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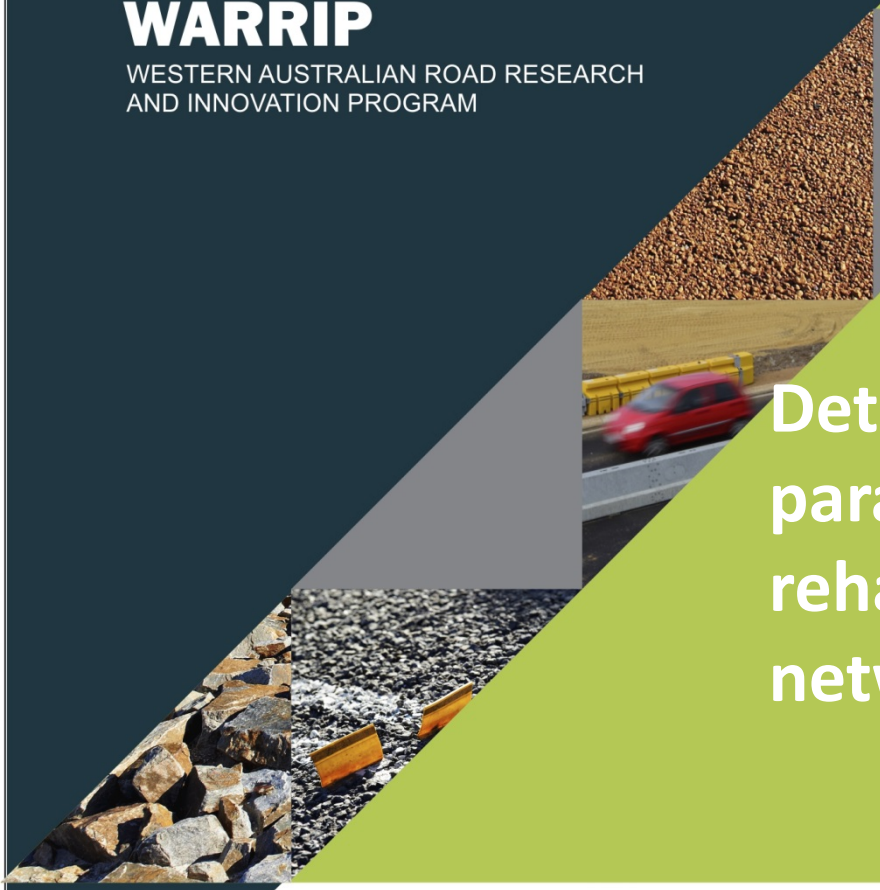
WESTERN AUSTRALIAN ROAD RESEARCH AND INNOVATION PROGRAM



Determination of pavement distress parameters for identifying potential rehabilitation sites in MRWA's road network

AN INITIATIVE BY:

THE GOVERNMENT OF WESTERN AUSTRALIA

mainroads WESTERN AUSTRALIA

arrb

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Suzie Chan

Webinar Moderator

- Senior Professional, Outreach & Events, Communications, ARRB
- P: +61 3 9881 1590
- E: training@arrb.com.au

