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THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Life cycle cost analysis to identify the need for drainage renewal in maintenance of road asset: Case Studies from a New Zealand road network

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AASHTO THE VOICE OF TRANSPORTATION
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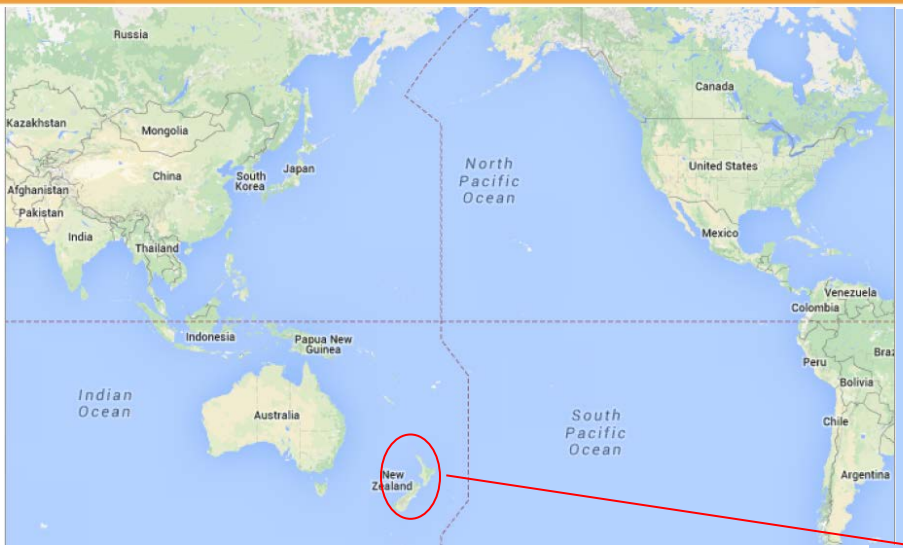
The world I come from

