be neglected.

6.4.3 Surface age & remaining life

The normal budget is able to maintain the current average surface age after 10 years, where after the average surface age continues to increase. The Trigger Model causes the average surface age to be less than four years for the analysis period, after a large investment in year two. The normal budget however, causes the average surface age to be reduced to a minimum of around 6.5 years and then rises to about 8 years in year 10. Figure 6.10 shows the average predicted surface ages for the network over 10 years. The differences between the different budget scenarios (expect the very poor budget) are not great and can also be derived from the small range (30-35 km/year) of the resealing quantities suggested.



Category	Excellent	Good	Average	Poor	Very Poor
Range (years)	0-5	5-8	8-12	12-15	>15

Figure 6.10 Predicted surface age average

6.4.4 Surface remaining life

Remaining surface life takes into consideration not only the age of the surface, but also the expected life. The remaining surface life is therefore quick to indicate an aging network in terms of its surfaces. A good rule of thumb is that the remaining life average and the average surface age combined should total the average expected life of the surfaces. Similar to pavement ages, the remaining life can indicate the risk of surface deterioration/failure due to age combined with environmental and traffic effects. The figure below shows that the remaining life of the network cannot be maintained at 6 years for the analysis period. In year 10 the average remaining surface life is 3.5 years and the average surface age is eight years, which in combination indicates that the average expected life of the surfaces is 10.5 years. The number of surfaces with little remaining life should be carefully managed, a they will tend to created an increasing surface failure risk. The normal budget is not able to maintain the current surface remaining life.

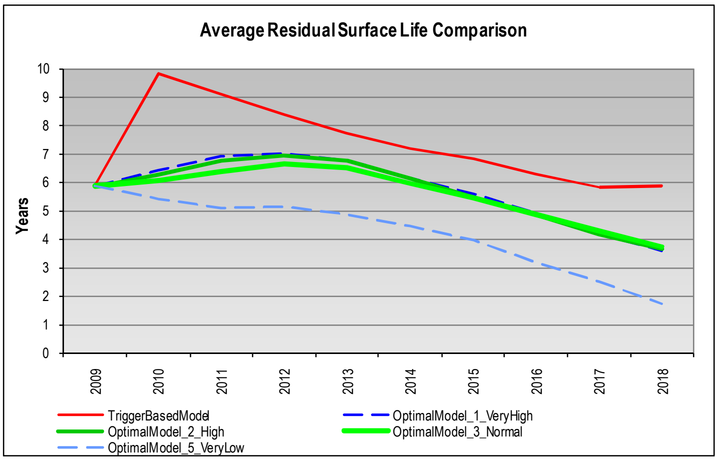
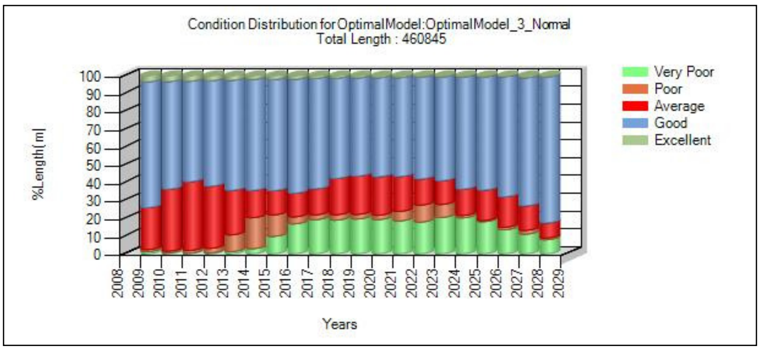


Figure 6.11 Predicted remaining surface life average for 10 years

6.4.5 Pavement Condition Index (PCI)



Category	Very Poor	Poor	Average	Good	Excellent
Range (years)	0-20	20-40	40-70	70-85	>85

Figure 6.12 Pavement Condition Index distribution

Figure 6.12 shows the distribution of the pavement conditions index, represents the general condition of a pavement in terms of various factors. These factors include rutting, roughness, texture and surface condition. Over the 20 year analysis period, there is a general improvement of the PCI as a result of the rehabilitation treatments during the middle of the period. There is however an increase of pavements in poor and very poor condition that are not addressed early in the analysis, this is however reduced but not eliminated, possibly because of a lack of investment in pavement renewals.

6.4.6 Pavement age

The Trigger Model improves the average pavement age of the network by almost three years initially, due to the large amount of pavement renewals done, and maintains an average of about 45 years for the full analysis period. The normal budget is not able to prevent the average pavement age from increasing, and at the end of the 20 year analysis period the average pavement age on the network is 57 years. This is due to the limit budget and limited pavement renewals being done.