Housekeeping

- Webinar is 60 mins
- inc. question time of 10 mins

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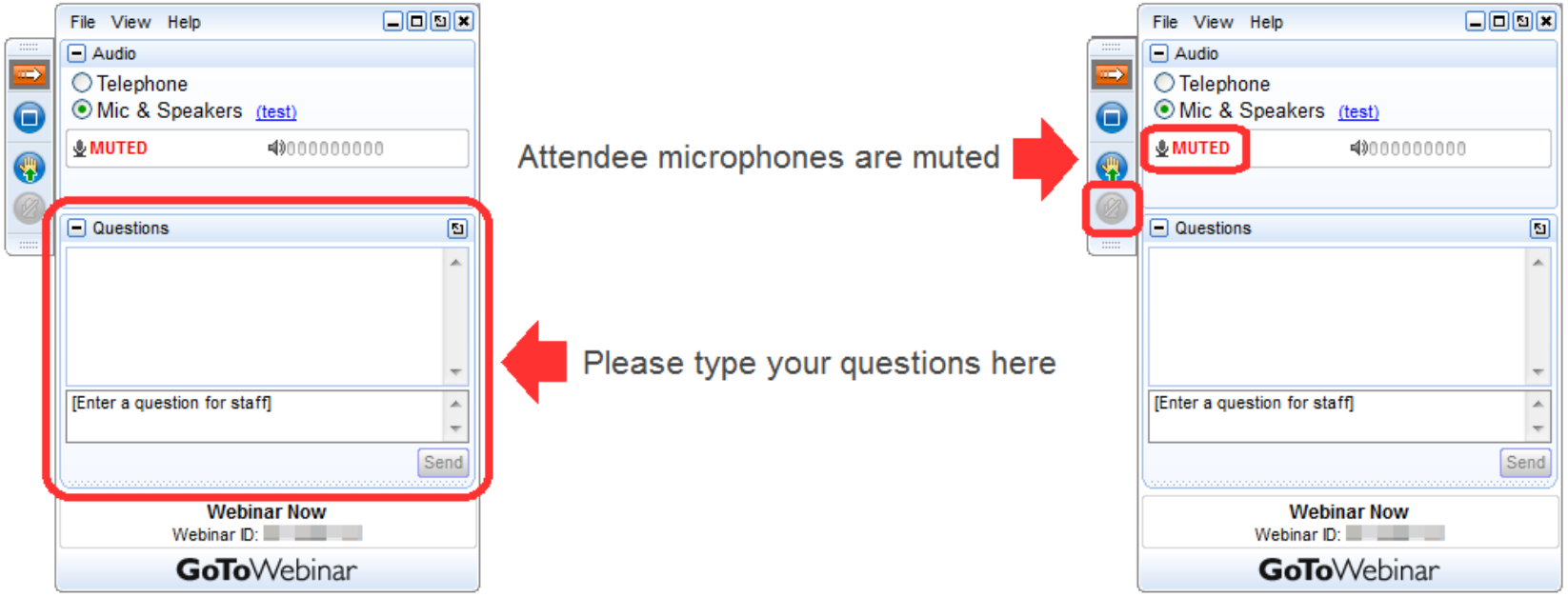
GoTo Webinar Functions



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Presenters

Dr. Tim Martin
National Discipline Leader –
Performance Modelling
Road Asset Performance, ARRB

Ranita Sen
Senior Technology Leader
Road Asset Performance, ARRB

Qindong Li
Asset Management Modelling & Analytics Manager
Asset Management
Main Roads WA

Webinar Outline

MRWA Maintenance challenges

- Largest geographically spread road jurisdiction in the world
  - Covering 2.5 million square kilometres
  - 19,000 km state network
  - Pavement & surfacing assets valued over $10 billion
- Limited fund vs increased community expectation
- More government scrutiny on funding need
- An aging work force

Solution: Work Smarter with Data

Objectives

Undertake a parametric analysis to determine the predominant structural distress modes to target MRWA rehabilitation work

Scope:

- Use 800 km list of verified MRWA rehabilitation sites
- Combine condition data and variables, including defects and maintenance costs
- Separate the sites into subnetworks (regions) in addition to full network
- Determine distress modes and other independent variables that identify rehabilitation

