

Roading Asset Maintenance Cost Guidelines

VERSION 1 ■ JUNE 2012



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Roading Asset Maintenance Cost Guidelines

VERSION 1 ■ JUNE 2012

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ABBREVIATIONS

BCR	Benefit Cost Ratio
dTIMS	deighton Total Infrastructure Management System
FWP	Forward Work Program
GIS	Geographic Information System
GPS	Government Policy Statement
IDS	Infrastructure Decision Support
IRI	International Roughness Index
km	kilometre
KPI	Key Performance Indicators
KPM	Key Performance Measures
LGA	Local Government Authority
LOS	Level of Service
LTCCP	Long Term Council Community Plan
MCI	Maintenance Cost Index
NPV	Net Present Value
NZTA	New Zealand Transport Agency
PA	Pavement
PBC	Performance Based Contract
PCI	Pavement Condition Index
RCA	Road Controlling Authority
SHAM	State Highway Asset Manual
SU	Surface
VKT	Vehicle Kilometres Travelled

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1. Introduction

Improved road asset management depends on collecting reliable data about routine reactive network maintenance costs and quantities, and applying generic approaches for gathering, analysing and applying information from maintenance cost data.

The New Zealand Roding network consists of 93,910 km. There are 10,908 km of state highway and 83,001 km of local roads; 61,878.60 km are sealed (65.9%). The 2009 NZ Transport Agency (NZTA) network statistics for maintenance and operational costs are summarised in Table 1. Typically roading accounts for more than 50% of local government budget investment.

Table 1 – 2009 Maintenance and Operation Cost Summary

	km	Maintenance and Operational Cost	\$/km
Local Roads	83,002	\$ 238,243,791	\$2,870.34
State Highway	10,908	\$ 319,803,780	\$29,318.28
Total	93,910	\$558,047,571	

Asset management seeks to use all known data sources to inform robust decisions about asset maintenance and renewal. Minimising the asset's whole of life costs while maintaining a prescribed level of service is the objective. Robust historic reactive maintenance cost data is a critical component to make informed asset management judgements.

Data collection and data management principles and electronic tools are well established and continuing to develop. Advances in computing technology, asset management systems, mobile devices and connectivity make it easier to review and record operational maintenance activity in an operationally timely way. They also improve the way asset management data is shared. Nonetheless, clear roles and responsibilities need to be defined to ensure data quality is maintained. Changes in operational practice have also allowed greater visibility of the network's activity and maintenance status, which enables streamlined fault, asset, and financial management. The information management demands sometimes require different staff skills or training in the asset management process.

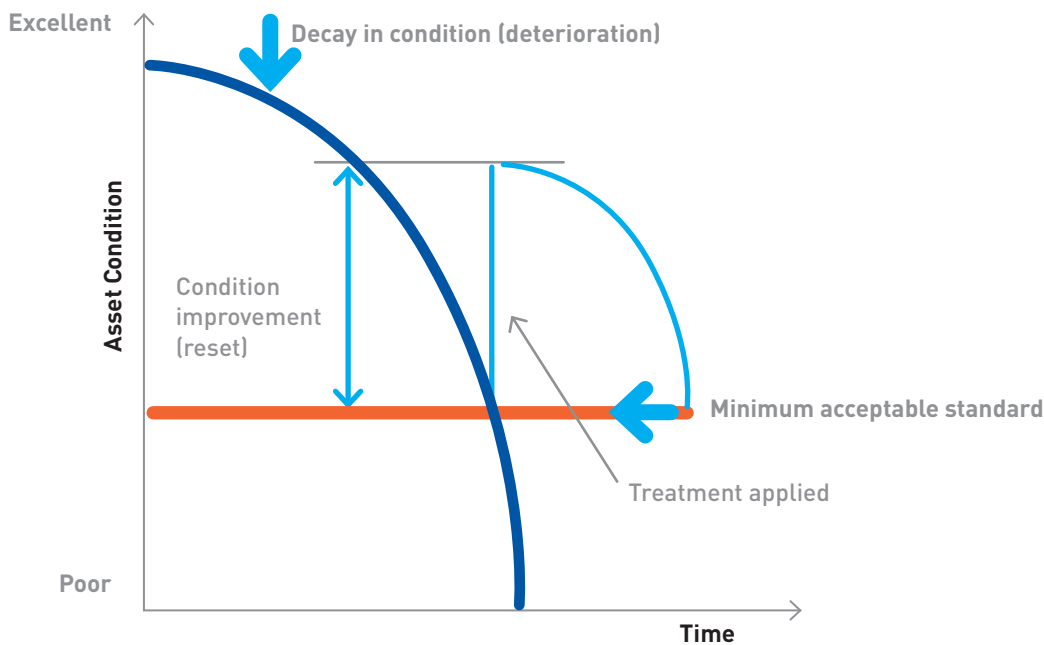
- >> Care should be taken at all stages to consider if data is appropriate, and particularly that no unrealistic data has crept into the maintenance costs.

2 Maintenance Core Processes

2.1 ROLES AND RESPONSIBILITIES

Road asset management involves ensuring corporate asset management goals, objectives and legal obligations are met. In road network maintenance operations there should be defined maintenance standards and strategies which support this intent. The basic cost and activity information being recorded accurately and consistently is a significant benefit and value to the asset's overall management. It is generally a feature of the maintenance contract's administration and deliverables.

Figure 1: Road asset deterioration and the impact of maintenance activity interventions.



Staff, consultants, and contractors involved in collecting and collating maintenance data need to understand the reasons it is being collected and the potential value the data adds to the overall asset management process. This makes it possible for innovation to be identified at all levels of the maintenance process, and improves the likelihood of a quality outcome. Communication between the participants should be open enough to consider the merits of innovation and new options within a contract. Road Controlling Authorities (RCA) need to ensure the maintenance data is checked for accuracy regularly by a designated trained person. The quality of analysis is heavily dependent on the data quality and timely availability for decision making. Maintenance cost data should be verified against claimed activity prior to payment as part of standard contract process.

With the increase in maintenance management systems and the range of maintenance cost data available, there is more demand for the skills to turn the data into useful information. Engineering science as a discipline has the mix of engineering and data skills needed to add value to organisations seeking to make more use of large and sometimes complicated data sets for front line asset managers.

2.2 MAINTENANCE ACTIVITIES

Road asset maintenance strategies need to consider how the asset will be maintained during its life before it is rebuilt. Road assets are maintained to delay the future date at which expensive capital replacement would occur. Levels of Service (LOS) are set to determine the asset's acceptable performance levels, which vary according to a road's role and utilisation. A road asset's deterioration (decay in condition) and the impact of maintenance activity interventions necessary to sustain it are illustrated in Figure 1.

Maintenance intervention activity produces an improvement in asset condition which raises the remaining condition level of the asset above the minimum acceptable level. Depending on the initial construction and maintenance strategies adopted, the asset can be sustained but at some point rehabilitation (reconstruction) is required. Understanding the point where the economic and service benefits of rehabilitation exceed the maintenance strategy's ongoing costs and performance limitations is an important asset management function. This requires tracking the extent, nature and location of network maintenance.

2.3 TYPES OF MAINTENANCE ACTIVITIES

Measured activities are the most relevant input to future maintenance management decisions, particularly pavement and surfacing activities. Road asset maintenance is broken into categories¹.

- Pavement (PA), generally resulting from the pavement's structural performance
- Surfacing (SU), from the surfacing layer's performance e.g. stripping and flushing
- Shoulder maintenance
- Drainage maintenance
- Minor structures/retaining walls
- Other.

Activities associated with the highway verge such as vegetation control, signs and delineator maintenance are often cyclical in nature and driven by levels of service arising from outside influences. Cyclical maintenance items are commonly contracted on a per kilometre or area basis rather than as individual items. Historically, drainage, shoulder and pavement (e.g. potholes) maintenance components have been managed on a cyclic basis. There is a strong trend toward maintenance activity managed on measured (e.g. m²) or each (ea) basis in modern maintenance contracts to better identify where costs are incurred on the network.

¹ www.nzta.govt.nz/resources/state-highway-asset-management-manual/SM020.html

2.4 PROCESS AND FOCUS – PHYSICAL WORK MANAGEMENT

Maintenance work carried out on roading assets requires effective management and accurate contract records with respect to the activity's nature, extent, cost and location. Maintenance management contracts should define the work's accurate measurement, coding, recording, and the way it links to the basis for payment. Maintenance contracts should be structured to cover all aspects of these processes and the timely provision of maintenance cost data to the client RCA. Supplying maintenance services (internal or external) to a RCA requires the following base maintenance activity data to be collected as part of the contract:

- What work was done
- How much work was done
- Where the work was done
- When it was done
- Why it was done.

Typical contracts used to procure maintenance activities for roading management in New Zealand are:

- **Alliances** – special arrangements in which groups of organisations combine in partnership and work together. For example, an alliance is currently contracted to operate and maintain the Auckland motorway network in a long-term agreement that began in 2008.
- **Performance-specified contracts** – awarded for 10 years to single suppliers who are responsible for providing all services. There are five such contracts operating in New Zealand, including one for maintaining the Auckland Harbour Bridge. Most resurfacing is done under performance-specified contracts.
- **Hybrid contracts** – awarded for five years and involve consultants and contractors working in a partnering arrangement to deliver services.
- **Traditional contracts** – awarded for varying terms and involve consultants managing suppliers who deliver physical works on the road network, in a similar way to traditional road engineering construction contracts. Most pavement strengthening works and bridge repairs are managed through this type of contract.

2.4.1 Advanced Road Asset Management

Advanced asset management requires additional activity status information to increase the usefulness of data. Examples include:

- Already completed maintenance
- Maintenance currently being completed or under action
- Maintenance programmed for future completion in the Forward Work Programme (FWP)
- Deferred maintenance: existing maintenance needs that have not yet been programmed for future completion.

If a road asset receives ongoing maintenance inspections and remedial work, the presence, type and extent of maintenance activity can be considered to reflect the asset's physical condition. In this respect the quantum of maintenance work, as reflected by cost or quantity, is a surrogate measure for condition.