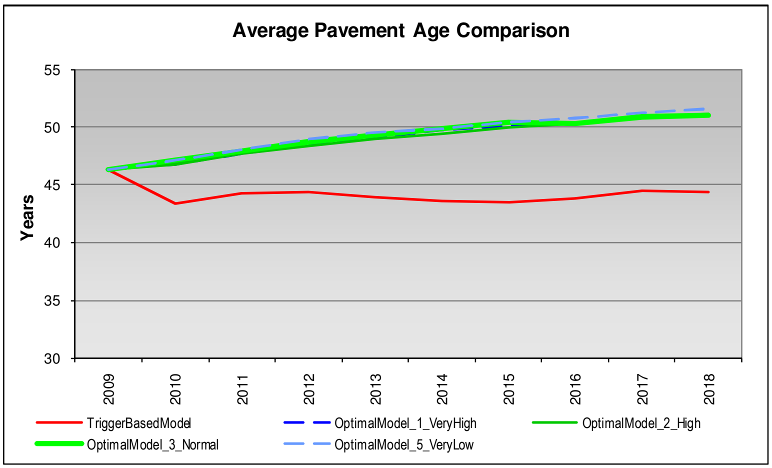


Figure 6.13 Predicted pavement age average for 10 years

7 Conclusion

The modelling process produced outcomes enabling the Invercargill City Council to use it in conjunction with the TSA, field validation and asset manager knowledge to make informed decisions regarding the future programmed maintenance on the network. The Optimal Model was discussed and compared to the unlimited budget of the Trigger Model.

The table below summarises the analysis outcomes:

		Trigger	Very High	Normal	Very Low
Work Quantities (km/year)	**Current**	**Predicted 10yr Average**			
Resurfacing (Chipseal)	28.0	71.3	35.0	34.3	22.6
Resurfacing (AC)	4.0	4.2	4.5	1.9	0.5
Pavement Refurbishment	3.0	9.4	3.79	3.81	3.29
Agency Cost ('000) - 10 year annual average					
Programmed Maintenance		$9,161	$4,945	$3,764	$1,998
Routine Maintenance Variances		-44%	-7%	0%	+19%
Estimated Maintenance Cost ($/km/year)[1]		$123	$205	$219	$260
Condition	**Current**	**Predicted average condition after 10 years**			
NAASRA	93	90.2	98.4	99.6	104.0
SII	5.06	0.9	15.6	16.4	26.5
Rutting	6.96	6.1	6.9	6.9	7.1
Surface Age	8.24	3.6	7.9	8.4	11.2
Pavement Age	46.31	44.4	51.1	51.0	51.6

7.1 Modelling achievements

- The **Normal Budget** (comparable to the Council's current budget) of *$4 million*, if the programme is followed, will not be able to maintain the average network condition at the current

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[1] The maintenance cost is based on the average maintenance cost for the last 3 years before analysis, and is forecasted based on conditions like traffic, roughness rutting etc. It is not to be used as an accurate estimate.

level over a ten year period., but will not be able to maintain the average surfacing condition, the surface age or the pavement age, and the predictions indicate an overall deterioration of the network. This budget would enable the Council to do the following maintenance:

    - Reseal: 34.3 km; AC: 1.9 km; Rehabilitation: 3.8 km
- According to the analysis setup, the **Very High Budget** of *$7 million* will also not be able to maintain the network in most of the conditions predicted over the analysis period. This needs to be investigated as the model setup might need adjustment to enable the budget to be spend more appropriately and generating strategies that will hold the network. This budget (and the way the model is setup) would allow the Council to do the following maintenance:
    - Reseal: 35 km; AC: 4.5 km; Rehabilitation: 3.8 km
- The **Trigger Model** suggests an average annual budget of *$9.1 million* to maintain the network, after initial investment of $36 million to address the apparent maintenance backlog. This budget would enable the Council to do the following maintenance:
    - Reseal: 71 km; AC: 4.2 km; Rehabilitation: 9.4km

7.2 Data issues

There were a number of data issues identified during the data preparation process and it is suggested that a data improvement plan be established and implemented to ensure continual updating and up keeping of the database.

7.3 Model improvements

This analysis is definitely in accord with the Council's aim to have a stable reusable model each year with minor adjustments.

A major improvement would result from reviewing documented maintenance decision making principles form the Council. If such documentation does not exist, it is suggested that the maintenance managers and the asset manager sit together to draft a document describing when and why programmed maintenance is executed on the network. This will enable the modeller to make sure that the intervention levels and intervention conditions in the dTIMS model match the network maintenance regime as closely as possible.

It is suggested that the current setup is used for the next network analysis, and to invest more time in investigating the operation of the expressions, compilation of treatments and resets to ensure a closer representation of the network.

8 Review of analysis

8.1 Review process

The analysis executed by Invercargill City Council was reviewed and the sections below describe the items reviewed. The review process followed a similar pattern as the analysis process, without doing any of the actions involved in the analysis process.

- Data validation
- model setup for local conditions
- changes to the default model setup
- output from the analysis in terms of
  - resulting treatments
  - frequency of treatments
  - profiling the number of strategies generated for each treatment length

8.2 Data validation

Data validation was performed on the data unloaded from RAMM to ensure data integrity when importing the data into the dTIMS and for the analysis. The aim is to have a complete and a technical acceptable dataset and understanding the weaknesses of the dataset. The data is therefore checked for empty values (NULL values) and values outside of acceptable ranges. All of the data validation is done within a MS Access database created to be used as an interface between the RAMM data tables, and the tables imported into dTIMS. Hence the database is called the Interface Database.