Analysis Methodology

Selection of rehabilitation samples

Selection of non-rehabilitation samples

Multivariate logistic regression analysis

Identification of significant predictors

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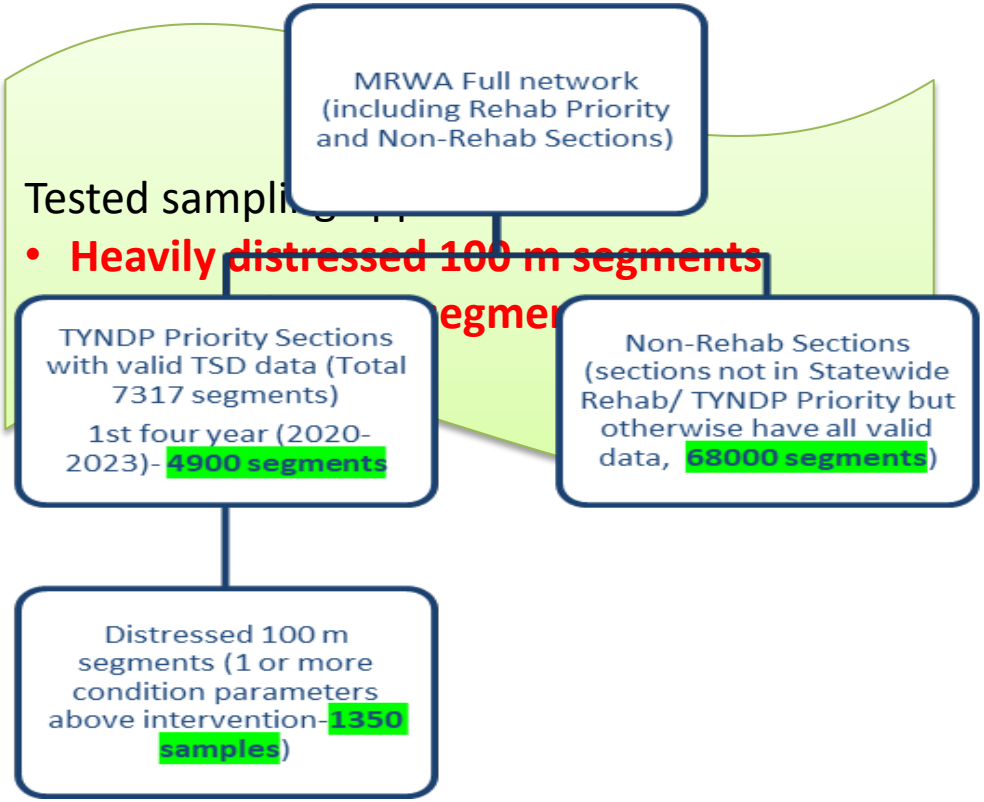
Rehabilitation sample selection

Selection of distressed segments

- Sections in the 1st four year of rehab program selected on condition
- Not all 100 m segments within a rehab section will be in bad condition
- Long rehab lengths because of
  - condition, efficiency, funding availability

Pin-pointed localised distressed 100 m sections using criteria:

- Maximum IRI > 4.1
- Maximum rut depth >15 mm
- Maximum D_0 > 800
- Maximum curvature > 300