New Zealand RCA's have asset management objectives to optimise long-term road maintenance. The aim is to achieve specified levels of service LOS and the desired long-term condition with cost-effective lifecycle management. Effective asset management requires all available maintenance history and condition data to be collated and interpreted to assess the merit of the maintenance activity strategy. This can only be confirmed if there is a robust maintenance cost history.

Use of consistent maintenance activity cost codes and associated activity/fault combinations aid the structured classification, and subsequent analysis of network maintenance costs. It is also used by NZTA as a funder to manage investment in road networks. Working examples of coding are available to network managers (NZ Maintenance Cost and Activity Codes²). A common code set is of considerable benefit for national analysis of road asset performance and road research into improving the effectiveness of road design and maintenance treatments in different network conditions.

² www.nzta.govt.nz/resources/state-highway-asset-management-manual/SM020.html

3.0 Maintenance Activity

3.1 WHAT IS RECORDED AND WHY

Infrastructure assets are expensive investments, take time to establish, and may have an economic life of up to 50 to 100 years. The way assets are managed has long-term implications for their ability to sustain a particular level of service, and the cost of sustaining that level of service³.

Physically managing infrastructure assets includes:

- **Maintenance** - activities that keep an asset in good working order
- **Renewal** - work that replaces an asset that has reached the end of its life with a modern equivalent asset
- **Upgrades** - totally new assets, or replacing an asset with something better
- **Disposal** - decommissioning and removing assets.

3.2 INPUTS

Road asset management primarily focuses on inputs which require maintenance funding. Inputs represent the effort or activities which occur during the maintenance process. Outputs are expressed by the asset's resulting condition. Managing the limited funding efficiently and effectively is the road asset manager's key responsibility. Monitoring usually gives a clear link between finance and inputs (e.g. maintenance activities in priced contract schedules. The link between existing condition measurement (output) and identified existing maintenance need (as determined by experienced practitioners) is sometimes less clear.

Maintenance activities provide the inputs to the maintenance process. The inputs include:

- Maintenance costs – \$/m², \$/km, \$/ea, \$/month or day, \$/tonne
- Frequency (count) – of maintenance activities, collated in the following categories – count/km, count/month, count/highway
- Dates and times of maintenance activities
- Policy affecting maintenance activities – these could, for example, minimise maintenance activity prior to major rehabilitation. Generally policies have a short to medium term effect on the timing of maintenance activities and may allow for a temporary reduction in the achieved LOS.

More specifically the asset management includes:

- What work was done and why – the specific repair type consistently described (Activity coded) e.g. PA Potfill-Holes (Cost group: Activity-Fault)
- How much work was done – the quantity of repair
- Where the work was done – location to appropriate measurement tolerance e.g. linear reference distance (±10 m) or spatial co-ordinates
- When work was done – repair date.

Maintenance and renewal work are core "business as usual" activities for managing infrastructure assets so they remain capable of providing an economic level of service over the life of the asset.

Infrastructure managers need effective systems for maintaining and renewing assets.

³ www.nzta.govt.nz/resources/planning-programme-funding-manual/

They need to:

- Have a long-term plan to identify and assess risk, prioritise and prepare for work needed on the infrastructure asset over time
- Manage day-to-day work, with systems, plans, policies, and procedures to put the long-term plan into action, carry out checks and evaluations, and establish audit processes to make sure planned work has occurred in keeping with policies and procedures, and that it has the desired effect.
- Undertake regular reviews to evaluate whether long-term plans and day-to-day maintenance management activities are effective or can be improved.

3.3 OPTIMISING MAINTENANCE

The Government Policy Statement⁴ (GPS - currently 2009/10 – 2018/19) was developed and issued under the Land Transport Management Act 2003. The Act is the main statute for New Zealand's land transport planning and funding system. Regional, city and district councils, NZTA and other approved organisations under the Act can receive money from the National Land Transport Fund for the land transport activities they deliver. These activities include constructing and maintaining state highways, local roads and public transport services.

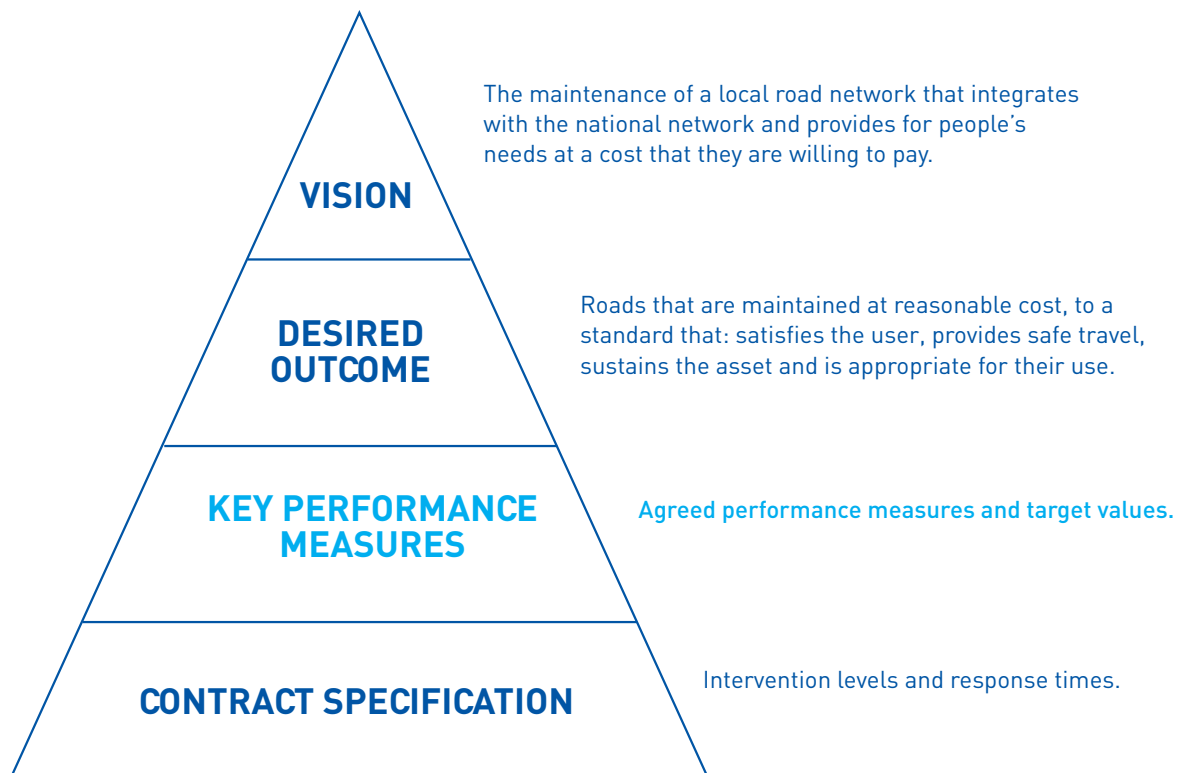
NZTA's Land Transport Programme considers the following factors (as described in the GPS) when planning and evaluating strategies and programmes and approving funding for activities:

- Increasing national economic growth and productivity improvements in infrastructure and services provision that enhance transport efficiency and lower the cost of transportation
- Considering networks from a national perspective
- Achieving value for money
- Encouraging integrated planning
- Making best use of existing networks and infrastructure
- Implementing and fostering a coordinated approach
- Considering the impact of volatile fuel price.

All funders expect the optimal level of network maintenance to consider a balance of road user costs, service levels and life-cycle costs. Asset performance in any network will be tempered by local economic, geological, and climatic conditions. Asset inspection and maintenance is prioritised according to risk priority – higher risks are managed ahead of lower risks – while balancing frequently occurring lower-level risks such as pavement deterioration, against the preventing rare and catastrophic risks.

⁴ www.transport.govt.nz/ourwork/KeyStrategiesandPlans/Documents/Amended-GPS-November-2010.pdf

Figure 2. NZTA's guidelines, outcomes, and contract specifications



RCA's maintain the LOS and maintenance practices used to align with the objectives of the New Zealand Transport Strategy, the Land Transport Management Act 2003, and Long Term Council Community Plans. This gives the best chance of optimising the NZTA funding contribution of network maintenance activities for the RCA.

Most RCA's provide road activity management plans to the NZTA annually for review. The RCA provides a statement on the completeness of their road assessment and maintenance management system (or equivalent) inventory database. If there is a significant difference between a RCA's levels of service and the NZTA's maintenance guidelines for local roads, this needs to be outlined in the activity management plan.

3.4 ASSET CONDITION

Asset condition measures include:

- **Visual inspections** – where faults are noted, usually from a moving vehicle, during the course of a periodic inspection
- **Asset inspection programmes** – such as regular programmed inspections by an RCA of their load-bearing and drainage structures, which may report, for instance, that structural integrity of structures is not diminished by lack of maintenance. Programmes can include annual surface rating condition surveys, high speed data collection, roughness surveys, test pit investigations, and targeted strength testing (generally Falling Weight Deflectometer (FWD)) to further assess the network asset condition and performance. Outputs of these investigations indicate the maintenance strategy efficacy, and support area wide pavement treatment selection.
- **Safety inspections** – these are safety focused, periodic drive-over inspections, which are expected to form part of a safety management system RCA use for their own asset management purposes (including maintenance activity cost data) e.g.
 - Change in the pavement integrity index (PII) of the sealed network
 - Length of the sealed network overdue for resurfacing
 - Maintenance Costs/network km or VKT
- **dTIMS model forecasts** – which make longer term optimised forecasts of network performance based on available network asset information, investment levels and maintenance costs.

3.4.1 Deferred Maintenance

Budget pressure on maintenance activity inputs can limit maintenance investment. The level of surfacing treatment may increase replacing more expensive rehabilitation, but ultimately flexibility reduces to the point where rehabilitation cannot be deferred. Maintenance activity costs outside of normal “service level” can increase, resulting in the ratio of reactive to/proactive activities increasing at the same level of investment.