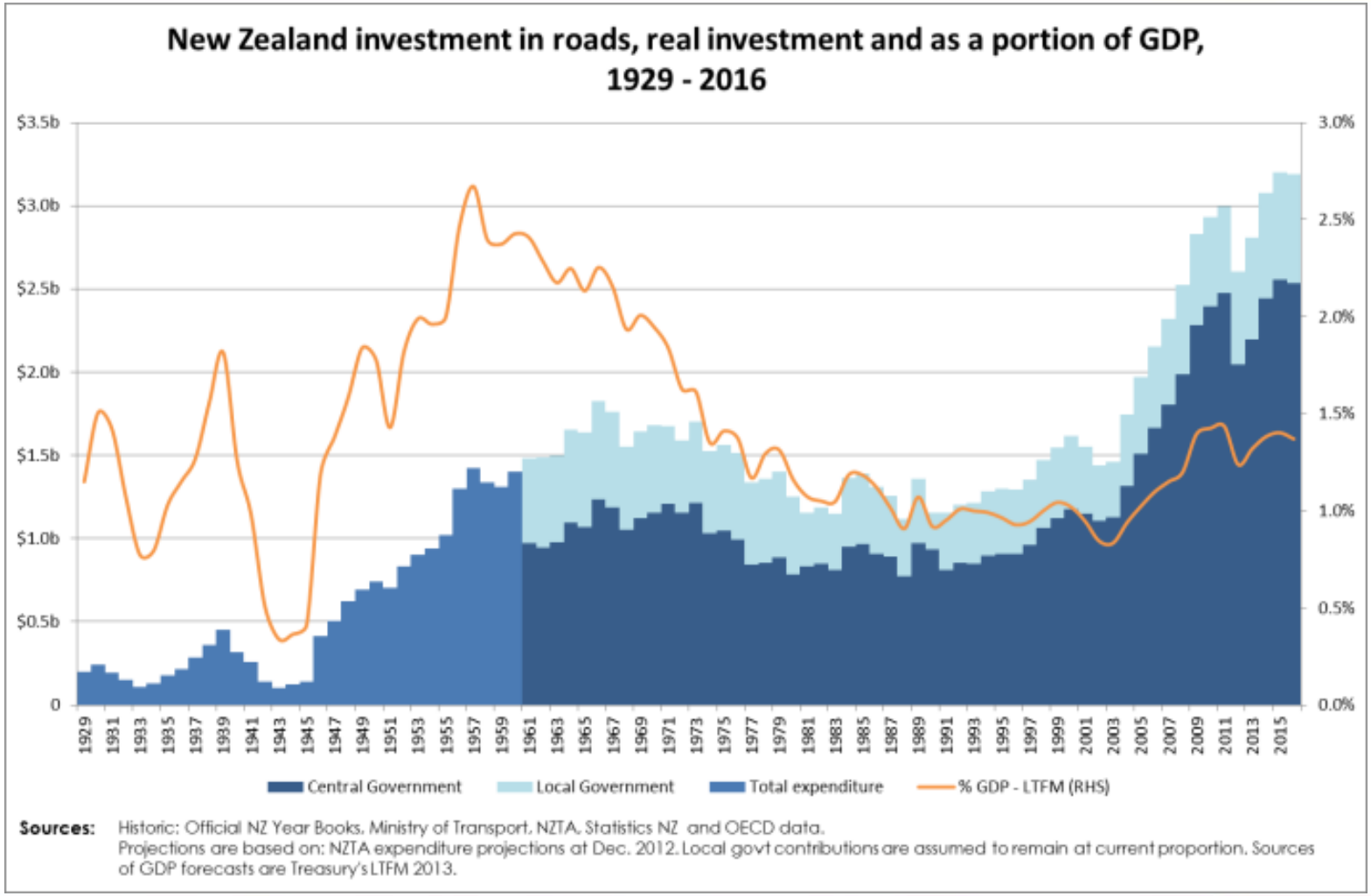
Background



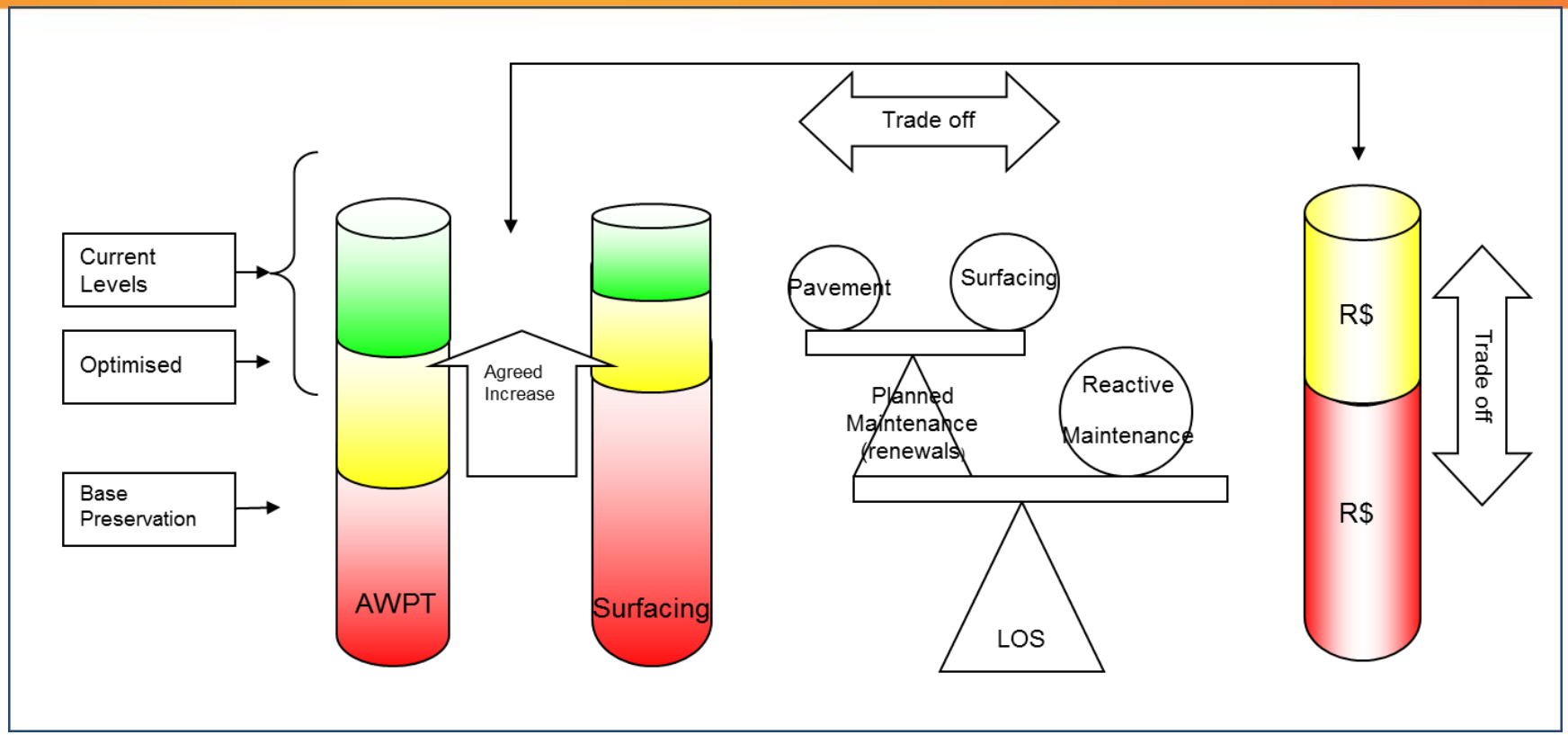
Road Length

- Total length 94,244km
- Sealed length 62,843km
- Rural length 74,688km
- $ Road Fund
  - State Highways 100%
  - Local roads 40-60%