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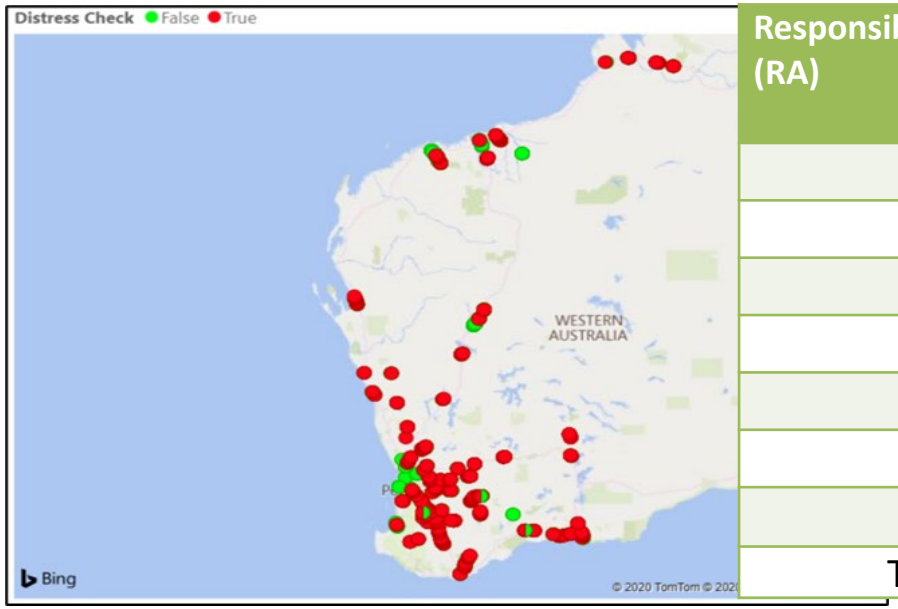
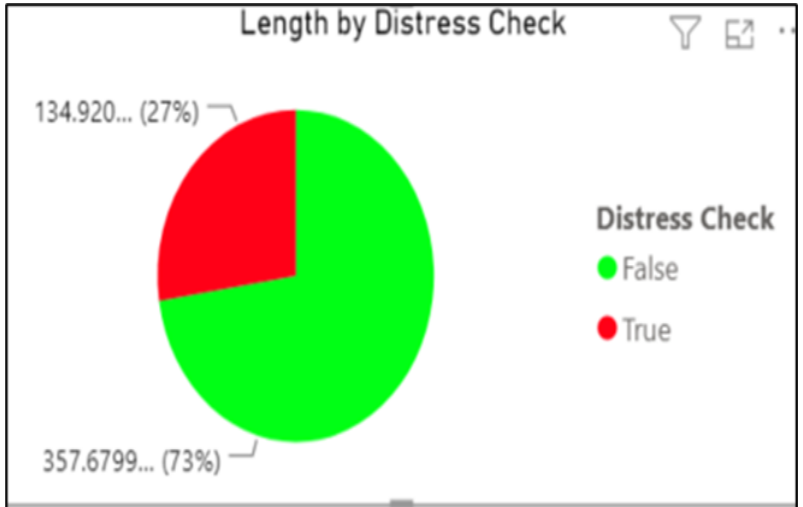
Rehabilitation sample selection: distressed 100 m segments



Responsibility Area (RA)	Region Name	No of rehabilitation sample
1	Great Southern	144
2	South West	36
5	Goldfields Esperance	147
6	Kimberley	77
8	Wheatbelt	667
11	Pilbara	131
14	Mid-West Gascoyne	149
Total		1351



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Rehabilitation sample selection