The RAMM data to be using in the analysis was unloaded from the ICC RAMM database. It was imported into the Interface database and processed to have the correct table structure for the dTIMS setup. A validation routine is executed on the data and the results are briefly discussed below.

The comparison of the results for the data validation done for the dTIMS analysis and during the post analysis review is tabled in Table 8.1. The totals of this table indicate fields with no data present from the RAMM database.

The fields are shown, as well as their importance to the analysis in terms of their usage and influence.

Table 8.1 Data Error Comparison

Importance	Field	For Analysis	Review
Low Priority	DEF_BB	1828	1822
	Edgeb	6	6
	Edgeb_p	6	6
	FLUSH	6	6
	HNEW	405	401
	HOLD	405	401
	HOLE_PATCH	6	6
	HOLES	6	6
	KC_Length	1619	1617
	RUTS	1487	1481
	SFC_Def	1368	1362
	SHOV_HSD	1487	1481
	SHOV_HSD_m	1487	1481
	SHOV_RATE	6	6
	Width_Pave	1	

Importance	Field	For Analysis	Review
Low Priority Total		**10123**	**10082**
Not Used	RAVELLING	6	6
	Surface_Area	1	1
	Zone	1828	1822
Not Used Total		**1835**	**1829**
Required	AADT_Est	1	
	AADT_Pct_Bus	49	
	AADT_Pct_HCV1	49	
	AADT_Pct_HCV2	49	
	AADT_Pct_LCV	49	
	AADT_Pct_MCV	49	
	AADT_Pct_PC	49	
	CHIP	1	1
	CRK_Alligator	6	6
	Pave_AvgThickness	27	
	SNP	66	
	Width_Surf	1	
Required Total		**396**	**7**
Required if HSD present	IRI	1488	
	RUTM	1487	1481
	TEXTURE	1488	1482
Required if HSD present Total		**4463**	**2963**
Required if NO HSD present	NAASRA	38	
	RUT_30	6	6
Required if NO HSD present Total		**44**	**6**
Required if RAMM SurfLife is to be used in Model	Surf_ExpectedLife	15	12
Required if RAMM SurfLife is to be used in Model Total		**15**	**12**
Required if Rating Data Present	INSP_Area	6	6
	INSP_Length	6	6
	INSP_Wheelpath	6	6
Required if Rating Data Present Total		**18**	**18**
Grand Total		**16894**	**14917**

It is evident from the tables that ICC does not collect and use high speed condition data for rutting and roughness, and that many low priority items have been left uncorrected for the analysis. Low priority values are assigned default values when imported into dTIMS if not addressed in the interface database.

There appears to be six sections where NULL values still exists in various data fields, even after the data correction and validation process. This will not affect the network average of the outcomes, but these sections will be misrepresented on an operational level (in the forward works programme).

8.3 Model setup for local conditions

The model setup needs to be adjusted to be appropriate for the local network conditions. There are various tables used to create customisable data inputs for the dTIMS software which is called transformation lookups. Although some of the lookups do not need to change for different networks and are updated periodically by the setup developers, there are many tables than need to be updated to reflect the behaviour of the local network.

The detail of the transformation lookups can be found in Appendix A:

There are various tables used to create customisable data inputs for the dTIMS software which is called transformation lookups. The following table lists the transformation lookups available for model customisation, and the sections to follow will show the changes made to the default model setup.

Table 8.2 Transformation lookup tables

Transformation Lookup	Description
01_Model_PavementCodes	Standard codes used in the model
06_Model_TrafficGrowth	Standard traffic growth rates
09_Model_HDMCrackingConsts	Standard HDM model constants
10_Model_TextureVariables	Characteristics for various chip grades
11_TriggerModel_AADTTriggers	Treatment triggers for AADT groups
12_UnitRate_ChipSeal	Chipseal unit rates
13_UnitRate_Preseal	Preseal unit rates
14_UnitRate_RehabilitationAC	Unit rates for AC and rehabilitation
15_Model_Calibration	Calibration coefficients for various models
16_TriggerModel_FGrpTriggers	Treatment triggers for functional groups
17_Model_FWPCodes	Forward works programme treatment codes
18_Model_SurfaceCodes	Surface type abbreviation and codes
21_OptimalModel_CondRanges	Upper and lower limits for optimal model
22_Local_Setup	Parameter for local network policies
24_Model_PresealRepairLimits	Limits for preseal repairs
26_Local_Setup_FWP_Years	Specify the committed programme period

The modeller made some changes to unit rates of the chip seal treatments, the preseal activities and the rehabilitation treatments. These changes are shown in Table 8.3, Table 8.4 and Table 8.5.