Time for Change

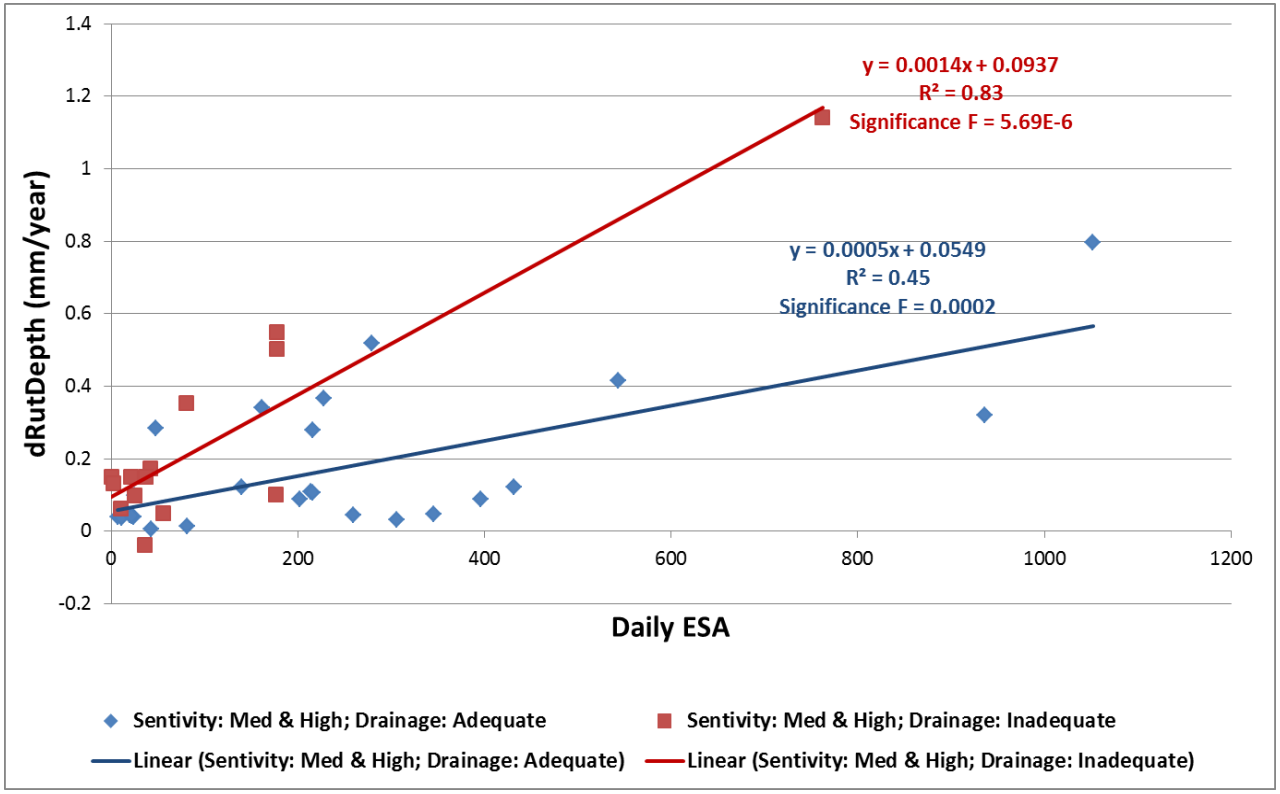


Network Outcome Contract Format



Paramount to show the LCC return from drainage improvements

Drainage Improvements Enhances Road Performance

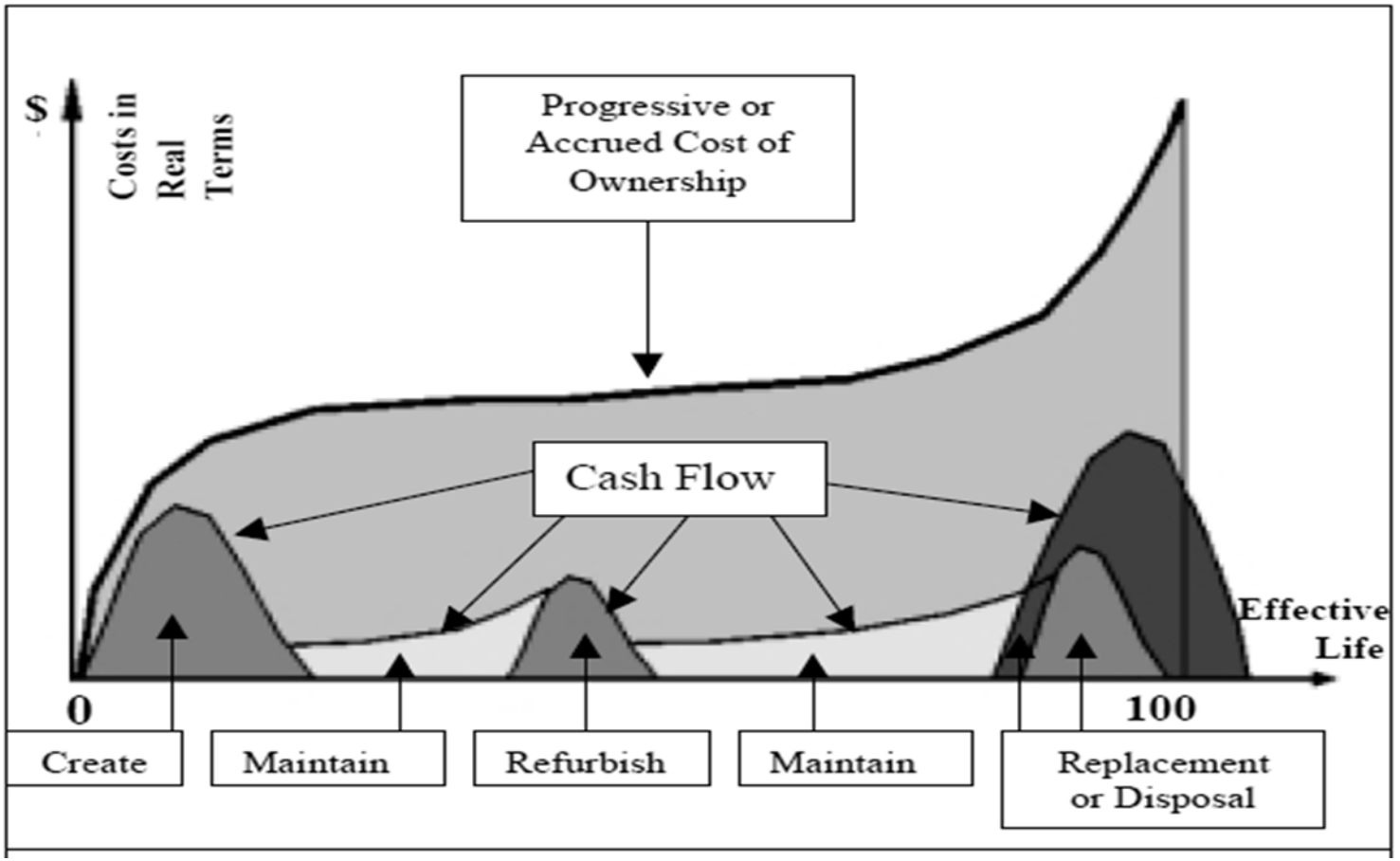


Quantifying the return on the investment

Objective of the Study

- The study aims to identify the rationale for investment in drainage improvement;
- Development of the maintenance cost model;
- Application of LCCA based on the maintenance cost model

Life Cycle Cost Analysis (Concept)



Application of LCCA (Tools)

Net Present Value (NPV)

- Difference between the discounted present value of the costs for two different treatment options of pavement or drainage renewal

  NPV= (PV Cost A- PV Cost B)

  Here PV= Discounted present value of costs or investment

  t = Total time period or life cycle (30 year)

  r = Discount rate (6%)

- NPV has to positive of any treatment to be acceptable

Application of LCCA (Tools)

Economic Indicator (EI)

- The EI can be defined as the ratio of the 30 year whole of life cost savings or comparative advantages achieved for a treatment or renewal work over the cost difference over a shorter period (usually the contract period) of selecting the option.

$$\text{Economic Indicator (EI)} = \frac{PV\ year\ 0-30\ Option\ B - PV\ year\ 0-30\ Option\ A}{PV\ year\ 0-x\ Option\ A - PV\ year\ 0-x\ Option\ B}$$

- Here x=7 years based on a surface life
- Option B is usually the Do Minimum option and Option A is the Do Something or Full Renewal
- The EI of any treatment need to be greater that 0.8 and less than 2.0 to be feasible (SM 018)