It is important to monitor the level of planned maintenance activity on network assets relative to the amount of unplanned or reactive maintenance. Clearly defining and locating activity based maintenance costs is important. This allows areas or activities which require a different maintenance intervention strategy or forward work prioritisation to be identified. Failure to monitor these effects will lead to problems with unplanned maintenance levels and put overall asset performance at risk. Asset management processes should be able to determine the deferred maintenance liability and use the maintenance cost history data to support funding requests, maintenance strategy changes and changes in the asset’s LOS.

Methods of assessing the level of deferred maintenance include:

- Tracking the detail of unplanned maintenance activity per month and calculating the percentage of planned versus unplanned maintenance activity costs per month
- Dividing the total sealed network length by the average annual rehabilitation length over three years
- Reviewing the dTIMS trigger model output to identify work that may need to be included in future plans. The trigger model is not investment limited and activates when a trigger condition is exceeded.

3.5 MAINTENANCE ACTIVITY MANAGEMENT

Maintenance activities in New Zealand have been contracted out through competitive tendering processes since 1991. Currently NZTA and other RCA's have a range of contractual arrangements for road maintenance activity. Some non-pavement roading maintenance activities have been purchased or supplied on a \$/month or \$/km basis (e.g. mowing). This has limited use in analysing maintenance inputs because the cost is spread uniformly across all road sections (cyclic cost) regardless of when or where inputs actually occur. Effective pavement cost management is aided by segmenting the roading network into "treatment lengths". These are defined as contiguous lengths of commonly performing sections of pavement and generally have common surface treatment type. Measuring maintenance activity units by dollars, number or m², period, and location is required to analyse maintenance activity.

Pavement maintenance is generally the biggest expense, and the basis for purchasing/supplying pavement maintenance activities has generally been in \$/m². This basis of measurement has the benefit of reflecting the proportion of the treatment length area under the pavement maintenance activity. This is useful in considering the economic value of alternate maintenance options into the future.

As management policy and contract pricing may affect maintenance input initiation in one or two consecutive years, averaging activity cost inputs over three or more years is appropriate.

3.6 DATA CAPTURE

The following data should be collected about maintenance activity:

- What was done (activity)
- How much was done (quantity)
- Where it was done (to ± 10 m)
- Why it was done (fault)
- When it was done.

Contract/Asset managers need to ensure that maintenance staff and contractors have adequate asset condition capture skills, and regularly quality review maintenance data. This provides the opportunity for feedback about improving the asset maintenance strategies, and confirms contractors are aware of why the maintenance data is collected, and the impact of poor data on asset management.

To be effective, condition surveys need to be regular and comprehensive in coverage. While collection of maintenance data by the staff responsible for programming and carrying out the work has the advantage of their knowledge about the maintenance work actually undertaken, independent rating surveys add value as an objective assessment of network condition. Both have value in road asset management and in supporting the analysis of maintenance activity information. Maintenance contracts should specify network observation and maintenance activity record keeping requirements to a standard that allows for effective subsequent analysis. This needs to be balanced with the cost of maintenance data capture and the contract/asset management benefits that can be derived from using the data. Timely network observations and analysis positively influences maintenance activity planning so a time related service level on submission of maintenance data should be included in contracts.

3.7 DATA CAPTURE SYSTEMS

The business requirement to collect maintenance data should drive the capture process. New Zealand maintenance contracts increasingly use mobile devices (smartphones, tablets, and laptops) to capture data. Manual, paper-based processes are also used, and are still effective with some complex data (e.g. network driveover sheets). Mobile devices can reduce the time needed to record and duplicate maintenance activities but software and hardware need to be practical to use in the field. Devices need to be supported by sound data processes, application software, user education, and quality control or the intended efficiencies may not be realised. Staff within the RCA and the contracting/consulting organisations need to have the technical skills and clear processes to operate and support systems used in contracts. The asset management software used should reflect agreed business rules and be available to all parties for access and update where required.

In recent years systems like RAMM Contractor have been developed and utilised for road maintenance contracts. The maintenance cost data collected in Contractor tables needs to be moved into the RCA accessible maintenance cost tables as part of the contract deliverable. Camera and global positioning system (GPS) equipped mobile devices and emerging asset management software makes it possible for more condition and location data to be collected, and additional spatial analysis and presentation of maintenance activity is possible. Technology can help minimise data entry duplication, significantly ease data sharing, and reduce transcription error but it needs to be cost effective and support the maintenance activity management business process. Manual methods should also be available as back-up where technology is used.

3.8 QUALITY ASSURANCE

Checking maintenance data quality to confirm it is a reasonable and reliable base for analysis is a constant discipline in asset management. It is important for asset managers to know the data's strengths and limitations when using it as a basis for making assessments and recommendations. RCA's should plan to improve data quality so it contains a minimum base of three years' reliable maintenance activity data to support analysis and decision making. Poor data quality has a negative effect on the usefulness of maintenance records and the confidence with which they can be used.

The three year minimum data set also gives some balance on the economic effects of changing unit rates over time.

Regular audits should be programmed to establish the quality of maintenance activity data. From these the need for further checks or process changes can be determined with contract participants.

Changes of staff (RCA or contractors) need to be well managed so record keeping quality is maintained and there is a common understanding of network maintenance strategies. Maintenance activity coding consistency⁵ and RCA staff/contractor training for the range of treatments relevant to the network are fundamental to managing network costs, NZTA reporting requirements, analysis to determine more timely maintenance processes, and for information sharing built on a solid base of national maintenance records.

Example:

NZTA's "SmartMovez" website has an MS-Excel based sheet for this New Zealand road network comparison (Road network condition tool⁶). This comparison is able to be made nationally because of consistent use of maintenance activity descriptions and datasets.

⁵ www.nzta.govt.nz/resources/state-highway-database-operation-manual/docs/SM050-appendix-4.pdf

⁶ www.smartmovez.org.nz/references/refs/data/road_network_condition

3.9 DATA OWNERSHIP

Asset owners need to define the ownership of contracted maintenance activity data. Contracts should identify ownership of collected maintenance activity and cost data, the submission requirements of the asset's full maintenance records, and any commercial sensitivity requirements.

The data should reflect the detail described in the underpinning maintenance contract and be transferred or made available to the owner on a regular basis. Asset managers also need to have access to current and comprehensive maintenance activity records, as these are used as inputs into longer term maintenance strategy decision making and renewal evaluation. It is more important that the data is collected accurately and regularly, than the particular type of service environment within which it is provided.

3.10 DATA FORMAT

Data exchange between organisations is usually transformed into a format such as a delimited text file, spreadsheet, or other agreed electronic data exchange format. Modern database systems are capable of creating data formats commonly used for exchanging data.

Highway asset managers need system(s) to facilitate their data management. Given the quantities of data involved, relational databases are more appropriate to use rather than spreadsheets. Practitioners often develop separate database (or spreadsheet) tools to address individual components of the management process (e.g. contract management, communications, inspections). While combining these functions into one integrated package is a common concept, integrated systems are, by their nature, more complicated, expensive, and reliant upon a higher level of computing skill and understanding. This has implications for an organisation's resources. Additional types of data retained can include:

- Network and inventory (e.g. drainage, pavements)
- Maintenance activity costs
- Communications (such as public enquiries)
- Documents (e.g. consents)
- Accidents
- Planned area type maintenance treatments (such as the Forward Work Programme).

Organisations can set up data systems by either purchasing a commercial one or building a system specific to meet its own needs and those of contributing funding organisations. RAMM is the most common road asset system in New Zealand at present.

4. Using Data

As the complexity of maintenance activity data varies considerably, the following items need to be taken into account before analysing it:

- **Costs by Treatment Length** – for practical maintenance management purposes roading asset costs should be linked to defined uniformly performing contiguous sections of the network rather than network wide cost allocation. Many networks use treatment lengths but any pragmatic road length grouping that enables the network to be divided into uniform treatment areas is useful. For rural areas this may be by road rather than individual treatment lengths.
- **Time frame** – the longer time period the entire maintenance data covers the better. In general a minimum three year period is useful to overcome potential distortions due to the effects of policy/strategy change, area maintenance (e.g. resealing), contract transitions and so on. In addition, input costs may vary over time depending on factors such as the suppliers' pricing policies. For maintenance costs, the inventory over the preceding two to three years are most directly relevant. In this way, the effect of time on the relative dollar values is insignificant. Adjustments for the consumer price index (CPI) can be included in the data cost analysis.
- **Summarisation/data processing** – relevant maintenance data needs to be summarised (e.g. averaged and weighted by length) within the selected lengths so the network is appropriately represented.
- **Data Quality** – a good understanding of any known limitations of the historical data is important. In some situations the data set may be inadequate to support analysis.

4.1 DATA ANALYSIS

Analysis and reporting tools for maintenance activities are a common part of road asset management practice. They require a reliable maintenance cost history in a form able to be used in computerised systems (notably, but not exclusively, RAMM to basic spreadsheets) maintained by road network managers. RAMM provides a generic New Zealand developed asset framework for programming, recording, sharing, and more consistently locating road maintenance activities between the RCA's and contracted entities involved in roading network maintenance and management. RAMM enables asset managers to benchmark performance and consider peer network performance. The impact of maintenance activity on network asset performance can be inferred, and refinement of maintenance activity evaluated.

The options for storing data include spreadsheets, databases, and specific asset management software. Databases are usually more suitable for long-term use as spreadsheets have limitations on the numbers of rows of information they can hold and this can be an issue for roading maintenance records. There is a trade off on matching resources in systems and staff skills for RCA's for data management and analysis. Good business discipline (process and quality assurance) is the backbone of maintenance activity management and its supporting technology.

In New Zealand conditions RCA maintenance records are extremely variable in quality, and older records are often in a form that is not economic or practical to incorporate in modern electronic systems. Each new maintenance contract represents an opportunity to establish a level of maintenance cost recording as a contract output. A well specified contract should allow good maintenance activities/cost data management and a reliable electronic recording/data transfer mechanism for the data owner.