Table 8.3 12_UnitRate_ChipSeal ($/m2)

Chip Grade	0-3		3-4		4-5		5-6		6-100	
Treatment	**Default**	**ICC**	**Default**	**ICC**	**Default**	**ICC**	**Default**	**ICC**	**Default**	**ICC**
ancRseal	8.1	6	7.15	6.5	5.6	6.3	5.1	4.8	5.1	3.7
ancDouble	9.4	8.4	8.5	7.9	8.5	8.82	9.4	6.72	9.4	5.18
ancSpecial	15	12	15	12	15	12	15	12	15	12

Table 8.4 13_UnitRate_Preseal ($/m2)

	Default	ICC
RutFill	15	18

Table 8.5 14_UnitRate_RehabilitationAC

	Typical treatment depth (mm)		$/100mm depth	
Treatment	**Default**	**ICC**	**Default**	**ICC**
ancACSurf	40	40	137.5	62.5
ancMill	40	40	25	20
ancCutToWaste	100	400	25	1
ancGBSmooth	100	100	20	9.5
ancACSmooth	40	40	137.5	62.5
ancGBExtra	100	100	15	9.5
ancACExtra	100	40	15	62.5

The unit costs in these tables were used in the analysis for the different treatments, and the resulting costs per kilometre can be seen, with the suggested quantities, in Table 8.10.

The local setup transformation lookup is used to define specific variables relevant to the network and also to apply certain council policies to the model. The following are the variables used in this lookup.

Table 8.6 Local setup variables

Local Setup Variables	
NetworkRegion	PermitPresealRepairs
Permit2ndCoatReseal	PresealRepairs_MaxExtent
2ndCoatWaitTime	NZTA_VOCUpdateFactor
IncludeExtraHCVData	1stCoatChipGrade
IncludeActualMaintenanceCosts	RHAB_ACTargetRoughness
UseRAMMExpectedSurfaceLife	RHAB_TargetRoughness
ACPolicy_TrafficLimitPerLane	YrsOfCommittedTreatments
ACPolicy_TrafficLimitPerLane_Urban	UseTNZPCI
RainfallPerMonth	Use2008SII
LimitGranularOverlay	Trigger-Based Model Options
TwoCoatAADTLimit	UseFGroupTriggerValues

Only the variables as listed in Table 8.7 were changed out of the fields listed in Table 8.6 in this lookup table for the analysis. More of the values could be expected be reviewed and changed to better reflect local maintenance practice.

Table 8.7 Local setup transformation lookup

comp_22_Local_Setup		
TextVal	**Default Setup**	**ICC Setup**
NetworkRegion	Hawks Bay	Southland
UseFGroupTriggerValues	FALSE	TRUE

The levels of service that the council needs to deliver to the road users, needs to be translated into approximate technical triggers for the various conditions used to predict the deterioration. The triggers would represent the worst conditions acceptable on the network. The average of the network should be similar to the end levels of service expected from the council.

Two approaches may be used to set the triggers up in the model setup. The first is by using different traffic groups, and the other is to create custom groups. The intention of the various groups is to be able to setup different triggers for different types of roads, as higher levels of service are expected from higher priority roads than other.

The council chose to use custom groups (FGroups) which they have based on the network hierarchy. The triggers to be used in the model were setup for each of the FGroups. These triggers should be network specific. The table shows the different triggers used for the analysis. The default setup had no values for the custom groups, as it was setup using the traffic groups.

Table 8.8 FGroup Trigger lookup transformation

TextVal	FGroup 1		FGroup 2		FGroup 3		FGroup 4	
PAVE_MCI_CONST	0	20000	0	20000	0	20000	0	15000
PAVE_IRI_CONST	0	7	0	4.2	0	5	0	5.5
PAVE_RUTM_THRESHOLD	0	30	0	25	0	25	0	30
PAVE_RUTM_EXCEEDENCE	0	20	0	20	0	20	0	20
PAVE_RUTACCEL_PROB_CONST	0	50	0	50	0	40	0	40
PAVE_RHABPROB_PROB_CONST	0	30	0	30	0	25	0	20
SURF_AC_TEXT	0	0.5	0	0.6	0	0.6	0	0.5
SURF_RSEAL_TEXT	0	0.5	0	0.6	0	0.6	0	0.5
SURF_SII	0	20	0	13	0	15	0	20
SURF_RSEAL_PINCH	0	0.3	0	0.3	0	0.5	0	0.5
SURF_RSEAL_THICK	0	60	0	60	0	60	0	60

TextVal	FGroup 1		FGroup 2		FGroup 3		FGroup 4	
SURF_AC_MCI_CONST	0	10000	0	10000	0	10000	0	80000
SURF_CRKINI_PROB_CONST	0	40	0	40	0	35	0	35

The changes made to the analysis expressions for this analysis are listed in the table below. The only change made was to set the base date.

Table 8.9 Changed analysis expressions

Name	Default setup	ICC setup
ancCONST_BaseDate	#01/07/2009#	#01/07/2010#

The base date change should have been made to #01/07/2009# if this analysis was done for year one being 2009/10. the start date for the strategy files are all 2009. The implication is that all the calculated ages of the surfaces and pavements are actually older by one year, and could potentially cause some ages to be negative. It could also have a small effect on maintenance costs calculations during the analysis preparation.