Distressed 100 m segments within a candidate rehabilitation section

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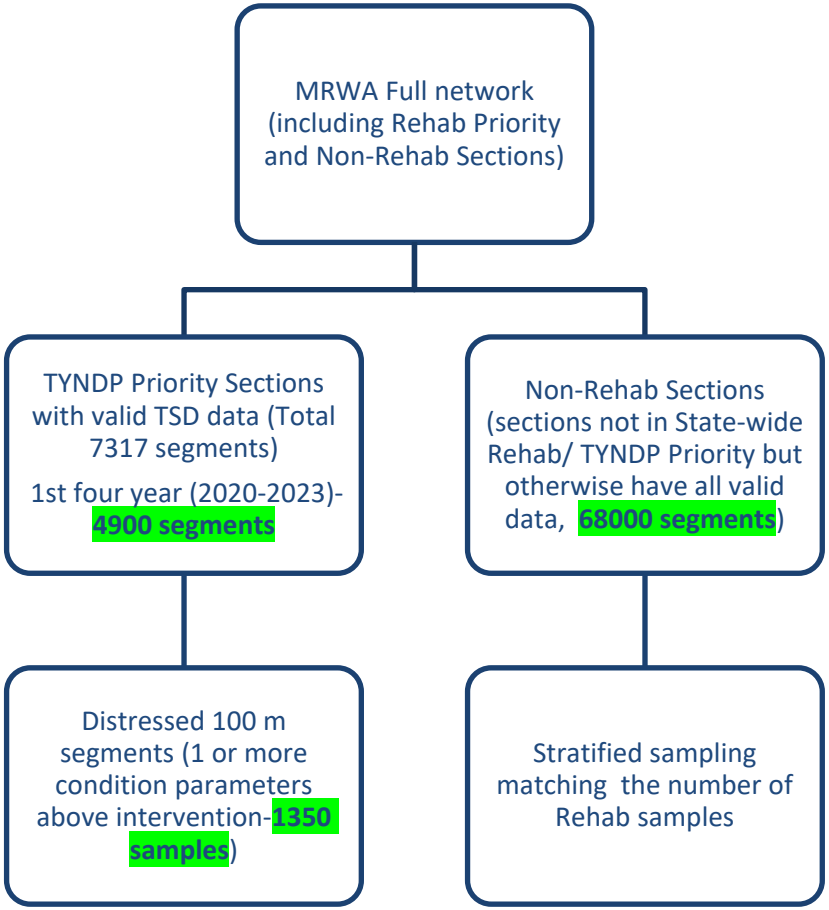
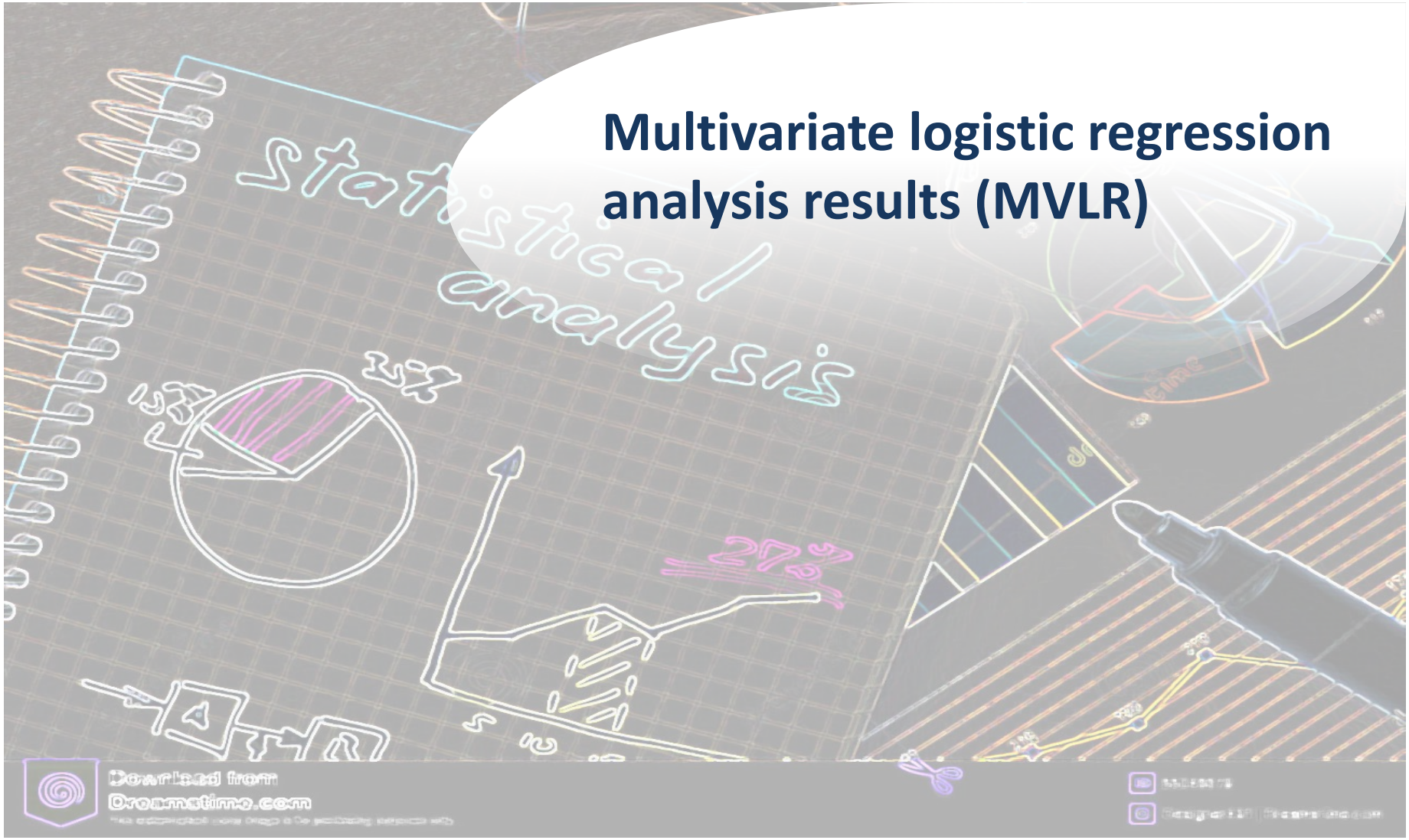
Non-rehabilitation sample selection