4.2 ANALYSIS METHODS

Maintenance activity cost data can be analysed in a number of ways including through Benefit Cost and Net Present Value.

TREATMENT ECONOMICS – BENEFIT/COST (B/C) AND NET PRESENT VALUE (NPV)

- Benefit Cost (B/C) is used as a mechanism for ranking potential projects. The procedures for undertaking this process are well described in the NZTA Economic Evaluation Manual Volume 1⁷ (Section SP3: General Road Improvements) and NZTA Annual Plan and DLTP Instructions for State Highway and RCA's respectively.
- Net Present Value (NPV) reflects locations where an area type treatment is demonstrated to be the least cost maintenance option. Procedures for applying this are also laid out in the NZTA Economic Evaluation Manual Volume 1⁸ (Section SP1: Road Renewals refers to the NPV process).

Local authorities have been required to operate in a “value for money” environment for some time and what is being proposed through the Procurement Manual⁹ is consistent with this requirement. Case making with a good maintenance cost history can be quite useful for project level prioritisation. dTIMS modelling also uses economic analysis to prioritise strategies by treatment length when a network model is based on maintenance cost and activity data extracts.

TRENDS – GENERIC VERSUS SPECIFIC COSTS

Roading network trends may be applied or derived on a general (network level) or specific (project level) basis. Examples of this are the Maintenance Cost Index (MCI) which is part of the dTIMS predictive modelling process (Section 5.4 Predictive Modelling); network wide general data used to derive time based relationships and values (e.g. growth rates); or the data may be more specific i.e. to the treatment length level. In the roading context it provides better quality output if specific local relationships are used. This requires:

- Appropriate and reliable local data, ideally to a treatment length level
- Skills and tools to analyse the data
- Knowledge of the network; the underlying geological and climatic processes, materials properties and sources, and maintenance practice
- If either of the first two are not present then the better option may be to use national or network generic data. The third requirement must be used in all analyses.

As with all data based analysis it is critical to ensure that the base data is reasonable. Simple checking of high and low values for quantities and rates for reasonability should be done before starting any analysis work.

80/20 RULE ASSESSMENT

The 80/20 Rule is simply that 80% of the maintenance effort is usually required on 20% of the asset. The graph in Figure 3 illustrates this.

This graph¹⁰ is taken from actual records from a state highway network that has 65% of expenditure occurring over 20% of the network. Maintenance data analysis will enable the asset components in the 20% to be identified and treated.

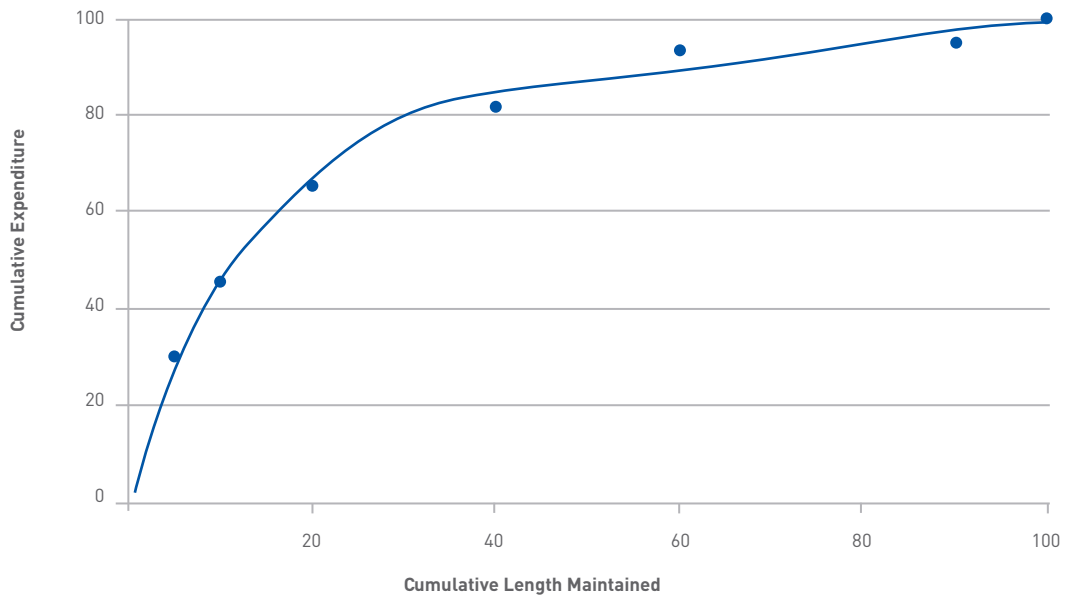
⁷ www.nzta.govt.nz/resources/economic-evaluation-manual/volume-1/index.html

⁸ www.nzta.govt.nz/resources/economic-evaluation-manual/volume-1/index.html

⁹ www.nzta.govt.nz/resources/procurement-manual/

¹⁰ Figure 9, section 8.2; www.nzta.govt.nz/resources/state-highway-asset-management-manual/docs/SM020-manual.pdf

Figure 3 – Cumulative Maintenance Expenditure by Network Length



Example: Unsealed Roading Maintenance Management Programme development

Maintenance cost records were used to develop unsealed road forward works programmes for two road sections of a rural North Island council. This involved analysing historical maintenance information which was largely based on responsive metalling to determine areas with greatest need. The intent of the work was to get the unsealed maintenance materials and technique right to protect the investment in expensive basecourse which could be lost without an effective “capping” wearing course, and to reduce unsealed road service requests. The work also would refine the forward work programme and provide a base for unsealed network performance measures.

As originally inferred by the asset engineers, the finding was that the historical unsealed maintenance cost profile had a fit similar to the Pareto principle (80% of the cost in 20% of the locations). The sections were steep terrain with over 100 vehicles/day, and subject to regular intense rainfall events. The analysis of the two areas indicated that one area had more than 70/30 (varied topography) and one less than 70/30 (average topography). They used this as a basis for spreading the unsealed maintenance funding in the appropriate proportion and lengths when the forward works maintenance programme was developed.

The maintenance contract required the maintenance metal volume data to be reported by the contractor by road name. That information in conjunction with maintenance records and field inspections was the basis of the initial studies’ assumptions. The modified programme treatment lengths (based on topography, gradients, curvature, traffic, and other factors) were assigned high, medium, and low wear rates and the metal volumes distributed across them. The forward work programme was then developed in MS Excel based on maintenance data, and programme iterations were reviewed and field verified for engineering sensibility.

Capturing treatment length information was not viable with the existing contract arrangements where basic programme compliance was already a challenge. The contractor was encouraged to improve wearing course application techniques, materials and management to maximise the period between applications and minimise costs. After some success in initial trials reliable wearing course material and construction is being continuously refined

4.3 SUMMARY ANALYSIS

The most common starting point for analysis is in \$/km, m²/km, number/km. This process summarises maintenance activity into each distinct section or treatment length. Summarised data can be expressed as:

- Cost/km
- Quantity/km
- Count/km.

The maintenance activity records need to be filtered according to activity cost codes to express directly relevant repairs (e.g. pavement) to maintain condition or level of service. Priority for intervention would normally be with the asset portions reflecting the highest level of input. This is where consistent maintenance treatment codes have significant benefits for analysis and interpretation. It also provides a check to confirm if the network is divided into appropriate treatment lengths. Where more than one maintenance strategy occurs in a treatment length, a decision to subdivide further can be considered to reflect practical network management.

4.3.1 Scheduling Road and Footpath Maintenance¹¹

The following example shows a defined condition assessment process including verification and consultation actions.

Example:

The Council aims to reduce the need for roading repairs by performing routine maintenance programmes throughout the city. The Council's process for scheduling road and footpath maintenance includes the following:

- Annual survey – a consulting engineer is employed to survey the conditions of every road and footpath in the city
- Computer analysis – the Council analyses collected road defect data and creates a provisional maintenance schedule based on a cost/benefit ratio for road users. A cost/benefit ratio for pedestrians is calculated for the footpaths.
- Verification – a Council roading engineer verifies the information and determines the appropriate treatment for each improvement project
- Scheduling – the Council consults with service authorities who regularly perform their own utility works to ensure there are no potential conflicts. Based on the factors above and on the Council's budget, roads and footpaths are scheduled for maintenance.

¹¹ www.wellington.govt.nz/services/rdstraffic/maintpro/maintpro.html

5.0 Advanced Analysis Methods

5.1 DATA MINING

Data mining describes a variety of applied statistical and other data analysis methods, which are available (sometimes contained within commercial off the shelf software), to operational maintenance practitioners. A copy of the original operational data can be extracted and linked to other related financial and quality data in applications optimised for analysis and reporting. This type of data is sometimes called a “data warehouse”. Reporting from live operational systems can have a performance impact in some situations.

Example: InRoads Performance Based Contract

The 10 year Performance Based Contract (PBC) requires InRoads to provide monthly reports on the contract’s current financial position, and to predict future costs, to satisfy management and governance expectations.

Operational information from contract activity is stored and sourced in the RAMM (asset management system), EXOR (a maintenance activity job management system) and Vision (a financial management system). To help redistribute this information, live extracts from each of the data sources are regularly transferred to an on-site server database.

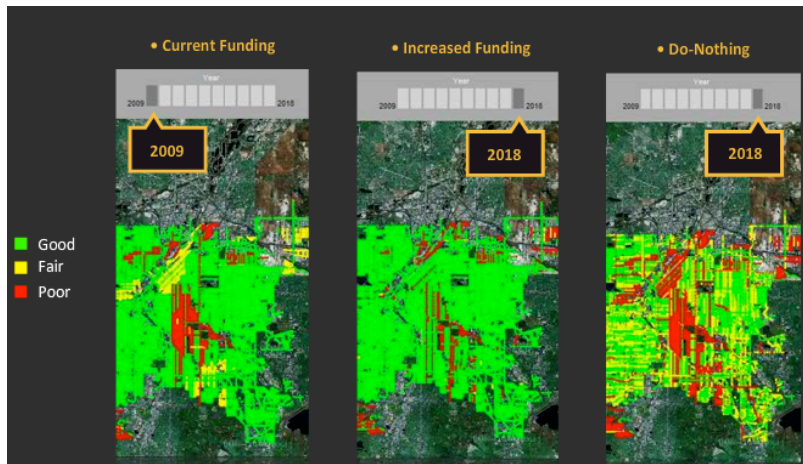
Custom-built web and office report templates specific to the needs of the contract use the data in the server database to produce monthly reports. InRoads use a “Pain Gain” report, which utilises Vision and EXOR data. The report determines the balance of expected asset quantity delivery, as stipulated in the PBC and associated variations, versus costs of delivery, material rate costs, and predicts the outcomes at the end of the contract. Other task-specific graphs using data from Vision enable Inroads to understand the underlying trends of cost versus Supply, and assess the best way forward in anticipation of the end of contract requirements.