8.4 Analysis outputs

There are a few key items that need to be considered when the outputs of the analysis are reviewed. For this review the treatment quantities and typical costs, the frequency of recurring treatments and the number of strategies generated are considered.

8.4.1 Treatment results

In Table 8.10 the treatment results of this analysis are tabled for the trigger and optimal models. The unit costs of the various treatments are shown with the suggested annual quantities. Comparing the suggested optimal normal quantities with the typical quantities done by the council, it is evident that some adjustments can be made to optimally maintain the network with the given limited budget.

The unit costs of the trigger and optimal normal budget compare well, indicating that the treatments are similar in terms of the composition of the ancillary treatments. The quantities, however, are significantly different, indicating the tension between the apparent backlog on the network addressed by the trigger model, and the ability to address the network maintenance issues with the limited budget available by the optimal model.

Table 8.10 Analysis result summary (10 year averages)

	Trigger Model			Optimal Model (Normal budget)		
Analysis results	**RESEAL**	**AC**	**REHAB**	**RESEAL**	**AC**	**REHAB**
Avg Annual Cost ($'000)	4,450	1,602	3,109	2,019	671	1,073
Length (km)	76.1	4.4	9.9	35.0	1.8	3.7
Unit Cost ($/km)	58,448	368,098	315,603	57,686	367,046	290,058
Typical Historic Cost ($'000)	1,359	1,426	969	1,359	1,426	969
Typical Historic Quantities (km)	25	4	1	25	4	1
Typical Historic Unit Cost ($/km)	50,000	500,000	250,000	50,000	500,000	250,000

The average past (3 years) cost for AC treatments are significantly different from the analysis results (optimal model, normal budget). This may indicate that the unit rates used for this treatment in the analysis are under estimating the actual costs to the council, or that AC pavement costs have been included in this average. The reseal and rehab treatments compare better, although the analysis costs are more expensive and future analyses should look for closer alignment, especially for usage in the budget constrained scenarios.

The average annual costs for the past three years for AC are much higher than predicted by the model, also reflected by the higher length of road resurfaced with AC by the council. Rehabilitation average annual costs are much the same, but the quantity suggested by the optimal model 3.7 times the achievement of the council. The unit rates might not be correctly reflecting the actual costs of the council for this treatment.

The reseal costs and quantities seem to be close in comparison with the historical and those suggested by the model.

8.4.2 Triggers and recurring treatments

It is important to note the sensibility of the timing between treatments and subsequent treatments. When there are treatments occurring within a short unrealistic period on the same section, the causes for the triggers need to be investigated to make sure that the triggers and the calibration factors are realistic and reflect the local network performance. The table shows the number of years between treatments and the relevant number of sections.

The different treatments have different expected lives, and it is network dependant in terms of the life expectance of the various surfaces and pavements. Typically rehabs should happen after the majority of the surface life had been utilised, except if the surfacing treatment is used as an maintenance holding action, and even then at least four to five years are expected to be gained from the holding action.

There are a few sections in this analysis which have treatments occurring much sooner than would typically be expected, like the rehab treatments happening 2 or 4 years after the previous treatment. Overall though there seem to be no major concerns.

Table 8.11 Recurring treatments

Number of years since previous treatment	Number of sections		
	AC	REHAB	RESEAL
2		1	
3			1
4		4	
5		2	11
6		2	93
7	4	3	159
8	2	3	337
9	1	2	169
10		2	89
11	3	3	60
12	4	2	140
13	3		113
14	2		71
15	2	1	32
16	1		20
17			9
18			3
No previous treatment	99	168	1128

8.4.3 Strategies generated

The optimal model generates a number of maintenance strategies for each section for the 20 year analysis period and then calculates the cost and benefit of each of the strategies. The strategies are then ordered according to their cost and benefit for all treatment lengths and selected as the budget allows.

If too many strategies are generated (i.e. >30), too many solutions are generated with marginal benefit and cost difference between the strategies, and leads to no benefit to the analysis. It is ideal to have unique and clearly identifiable strategies which would represent a variety of viable options.

The main issue with too many strategies is that it can create issues with the file size limitations, and increases analysis run time. Additionally it can be an indication of non optimal settings in the model.

The opposite is that there are no strategies generated to choose from. Typically this is seen by sections having only two strategies generated, the maintenance only and do nothing strategies. This is worse than the problem above as it leaves sections with no programmed maintenance when no treatment options are selected. This is generally caused by the combination of the settings used in the analysis, resulting in situations where no solution is found.

During this analysis 5.2% (32 km) of the treatment lengths had no maintenance strategy generated. This means that these treatment lengths have no options included for any of the rehab, AC or reseal treatments over the 20 year analysis period. These sections will increase in pavement and surface ages, and the condition would continue to become worse, which will have an effect on the network averages for these conditions and the required investment need could be under stated.