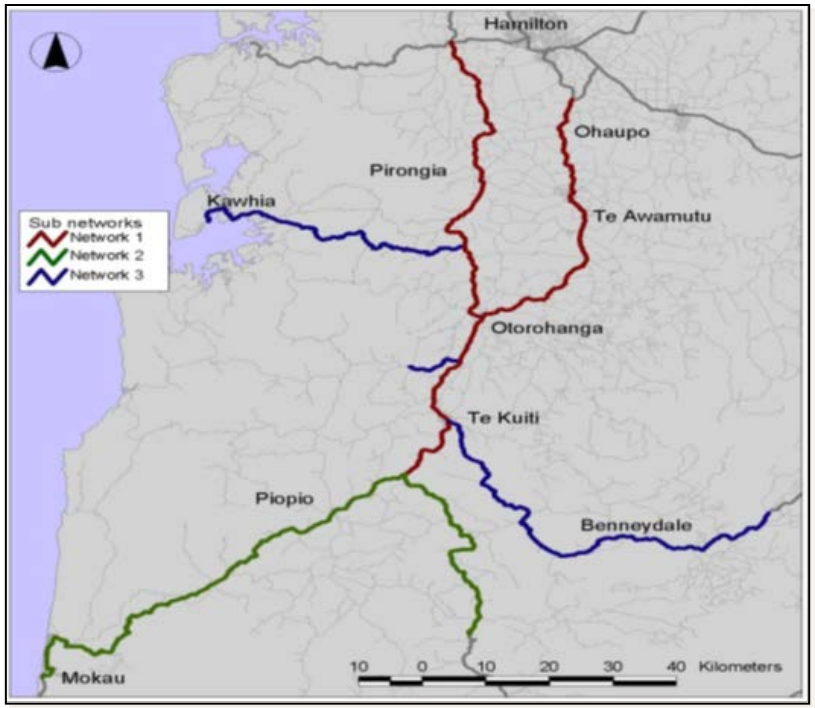
Methodology

- Economic assessment based on the methodology sated by New Zealand Transport Agency (NZTA)
- The maintenance cost models were developed based on the historical expenditures obtained from the Road Assessment and Maintenance Management (RAMM) database
- Cost models were used to predict the future maintenance cost during the LCCA (NPV and EI)
- Have used drainage improvements that coincided with renewal works

Road Network Under Study

Sub-network	Road class	Rural (Km)	Urban (Km)	Total (Km)
1	Regional Strategic Highway (RSH)	125.73	20.61	146.34
2	Regional Connector	56.80	4.23	61.03
3	Regional Distributor	136.31	2.36	138.6
Total		318.84	27.20	346.04

- Road network under Performance Specified Contract since 1999
- Converted to a Network Outcome Contract (NoC) on December 2014
- AADT is in the range of 500 to 10000
- Average precipitation (800-1600 mm) is 1250 mm
- The geography varies from rolling ground to windy Gorge with large tributaries along the road pavement



Prioritization of Drainage Sites

Priority (1: High to 5 Low)	Symptoms of the Sites Selected for Drainage Renewal
1	Visible surface water near the edge of seal and null or non-functional drainage measures;
2	Outside wheel track shows premature failures in the form of rutting or shear. Side drains are not adequate (less than 400 mm deep and 2.0 m offset from the edge of the seal);
3	Programmed for resurfacing due to asset preservation level (Extended flushing or threshold texture);
4	Any changes in land use causing frequent inundation or saturation of ground on the side road; and,
5	Inadequate side drains (less than 400 mm deep and 2.0 m offset from the edge of the seal) though not showing any symptoms of premature failure.