InRoads benefits from having easy up to date access to maintenance activity and cost information, which improves the reporting process and the quality (and thus trust) placed on outputs. Asset managers can then focus on their decision making processes with greater confidence.

5.2 SPATIAL DATA

Viewing data spatially provides an opportunity to identify areas which may need maintenance intervention or have been absorbing significant maintenance effort. The map-based presentation is often helpful to indicate at a network level the asset maintenance trends and patterns to a wider audience when comparing options and strategies. An example of spatial data presentation is shown in Figure 4.

Figure 4 – Spatial display network condition for different maintenance funding levels



The map views show derived network condition in terms of pavement condition index (PCI) based on using dTIMS to analyse network data including maintenance costs to predict the long term network condition. This way of presenting data has real advantages for quickly identifying and querying areas where maintenance activity on a network is likely to be putting long term condition at risk. The presence of “hotspots” or patterns of maintenance activity is sometimes more easily identified using a spatial view. Linking extracted maintenance activity data to a GIS system enables this type of reporting to relatively easily display current and future work for analysis or public information. These types of tools are becoming increasingly accessible to maintenance management practitioners and are contained in some commercial off the shelf systems. Most RCA’s have their own information (GIS) systems which can display layers populated with any relevant extracted maintenance activity data.

5.3 CLUSTERING

Cluster analysis of data involves sorting data into groups (or clusters) so common factors can be identified. This applies statistical rigour to the pattern of occurrence being investigated to confirm it is beyond normal data variance, and the data is sufficient to support the observed pattern. In the context of roading asset management clustering techniques can be used to identify groups within treatment lengths, those which behave similarly e.g. groups with similar levels of high (or low) maintenance activity. Specialist software packages such as SPSS and SAS (statistical analysis software applications) have cluster detection capability but increasingly this functionality is being incorporated into GIS application layers and analytical statistical add-ins for spreadsheets. Cluster analysis has been widely used for accident analysis but applying these techniques across a wider range of roading asset management functions is possible.

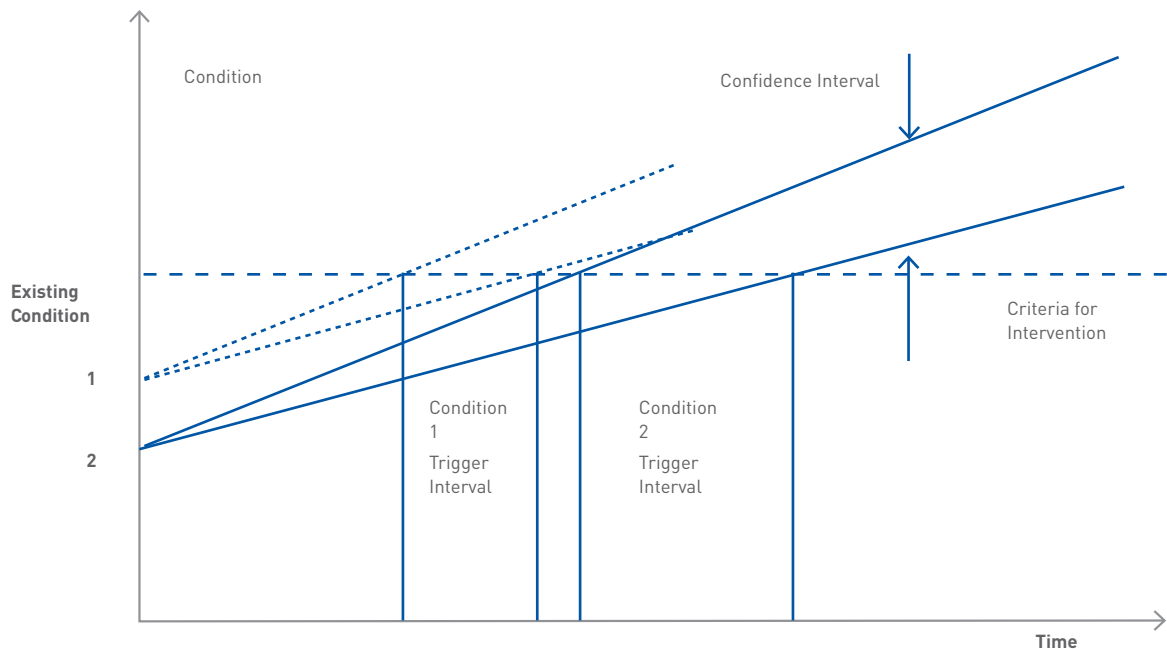
Both spatial data viewing and clustering are performing similar functions through different means. Knowledge of the maintenance contract environment and the network add considerable meaning to the application of these techniques. In the future spatial tools may aid the packaging of maintenance activity work.

5.4 PREDICTIVE MODELLING (dTIMS)

The desire to improve physical works maintenance management on the road asset and gain a better insight into its future maintenance needs is a universal goal for road managers. dTIMS predictive pavement modelling in the New Zealand roading context has developed significantly with support from NZTA and Ingenium/IDS. Reliable maintenance data is essential.

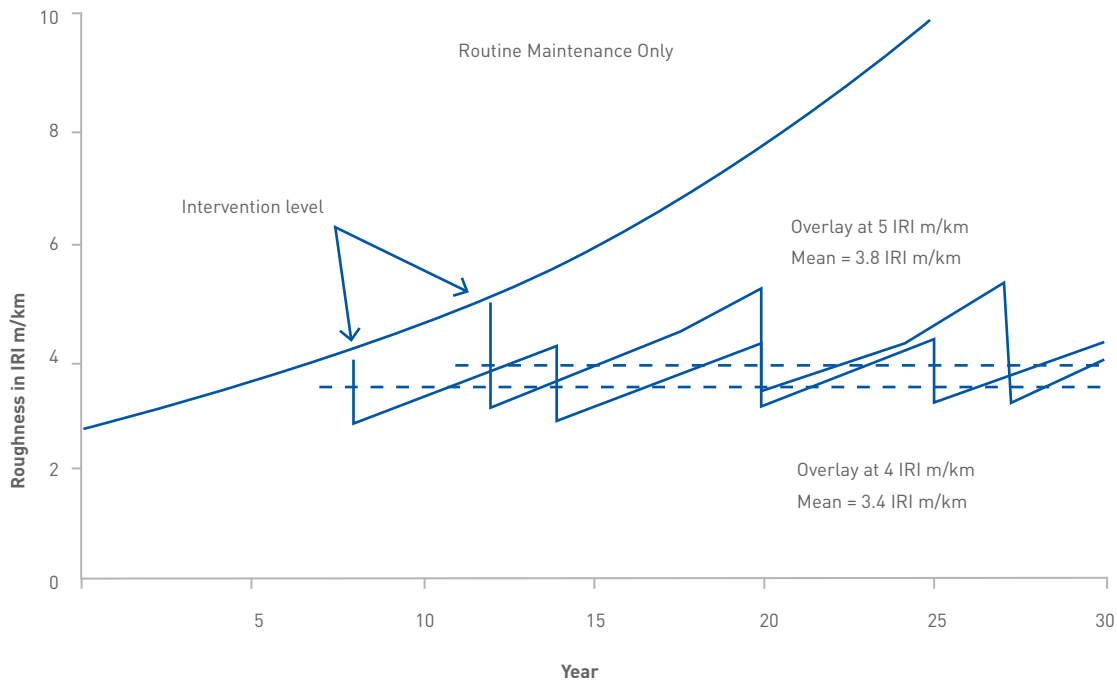
Routine maintenance costs are determined by calculating the cost of repairing various faults such as cracking and potholes, and adding an allowance for cyclic maintenance and additional maintenance costs. The basis of the calculation is determined by a particular treatment length's condition in a particular year according to the range of deterioration models. These models determine a benefit cost/NPV value for each possible scenario dTIMS generates. Trigger levels/ranges (Figure 5) are set based on the network's level of service limits and local conditions. An example of two intervention scenarios as they would affect IRI over time is shown in Figure 5.

Figure 5 – dTIMS model Condition Trigger Intervention



Routine maintenance activity and therefore costs increase over time. When the pavement deteriorates and it becomes necessary to rehabilitate the section, the rehabilitation is valued against the benefits generated. If an acceptably high benefit cost ratio (BCR) of the planned strategy is not obtained the net present value (NPV) of the costs is determined. When the NPV cost difference between the proposed maintenance treatment and the existing maintenance cost is positive, the action can be funded under the current funding policy. The NPV can only be positive for pavements that have deteriorated to such an extent that the routine maintenance option becomes more expensive than the treatment (analysed over the life cycle of the road). This can also be established by calculating the routine maintenance cost ratio to the strategy cost (e.g. 10%). The strategy cost is the total agency cost over the analysis period.