Table 8.12 Number of strategies generated

Number of strategies	Number of treatmentlengths	Percentage of treatment lengths
2	**95**	**5.2%**
4	358	19.6%
6	281	15.4%
8	298	16.4%
10	200	11.0%
12	183	10.0%
14	113	6.2%
16	89	4.9%
18	87	4.8%
20	49	2.7%
25	45	2.5%
30	7	0.4%
>30	**17**	**0.9%**

8.5 Conclusions and Recommendations

The overall performance of the analysis seems to be acceptable. The question however needs to answered is : “How appropriate is the model to the Invercargill City Council network?” This question entails the appropriateness of following

- data validation and preparation,
- the triggers selected for the network,
- the representation of the network deterioration in the deterioration models contained in the setup,
- the implementation of council policies and maintenance practises in the analysis,
- the unit costs of various treatments and
- realistic strategy generation.

This review considered some of the aspects involved in the modelling process to establish the appropriateness of the model to the Invercargill CC network.

Data preparation

For the purpose of the review, the dTAG_TL table (the most referenced table in the analyses) was exported from the dTIMS setup and was validated using the same procedure as the initial data validation.

It was discovered that most of the low priority data items were left unchanged. Included in this group are surface thicknesses and kerb and channel lengths. Although classed as low priority, these variables can play a role in the analysis (e.g. treatment costs), as some of the council policies depend on these variables.

From the validation it was clear that the council does not have high speed data available and therefore the manual rut rating and NAASRA readings were used.

There were six sections which had data for various fields missing and were not corrected during the data preparation process.

The overall condition of the council's data seems to be in a fair condition, with not too much data missing for the fields with higher importance. The SNP however, is the main weakness of the dataset.

Transformation lookup tables

Overall the analysis setup seems to be generic as very few changes were made to the IDS Base setup to ensure appropriateness for local conditions. Local council policies regarding the application of AC and two coat seals, roughness resets after renewal and average expected rainfall might have been some of the variables expected to change.

The unit costs for the various treatments were changed to be in accordance to the current costs on the ICC network, but may need further work to align with actual costs (compared to historical costs).

The modeller chose to classify the road network into custom groups based on hierarchy and has set up the treatment triggers to be appropriate for the different groups of roads. If there are little differences between the hierarchy groups of roads, it may also be simpler to use the urban ad rural classification as custom groups.

No changes were made to the optimal condition ranges. These ranges provides the upper and lower limits of variable conditions within which strategies are eligible to be generated. Similar to the triggers for the trigger model, these are network specific, and should therefore be reviewed and appropriately adjusted.

No changes were made to the calibration/growth factors in the model. It is unlikely that these would be the same among different networks, as traffic, climatic and maintenance practises are different.

Expressions

Changes to the expressions require a good understanding of the NZ setup, therefore changes in this area are more likely to occur as a setup is advanced through iterations. The base date was changed to a year in advance, resulting in the calculated ages of pavements and surfaces to be one year more than the reality.

Analysis outcomes

The trigger and optimal (normal budget) provided similar costs per kilometre for treatments, the quantities are much different. The trigger suggested almost double the quantities of the normal budget. Expressing the vast difference between what needs to be done (according to the triggers) and what can be afforded to be done (constrained budget).

There were some sections with subsequent treatments with short intervals. These recurring treatments are often an indication of triggers or calibration factors that needs adjustment. The sections with such short treatment intervals should be investigated in the model to establish the cause.

The analysis generated 16,830 strategies from 1822 treatment lengths. Ninety-five treatment lengths have no maintenance strategies generated for them. For these sections, only two options exist , routine maintenance only or a do-nothing scenario. These sections should be investigated to ensure that they are not in need of short term programmed maintenance.

Recommendation

This analysis can be classified as providing moderate confidence on an operational level for the network. The model setup should be customised to be specific to the Invercargill CC, and subsequent analyses will improve in outcomes that will reflect the performance of the ICC road network. This customisation needs to be based on local network knowledge and historical information.

It is important that the results of the analysis be checked in the field to determine areas that may be improved upon in the model setup and data correctness (including treatment length definition). Subsequent analyses should incorporate the findings of such field validations.

Appendix A: Abbreviations and descriptions

Table A.1 Hierarchy descriptions

RAMM Name	Description
CARPARK	Carpark
LOCAL ROAD	Local road
COLL/DIST ROAD	Collector/District Road
DIST ART ROUTE	District Arterial Route
DIST ART:SCENIC	District Arterial Scenic Route
REG ART ROUTE	Regional Arterial Route
STRATEGIC ROUTE	Strategic Route