criteria is set by NZTA to ranks the drainage renewal works for prioritization

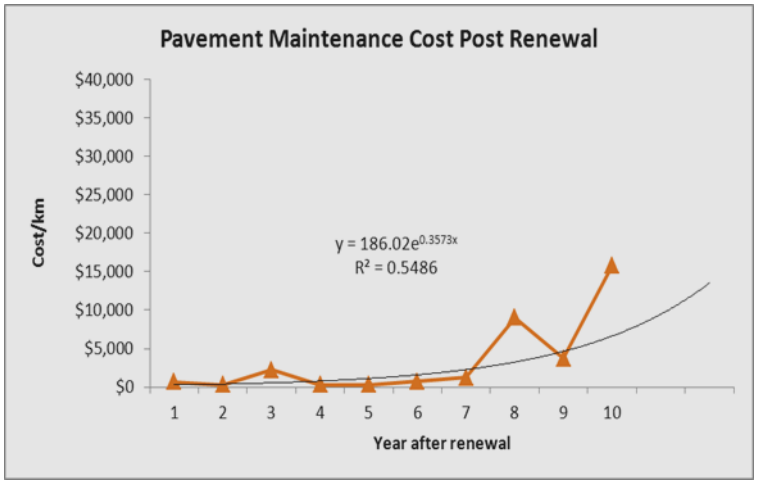
Drivers of Drainage Renewal

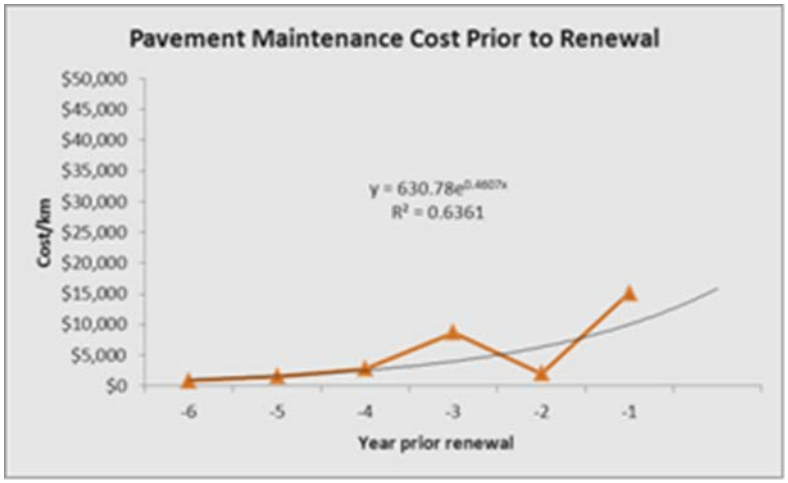
- Prevent moisture captured in road shoulders and road profile;
- Remove stagnant moisture on the surface, near the edge of the seal;
- Increase the life cycle of the road pavements through improvement of sub-surface drainage;
- Reduce the risk of premature failure through the shear and permanent deformation due to moisture in the pavement formation;
- Prevent the pumping and blistering effects in the surface layer especially at cut or box cut sections by lowering the ground water table; and,
- Improve the efficiency of existing drainage measures through installation and replacement of existing kerb and channel, sub-soil drains and manholes.

Maintenance Cost Model (Surface Failure)

Mode of Failure: Flushing, bleeding, loss of skid resistance

1.	Pavement related costs prior to renewal	$y = 630.78\ e^{0.4607\ x}$
2.	Pavement maintenance cost after renewal	$y = 186.02\ e^{0.\ 3573x}$
3.	Surface maintenance cost prior to renewal	y = 3461.3x-5334.6
4.	Surface related costs after renewal	y = 142.56x- 291.85
5.	Shoulder maintenance cost prior to renewal	y = 223.62x - 541.23
6.	Shoulder maintenance costs after renewal	y = 147.25x - 290.12