Figure 6 – Impact Intervention Level on IRI

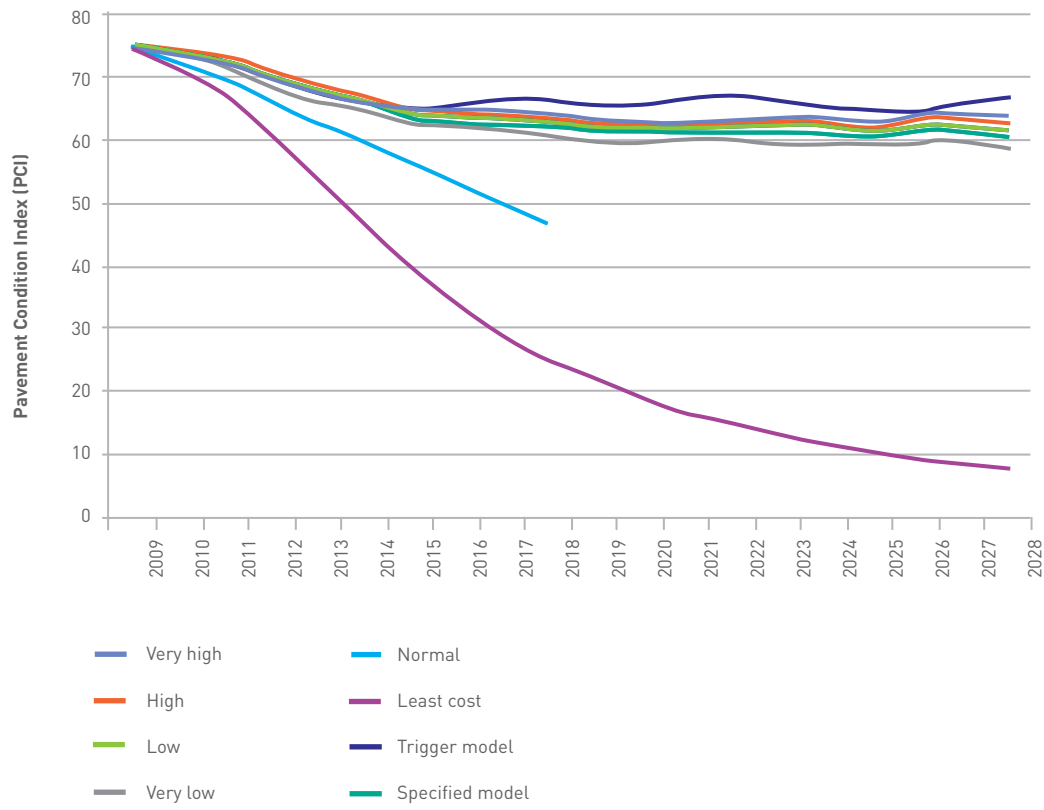


The dTIMS pavement deterioration modelling analysis results in range of possible maintenance activity scenarios that can be presented and compared with the specified FWP. Model scenario options are:

- The trigger model runs with no budget limitation. This is so the deterioration of assets exceeding trigger levels but which are not addressed in the forward work program (FWP) can be seen
- A maintenance only (least cost/do nothing) model
- The network performance prediction for the current FWP or specified model
- A range of budget constrained optimal models which attempt to optimise the network Pavement Condition Index (PCI). These can be used to show the impact of alternate funding scenarios

The models provide individual project level outcomes and an overall network condition outcome for each modelling run as shown in Figure 7. For PCI a higher value (100) is best with a range from 0 –100.

Figure 7 – dTIMS Network PCI Condition by Budget



The initial maintenance cost value is set based on the average of the last three years pavement and surfacing data or a default value is used if this information is not available. The maintenance cost index (MCI) is then applied to an expression to calculate an estimate of routine maintenance costs.

In summary, the New Zealand dTIMS process involves:

- Calculating the MCI which seeks to model pavement and surfacing maintenance costs to trigger rehabilitation works
- Calculating Routine Maintenance Costs based on the prediction of various faults and unit rates for repairs plus an additional amount for cyclic and additional maintenance. Planned costs can also be included if they are known.

5.5 MARKOV MATRIX

The Markov Matrix is an advanced statistical tool for measuring the outcome of current maintenance policies. It is a tabular expression of the probability of a change in input level occurring (and hence cost) with time based on the current level of input. From this an appreciation of risk with respect to all likely future conditions is also able to be determined. An example of a portion of a Markov Matrix developed for a state highway network is shown below (Figure 8). An advanced level of data analysis is required to develop a Markov Matrix for a network.

Figure 8 – Markov Matrix Example

range	0-\$1,000 /km	\$1,000 - \$5,000/km	\$5,000 - \$10,000/km	\$10,1000 - \$20,000/km
\$0-\$1,000/km	72.7%	35.1%	21.7%	20.4%
	76.0%	41.5%	14.7%	31.7%
	75.1%	47.7%	17.0%	28.4%
	61.9%	31.3%	20.6%	22.5%
	78.8%	49.8%	43.6%	64.6%
\$1,000 -\$5,000/km	17.0%	24.8%	40.3%	30.2%
	13.3%	25.6%	25.3%	16.8%
	18.2%	37.3%	26.1%	34.7%
	29.1%	42.6%	27.9%	41.9%
	16.1%	37.5%	32.5%	21.0%
\$5,000 - \$10,000/km	3.6%	19.8%	14.2%	27.0%
	5.0%	21.8%	34.4%	15.7%
	3.3%	6.9%	43.5%	23.0%
	4.8%	14.0%	6.1%	14.0%
	3.6%	7.1%	10.0%	6.8%
\$10,000 - \$20,000/km	4.3%	11.7%	10.0%	15.9%
	3.5%	8.8%	13.9%	18.1%
	2.4%	6.2%	9.2%	9.2%
	3.7%	9.5%	39.9%	7.1%
	3.6%	7.1%	10.0%	6.8%

From Figure 8, the percentage probabilities that a section of asset existing at a cost range of \$10,000 - \$20,000/km in 2010/11 will be:

- 31.7% for \$0 - \$1000/km in 2011/12
- 16.8% for \$1000 - \$5000/km in 2011/12
- 15.7% for \$5000 - \$10000/km in 2011/12
- 18.1% for \$10000 - \$20000/km in 2011/12.

If it is shown that an increasing percentage of the asset is moving from a high maintenance input state to a lower input state over time then that would be a positive outcome. Conversely, the reverse trend would indicate the need for change in maintenance practices.

6. Conclusion

RCA's in New Zealand have a wide range of pressures to do more with less, and reducing road maintenance costs is a potential means of achieving this. Maintenance activity managed in a well supported contract, with a clear maintenance activity cost data process, is a sound basis for undertaking analyses and making informed asset management decisions. Realistic quality assessments and the need for all parties to be aware of why robust maintenance records are necessary allows more detailed inference and innovation on asset strategies. Technology is positively influencing the way data is captured and stored, but it does not guarantee quality or good process. Before any analysis is attempted a good assessment of the data quality is required to ensure the data is reasonable enough to support the analysis.

The situation and skill set available to each RCA will be different. Information management skills can add additional analysis options which support better decision making on where maintenance activity should be focussed, or is where it is not being effective, or is not optimal for the funding available.

There is significant potential to utilise a robust maintenance activity cost history to improve and optimise future asset performance in a road network.

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8. References

These reference information sources support better road asset management generally. They include some Land Transport Policy documents applicable to New Zealand.

INTERNATIONAL INFRASTRUCTURE MANAGEMENT MANUAL – REVISED 2006

The 2006 edition includes the latest theory and best practice in asset management in an easy to follow and user-friendly format. It is well recognised by asset managers around the world as a definitive document for asset management theory. The manual starts with basic asset management principles and works through to practical steps for implementing advanced asset management systems within an organisation.

The 2006 manual contains sections outlining asset management practice in NZ, AUS, SA, UK, and US.

NAMS Group, PO Box 25415, Panama Street, Wellington, New Zealand

- » **Web Link:** www.nams.org.nz/pages/72/international-infrastructure-management-manual
Contents Index: www.nams.org.nz/assets/file/Manuals%20&%20Order%20Forms/IIMM%20Contents.pdf

INTERIM STATE HIGHWAY ASSET MANAGEMENT PLAN

This plan describes the services that our state highway system provides now, and in the future how we intend to manage the assets we use, and how we intend to fund the work that is needed.

Plan 2010/11 Version as at 24 June 2010

NZ Transport Agency Published July 2010

ISBN: 978-0-478-36438-5 (PDF) 978-0-478-36439-2 (print)

- » **Web Link:** www.nzta.govt.nz/resources/state-highway-asset-management-plan/docs/interim-state-highway-asset-mgmt-plan-2010.pdf

NZTA SMARTMOVEZ WEB SITE

This site has several data tools and statistical summaries which NZTA is making available from the range of data it collects.

- » **Web Link:** www.smartmovez.org.nz/data; www.nzta.govt.nz/resources/state-highway-database-operation-manual/docs/SM050-appendix-4.pdf; www.nzta.govt.nz/resources/state-highway-database-operation-manual/docs/SM050-appendix-4.pdf

GOVERNMENT POLICY STATEMENT ON LAND TRANSPORT FUNDING 2009/10 – 2018/19

MAY 2009 AMENDED NOVEMBER 2010

NZ Government

ISBN: 978-0-478-07231-0

- » **Web Link:** www.transport.govt.nz/ourwork/KeyStrategiesandPlans/Documents/Amended-GPS-November-2010.pdf

GUIDE ON TRANSPORT PLANNING AND FUNDING IN NEW ZEALAND – THE LAND TRANSPORT MANAGEMENT ACT 2003

December 2008, Local Government New Zealand

» **Web Link:** [www.lgnz.co.nz/library/files/store_021/ KnowHowguideontransportplanningandfundinginNZ.pdf](http://www.lgnz.co.nz/library/files/store_021/KnowHowguideontransportplanningandfundinginNZ.pdf)

AUSTROADS GUIDE TO ASSET MANAGEMENT PART 4: PROGRAM DEVELOPMENT AND IMPLEMENTATION

Summary

The aim of this Guide is to give practitioners guidance for decision making with respect to good practice asset management at a network level for programme development and implementation. Programme development involves identifying asset requirements, setting appropriate levels of service. For maintenance intervention in developing a maintenance works programme, the development of a total needs programme and its evaluation, selection of maintenance treatment and capital works options and the process of prioritisation and optimisation of the programmed works to ensure best value for money. Programme implementation covers developing appropriate delivery arrangements of the works programme and includes public reporting and information dissemination about the programme and the media used achieve this.