Table A.2 dTAG_TL field and RAMM field relationships

dTAG_TL Name	Description
ElementID	RAMM.Road_name+start_m (unique)-exp
Road	RAMM.Road_name
From	RAMM.tl_start_m
To	RAMM.tl_end_m
treat_length_id	RAMM.Treat_Length_id (unique)
AADT_est	RAMM.traffic_adt_est
AADT_Pct_Bus	RAMM.pc_bus
AADT_Pct_HCV1	RAMM.pc_hcv_i
AADT_Pct_HCV2	RAMM.pc_hcv_ii
AADT_Pct_LCV	RAMM.pc_lcv
AADT_Pct_MCV	RAMM.pc_mcv
AADT_Pct_PC	RAMM.pc_car
Ravelling	RAMM.scabbing
CHIP	RAMM.first_chip_size
CRK_Alligator	RAMM.alligator
CRK_Alligator_Prev	RAMM.prev_crack_length
DEF_FWD	RAMM.dtims_peak_defl
Edgeb	RAMM.Edgeb
Edgeb_p	RAMM.Edgeb_p
FLUSH	RAMM.flushing
Hierarchy	RAMM.hierarchy
HNEW	RAMM.Surf_depth-exp
HOLE_PATCH	RAMM.patches
HOLES	RAMM.holes

dTAG_TL Name	Description
INSP_Area	RAMM.insp_area
INSP_Length	RAMM.insp_length
INSP_Wheelpath	RAMM.insp_wheelpath
IRI	RAMM.hsd_iri_avg
KC_Length	RAMM.dtims_kc_length
Lanes	RAMM.tl_lanes
NAASRA	RAMM.naasra_avg
Not_Raise	RAMM.dtims_no_raise
Pave_AvgThickness	RAMM.avg_pave_depth
Pave_Date	RAMM.layer_date
Rehab_Stab_Depth	RAMM.rehab_stab_depth
RUTM	RAMM.hsd_rutting_avg
RUTS	RAMM.hsd_rutting_stdev
RUT_30	RAMM.rutting
SFC_Def	RAMM.length_below_rt
SHOV_HSD	RAMM.hsd_shoving
SHOV_HSD_m	RAMM.hsd_shoving_surv_m
SHOV_RATE	RAMM.shoving
SNP	RAMM.snp
Surf_Date	RAMM.surface_date
Surf_ExpectedLife	RAMM.top_surface_life
Surf_Num	RAMM.number_seal_layers-exp
Surface_Area	RAMM.tl_surface_area
TEXTURE	RAMM.hsd_texture_avg
TL_Name	RAMM.tl_name
Type_Base	RAMM.rehab_stab_depth-exp
Type_Pave	RAMM.pavement_type
Type_Surf	RAMM.surf_material
Type_Surf_Function	RAMM.surf_function
Urb_Rural	RAMM.urban_rural
Width_Pave	RAMM.tl_width-exp
Width_Surf	RAMM.surf_width-exp

Appendix B: Transformation Lookups

Table: B.1 10_Model_TextureVariables

	>=0 to <3	>=3 to <4	>=4 to <5	>=5 to <6	>=6 to <7	>=7 to <8
SLOPE_ST	0.85	0.85	0.8	0.5	0.5	0.15
SLOPE_AM	0.02	0.02	0.02	0.02	0.02	0.02
SLOPE_AM_OGPA	0.01	0.01	0.01	0.01	0.01	0.01
RESET_ST	3	2.8	2.6	2	1.6	1.4
RESET_AM	1	1	1	1	1	1
ALD	10.75	8.75	6.75	4.75	3.25	-1
FollowingChipGrade_1CHIP	4	5	3	2	3	-1
FollowingChipGrade_2CHIP	2	3	4	3	4	-1
P17_SurfLifeFactor_1CHIP	1	1	0.7	1.375	1	-1
P17_SurfLifeFactor_2CHIP	1	1	0.7	1.375	1	-1
SurfLifeFactor_AC	1	-1	-1	-1	-1	-1

Table: B.2 12_UnitRate_ChipSeal

	>=0 to <3	>=3 to <4	>=4 to <5	>=5 to <6	>=6 to <100
ancRseal	6	6.5	6.3	4.8	3.7
ancDouble	8.4	7.9	8.82	6.72	5.18
ancSpecial	12	12	12	12	12

Table: B.3 13_UnitRate_Preseal

	Rate
Preseal	15
RutFill	18

Table: B.4 14_UnitRate_RehabilitationAC

	TRTDepthmm	CostPer100mm
ancACSurf	40	62.5
ancMill	40	20
ancCutToWaste	400	1
ancGBSmooth	100	9.5
ancACSmooth	40	62.5
ancGBExtra	100	9.5
ancACExtra	40	62.5

Table: B.5 15_Model_Calibration

	>=0 to <200	>=200 to <500	>=500 to <2000	>=2000 to <4000	>=4000 to <10k	>=10k to <20k	>=20k to < 1000k
NULL	-1	-1	-1	-1	-1	-1	-1
HDM_KCP	0.7	0.7	0.7	0.7	0.7	0.7	0.7
HDM_KPI	1	1	1	1	1	1	1
HDM_KPP	1	1	1	1	1	1	1