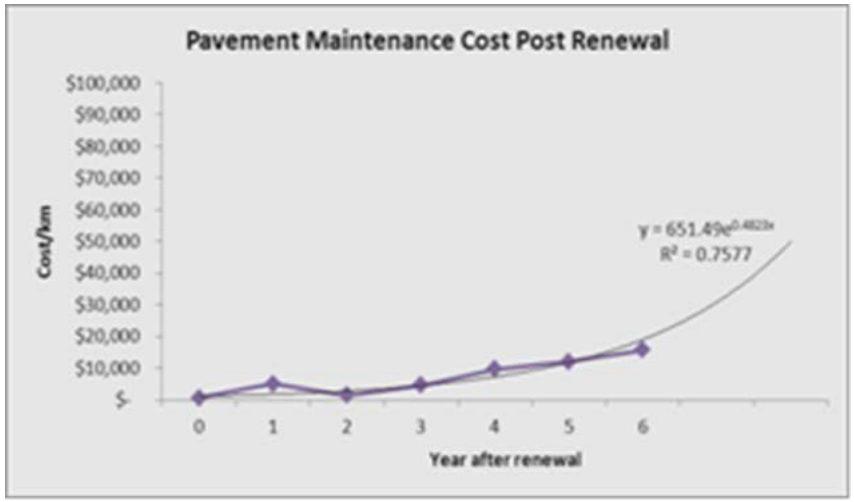


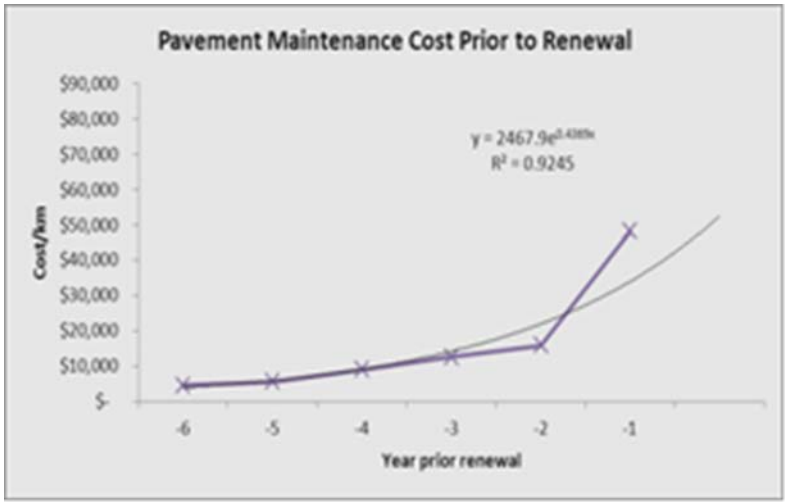


Maintenance Cost Model (Pavement Failure)

Mode of Failure: Rutting, shear and cracking

1.	Pavement maintenance cost before renewal	$y = 2467.9\ e^{0.4369x}$
2.	Pavement maintenance cost after renewal	$y = 651.49\ e^{0.4823x}$
3.	Surface maintenance cost before renewal	y = 142.56x - 291.85
4.	Surface maintenance cost after renewal	y = 353.14x - 769.39
5.	Shoulder cost before renewal	y = 147.25x - 290.12
6.	Shoulder related costs after renewal	y = 223.62x - 541.2





Output of the Economic Assessment

Site Name	Drainage Renewal Cost	Do Minimum (Discounted Total Cost in NZD) 30 Year	Drainage Renewal (Discounted Total Cost NZD) 30 Year	NPV (NZD)	EI	Comments
(A)	74000.00	493,154.00	475,728.00	17,426.00	0.12	NPV +ve, but EI<0.8*
(B)	82460.00	315,626.00	274,106.00	41,520.00	0.18	NPV +ve, but EI<0.8*
(C)	30900.00	164,953.00	152,339.00	12614.00	0.22	NPV +ve, but EI<0.8*
(D)	48100.00	547,102.00	490,573.00	56,529.00	0.26	NPV +ve, but EI<0.8*
(E)	29780.00	173,766.00	163,649.00	10,117.00	0.11	NPV +ve, but EI<0.8*
(F)	56950.00	239,443.00	201,650.00	37,793.00	0.85	NPV and EI both acceptable based on criteria set by NZTA

Concluding Remarks

- Indicates a positive gain in economic efficiency from the investment in drainage;
- Demonstrates the utilization of LCCA tools such as NPV and EI to rationalize the targeted drainage investment;
- NPV values in the case studies are positive reflecting an economic gain from the drainage renewal works;
- The low EI values are mostly due to the shorter 7 year analysis period and a major investment in the first year compared to the regular maintenance works in Do Minimum;
- However, positive EI values indicates an economic efficiency within the contract period (7 years);
- Long term performance monitoring of the road section can help in validating the economic assessment method

Acknowledgement

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