Keywords

Asset management, Road network, Level of service, Monitoring, Investment, Road funding, Project Management, Maintenance costs, Decision process

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Austroads Project No. AP1176

Austroads Publication No. AGAM04/09

AUSTROADS GUIDE TO ASSET MANAGEMENT PART 7: ROAD-RELATED ASSETS PERFORMANCE

Summary

Austroads has undertaken to produce a comprehensive library of guides which cover the design, construction, maintenance, and operation of the road network for use by road authorities in Australia and New Zealand. They represent an agreed approach to the work road authorities undertake in relation to the road network. The aim of Part 7 of the Guide to Asset Management is to provide guidance on the application of asset management concepts and principles for the management of a broad range of diverse road related assets. The strategy framework is applicable to all road system assets. Guidance on managing the specific performance characteristics of pavements and structures is provided in Parts 5 and 6 respectively of the Austroads Guide to Asset Management.

Keywords

Asset management, roadside management, road-related assets, infrastructure, level of service, risk management, roadside assets, signs and delineation, street lighting, electronic traffic management assets, barriers

First Published March 2009

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Austroads Project No. AP1395

Austroads Publication No. AGAM07/09

NZTA PLANNING, PROGRAMMING AND FUNDING MANUAL

Published: 25 Aug 2008

This manual sets out the NZTA's policies, procedures and guidance for the planning and management of land transport activities that can be funded from the national land transport fund. This manual will guide the 2009/10 – 2011/12 regional land transport programmes (RLTPs) and the National Land Transport Programme (NLTP) – the first three-year transport programmes. It sets out policy and procedures for developing and managing the RLTPs and NLTP during those cycles. The manual was also used to manage the 2008/09 NLTP. The procedures described in this manual have been developed to assist approved organisations to prepare and plan projects and activities for which they seek funding from the NZTA, within the framework of the NZTA's overall funding allocation process. The manual is also available in PDF, either as the whole document or in parts. The PDF version is the master document.

Publication details

Author: NZ Transport Agency

Published: 25 Aug 2008

» **Web Link:** www.nzta.govt.nz/resources/planning-programme-funding-manual/ppfm-pdf.html

» **Also known as:** PP&F manual

APPENDIX 1

EXAMPLE: HAWKE'S BAY/GISBORNE REGION

The Hawke's Bay and Gisborne regions have relatively long and reliable historical maintenance quantity and cost records. A revised maintenance costs procedure made use of these records to predict future maintenance costs for sites being considered for rehabilitation. The Gisborne network had a new maintenance contract with substantially increased unit rates for pavement repairs so the value of this means of predicting costs was limited for this area of the network. As the costs for repairs are factored by a unit rate, a revised approach was developed to predict future maintenance quantities from which costs can be derived, given a higher unit rate for the maintenance activity.

METHODOLOGY

When considering the economics of various maintenance treatment options for a particular site the ability to forecast maintenance costs is a useful tool. Besides providing the means to forecast maintenance costs based on historical data, the methodology also allows for an assessment of immediate pavement needs to be added into the equation where there is an immediate need for repairs.

Data is sourced from maintenance cost information and transferred to a data extract spreadsheet based on the location of the site being considered, and activity costs grouped into pavement, surface and shoulder categories.

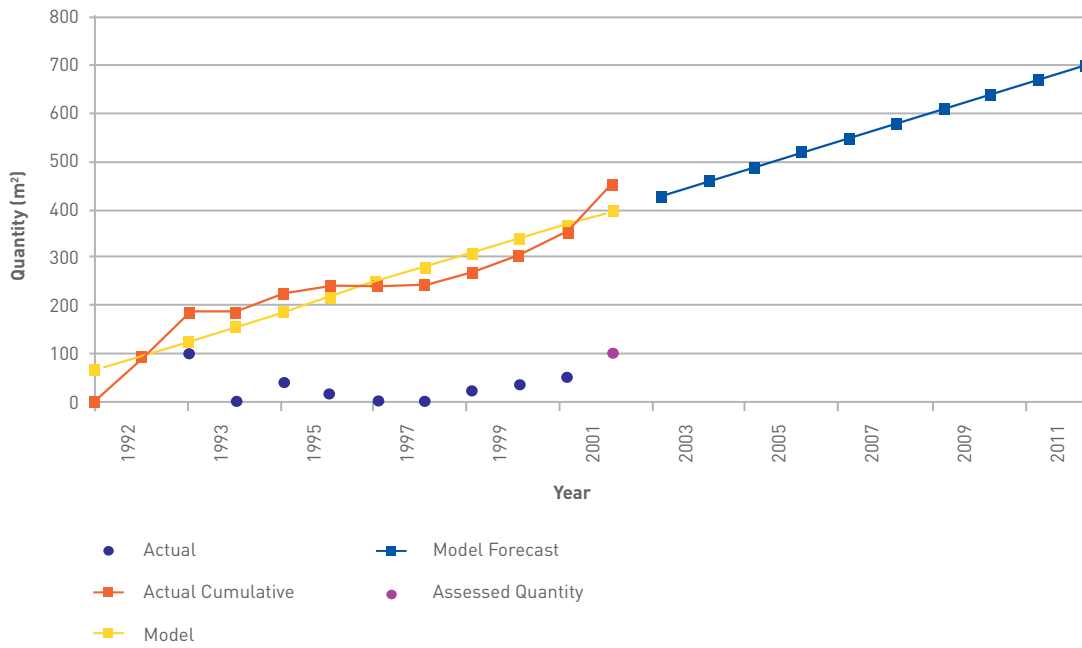
HISTORIC UNIT RATES

It is important to independently verify the historic unit rates calculated for each of the pavement, surfacing, and shoulder maintenance costs for the site. This can then be used to identify anomalies in the maintenance record and provide the means to compare historic unit rates with current and future contract rates for key maintenance activities. Care needs to be taken to ensure that rates and quantities are reasonable at all times.

QUANTITY ANALYSIS

Analysis of maintenance quantities for each year is undertaken as a baseline. Against this the multi-year trends of maintenance quantity is compared. Analysis iterations suggest a linear trend best reflected historic maintenance costs (Figure 9). Based on this a linear regression model was used to assess the significance of historic rate of change of quantities and forecast future maintenance quantities.

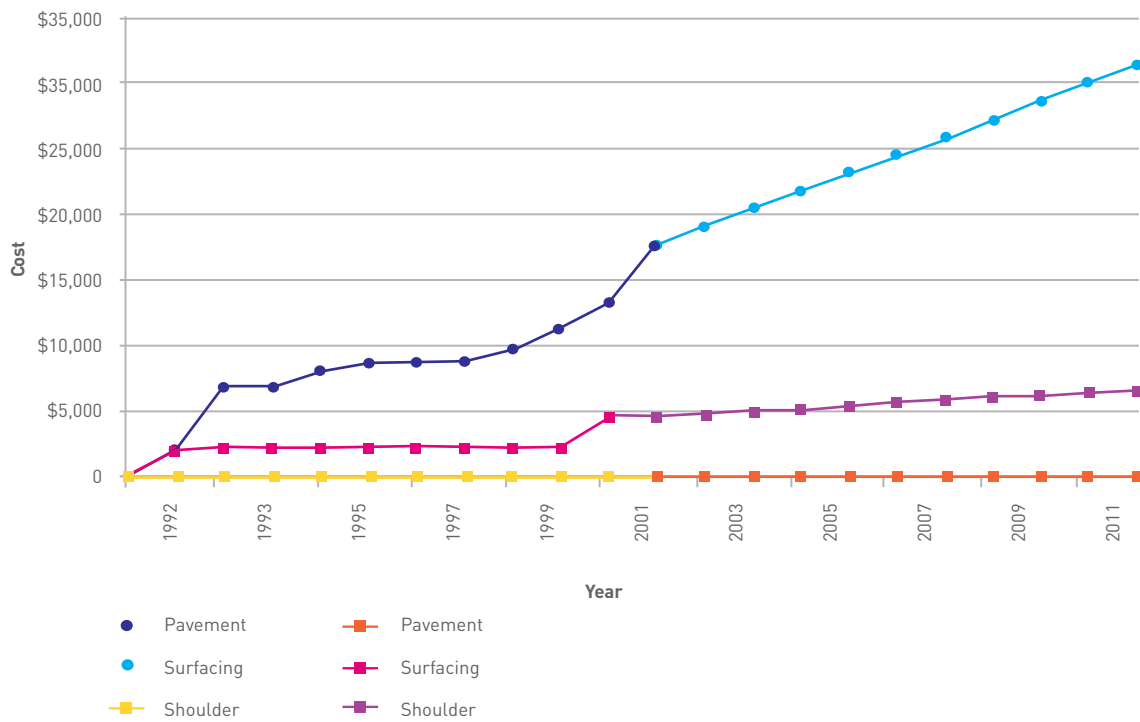
FIGURE 9 – Example Pavement Quantities Forecast



COST ANALYSIS

A cost analysis worksheet combines the historic costs with the forecast costs to check the sensibility of the outcome. An adjustment is made to the forecast maintenance cost to ensure the forecast start values passes through the last actual maintenance costs value for each cost group.