	>=0 to <200	>=200 to <500	>=500 to <2000	>=2000 to <4000	>=4000 to <10k	>=10k to <20k	>=20k to < 1000k
HDM_KGE	0.4	0.4	0.4	0.4	0.4	0.4	0.4
HDM_KGP	0.6	0.6	0.6	0.6	0.6	0.6	0.6
MCOST_CALIB	0.7	0.7	0.7	0.7	0.7	0.7	0.7
MCOST_CCI	1.11	1.11	1.11	1.11	1.11	1.11	1.11
PROB_CRKINI_UNSTAB	40	40	40	40	40	40	40
PROB_CRKINI_STAB	35	35	35	35	35	35	35
PROB_EDGEINI	50	50	50	50	50	50	50
PROB_RUTACCEL	30	30	30	30	30	30	30
CRKINI_PROB_CALIB	0.64	0.64	0.64	0.64	0.64	0.64	0.64
CRKINI_PROB_CALIB_TAC	0.75	0.8	0.8	0.85	0.9	0.9	0.9
RUTM_PROG_THIN_ST	1.8813	1.8813	1.8813	1.8813	1.8813	1.8813	1.8813
RUTM_PROG_THICK_ST	0.8733	0.8733	0.8733	0.8733	0.8733	0.8733	0.8733
RUTM_PROG_THIN_AM	0.9467	0.9467	0.9467	0.9467	0.9467	0.9467	0.9467
RUTM_PROG_THICK_AM	0.7685	0.7685	0.7685	0.7685	0.7685	0.7685	0.7685
FLUSHING	1	1	1	1	1	1	1
PROB_CRKINI_AM	60	60	60	60	60	60	60

Table: B.6 16_TriggerModel_FGrpTriggers

TextVal	2	3	4	5
PAVE_MCI_CONST	20000	20000	20000	15000
PAVE_MCI_FACTOR	0	0	0	0
PAVE_IRI_CONST	7	4.2	5	5.5
PAVE_IRI_FACTOR	0	0	0	0
PAVE_RUTM_THRESHOLD	30	25	25	30
PAVE_RUTM_EXCEEDENCE	20	20	20	20
PAVE_RUTACCEL_PROB_CONST	50	50	40	40
PAVE_RUTACCEL_PROB_FACTOR	0	0	0	0
PAVE_RHABPROB_PROB_CONST	30	30	25	20
PAVE_RHABPROB_PROB_FACTOR	0	0	0	0
SURF_AC_TEXT	0.5	0.6	0.6	0.5
SURF_RSEAL_TEXT	0.5	0.6	0.6	0.5
SURF_SII	20	13	15	20
SURF_SKIDDEF_PCT	0	0	0	0
SURF_RSEAL_PINCH	0.3	0.3	0.5	0.5
SURF_RSEAL_THICK	60	60	60	60
SURF_AC_MCI_CONST	10000	10000	10000	80000
SURF_AC_MCI_FACTOR	0	0	0	0
SURF_CRKINI_PROB_CONST	40	40	35	35
SURF_CRKINI_PROB_FACTOR	0	0	0	0

Table: B.7 21_OptimalModel_CondRanges

TextVal	Lower Limit	Higher Limit
RSEAL_CRKINI_PROB	35	50
RSEAL_TEXTURE	0	1.5
AC_CRKINI_PROB	35	50
AC_TEXTURE	0	0.6
AC_RUTEXCEEDENCE	10	30

TextVal	Lower Limit	Higher Limit
RHAB_PROB	20	30
RHAB_ACCELRUT_PROB	25	40
	0	0
Other Options	0	0
CRACKAREA_DISCARD_LIMIT	0	20
WAIT TIME PERIOD	0	2

Table: B.8 22_Local_Setup

TextVal	2
NetworkRegion	Southland
Permit2ndCoatReseal	TRUE
2ndCoatWaitTime	2
IncludeExtraHCVData	FALSE
IncludeActualMaintenanceCosts	TRUE
UseRAMMExpectedSurfaceLife	TRUE
ACPolicy_TrafficLimitPerLane	99999
ACPolicy_TrafficLimitPerLane_Urban	1500
RainfallPerMonth	120
LimitGranularOverlay	50
TwoCoatAADTLimit	5000
PermitPresealRepairs	TRUE
PresealRepairs_MaxExtent	0.3
NZTA_VOCUpdateFactor	1.00
1stCoatChipGrade	3
RHAB_ACTargetRoughness	2.3
RHAB_TargetRoughness	2.7
YrsOfCommittedTreatments	1
UseTNZPCI	FALSE
Use2008SII	TRUE
Null	Null
Null	Null
Trigger-Based Model Options	Null
UseFGroupTriggerValues	TRUE
Null	Null

Table: B.9 24_Model_PresealRepairLimits

TextVal	2	3	4	5	6
ROUGHNESS_IRI_URBAN	6.8	5.71	5.71	4.5	4.2
ROUGHNESS_IRI_RURAL	5.71	5.71	4.9	4.9	4.2
RUTTING_MM	15	15	15	15	15

Table: B.10 26_Local_Setup_FWP_Years

TextVal	2
YrsOfCommittedTreatments	1
YrsToIncludePROJ	10