FIGURE 10 – Example Pavement Cumulative Cost

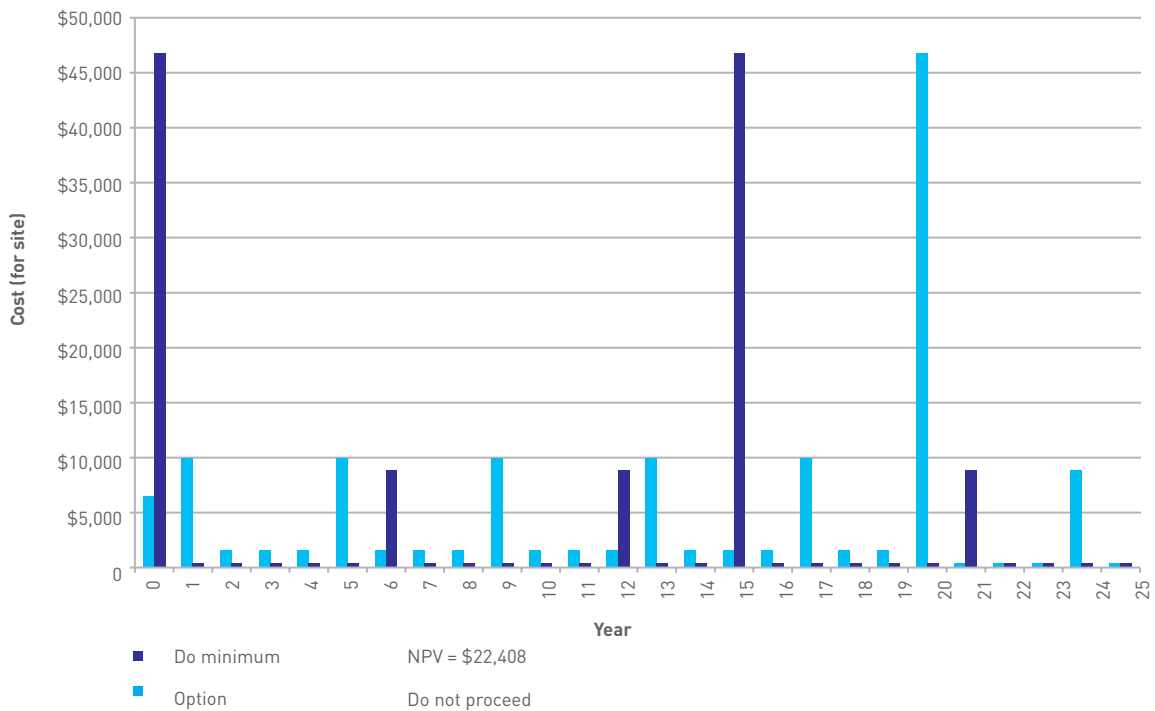


LIFE CYCLE ANALYSIS

The forecast maintenance costs and quantities are used to support a Net Present Value (NPV) type analysis spreadsheet based on a “do minimum” and up to two maintenance treatment options. Values could be transferred to a BCR analysis as needed. One-off maintenance costs identified from field inspection in the current year can be included in the life cycle analysis.

All costs are for the project site, not per kilometre; therefore a site length is required. This allows projects to be evaluated based on a forecast of future maintenance costs using historical maintenance cost records and suitable unit rates.

FIGURE 11 – Example Life Cycle Costs



ALTERNATIVE METHODOLOGIES

Although the proposed methodology is essentially pragmatic, it may not work for every circumstance, so each site should be considered on a case-by-case basis.

Care should be taken at all stages to consider if the data is appropriate, particularly that no unrealistic data has crept into the maintenance costs.

APPENDIX 2

EXAMPLE: INROADS/WESTERN BAY OF PLENTY: CONSUMING SEAL RESIDUAL LIFE ASSESSMENT

This material is adapted from an extract from a 2009 review paper about the InRoads/Western Bay of Plenty District Council Performance Based Contract (PBC-01) where maintenance data is used to analyse seal residual life.

CONTEXT: A SIGNIFICANT CONCERN OF THE RCA REGARDING PBC'S IS THAT THEY CONSUME THE SEAL'S RESIDUAL LIFE AND LEAVE ASSET OWNERS WITH A LIABILITY.

Resealing and pavement reconstruction budgets invariably comprise the largest value in any long term maintenance and construction contract. Failure to manage them well leads to significant negative downstream effects, so they must be well controlled and well defined in the contract. After eight years, the review authors asked "where the contract was placed in relation to the Residual Life Key Performance Measures (KPMs), would those managing the PBC change them, and if so, why?"

INTRODUCTION

Residual seal life is a crucial aspect of a PBC. Conventional methods of measuring can be counterproductive. The danger in any PBC is that contractual KPMs like residual seal life can drive adverse practice that was never intended or foreseen at the time of document preparation. The residual seal life KPM set at the time of PBC-01 tender was not designed to be optimal; it simply matched the apparent seal life available at handover. No attempted modelling of an optimal regime was undertaken at that time. This is why within the district there are seals that have exceeded the expected design life and yet remain completely waterproof and are exhibiting no signs of ageing (stripping, scabbing, or oxidation). The requirement to seal these roads, simply to meet a contractual KPM is both costly and counter-productive.

BEST FOR NETWORK PHILOSOPHY

As the Western Bay of Plenty's moisture sensitive pavements and subgrades mainly consist of volcanic ash, their optimal long term performance is directly proportional to having a waterproof seal at the surface, so once the seal malfunctions, then more expensive pavement repairs or even reconstruction becomes necessary within a short time. Conventional maintenance practice on these roads, therefore, is to ensure the surface is fit for purpose and functioning well.

There is a generally held view that risk to a network is reduced if it is resealed as soon as possible rather than deferring the work and risking expensive pavement repairs. Most RCA's seal when the theoretical design life has expired as a standard.

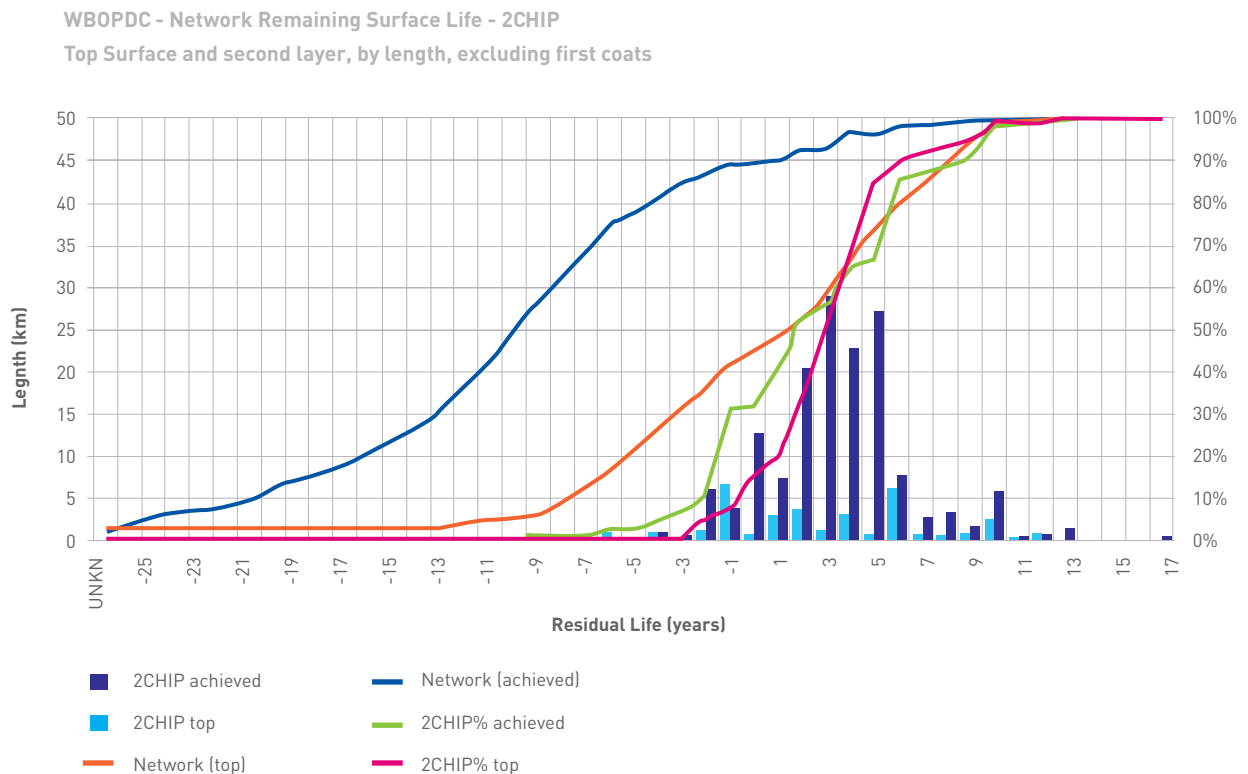
In PBC-01 a different approach has been taken in that as reseals are part of the contract lump sum with no underpinned quantities, they need to be justified and verified as necessary to meet a contractual KPM. This has resulted in the maintenance intervention strategy being carefully managed to extract the maximum life out of each seal.

The entire network is inspected each year by a senior project team to determine the optimal timing for the next reseal, with the support of full maintenance data summaries of all work undertaken and its known history. Where seals are beyond their expected default life, they

get termed as “vulnerable seals” and are included in a special monthly report of the faults found from each one to six weekly programming/fault inspection. This ensures that at the first sign of deterioration (e.g. scabbing, cracking, chip loss, surface failure) decisions about whether to advance a reseal and minimise the risk of expensive pavement repairs can be made. This maintenance model allows the InRoads team to respond almost immediately to rectify any unforeseen problems. During the course of the project, this experience has also made it possible for them to comfortably push some seals well beyond their theoretical default lives, until the first signs of distress in the seal. This needs to be well managed, with regular detailed targeted inspections of “vulnerable seals”. This process results in a “best for network” sealing regime where the seal’s actual field performance is assessed in terms of the available maintenance and condition data to produce a projected reseal programme for the next year (Figure 12) utilising the maximum available surface life. The key to this is regular field observation and timely summarisation of maintenance activity data being available to network asset managers in the field

Despite the success this methodology has on optimising seal life, there is not sufficient understanding of how far each “vulnerable” seal can be pushed more than a year beyond their expected life. A potential “bow wave” of increased reseal length into future years appears when compared to traditional years’ resealing which needs to be understood and managed effectively. The risk and maintenance data based evaluation process allows exceptions to be managed effectively.

Figure 12 – WBOPDC Network Remaining Surface Life - 2 Chip



The PBC-01 team has also found that unstable seal layers are the leading cause of reconstruction required towards the end of a pavement’s life cycle (in the multi layered seals). By avoiding resealing too soon, it is possible to defer the onset of pavement reconstruction.