Selection of non-rehabilitation samples



Responsibility area (RA)	Total non-rehab 100 m segments	No of samples
1	6846	143
2	7123	36
5	5216	150
6	5292	77
8	10968	646
11	12879	132
14	18495	150

Multivariate logistic regression analysis results (MVLR)



MVLR: assumptions & outputs

*Statistical technique **predicted relationship between** predictors and predicted variable where the dependent variable is **binary** (e.g. rehabilitated / not rehabilitated)*

Assumptions

- adequate sample size
- absence of multicollinearity

Outputs

- statistical **significance** of the model
- percentage correct prediction by the model
- significant predictors ($p < 0.05$) of the regression coefficients for the independent variables
- R square values (e.g. Nagelkarke R square)

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Analysis results: whole network

Combinations	Max IRI	Max Rut	Max D0	Max curvature	Avg IRI	Avg Rut	Avg D0	MMIS_Cost	AADT	Pct HV	Model pred	Nagelkerke R squa	Significant parameters
Comb 1	√										58.10%	0.05	IRI
Comb 2		√									74.90%	0.348	Rut
Comb 3			√								66.00%	0.158	Do
Comb 4	√	√									75.70%	0.37	IRI, Rut
Comb 5	√	√	√								79.60%	0.468	IRI, Rut, D0
Comb 6	√	√	√					√			80.20%	0.491	IRI, Rut, D0, MMIS_Cost
Comb 7	√	√	√	√				√			79.70%	0.493	IRI, Rut, D0, MMIS_Cost, Curvature
Comb 8					√	√	√				74.50%	0.353	IRI, Rut, D0
Comb 9					√	√	√	√			74.60%	0.382	IRI, Rut, D0, MMIS_Cost
Comb 10	√	√	√					√	√	√	80.10%	0.495	Rgh Rut, D0, MMIS_Cost, AADT, Pct HV
Comb 11	√	√	√							√	79.60%	0.471	Rgh Rut, D0, Pct HV

Model selection basis:

- all independent variables in the model must be statistically significant ($p < 0.05$) with regression coefficients of sufficient magnitude
- independent variables must not have a negative regression coefficient

Analysis results: whole network

Combination 11

Classification Table[a]

	Observed		Predicted: Rehab_Need 0	Predicted: Rehab_Need 1	Percentage Correct
Step 1	Rehab_Need	0	1042	293	78.1
		1	256	1095	81.1
	Overall Percentage				79.6

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Max Roughness	.307	.050	37.101	1	.000	1.359
	Max Rut	.238	.011	480.212	1	.000	1.268
	Max D0	.003	.000	229.703	1	.000	1.003
	Perc_Heavy	.012	.004	9.090	1	.003	1.012
	Constant	-6.085	.291	437.557	1	.000	.002

a. Variable(s) entered on step 1: Max Roughness, Max Rut, Max D0, Perc_Heavy.

Identification of rehabilitation sites

= 0.307*Max IRI + 0.238*Max Rut + 0.003*Max D0 + 0.012*Pct HV – 6.085

Threshold value= 1.481

Analysis results- region specific

Network/ region	Region Name	Equation to identify rehabilitation candidates	Threshold values for rehab. sites
RA1	Great Southern	0.342*Max IRI + 0.004*Max D0 + 0.173*Max Rut – 5.993	1.238
RA2	South West	0.356*Max Rut – 4.617	0.723
RA5	Goldfields Esperance	0.236*Max Rut – 3.334	0.206
RA6	Kimberley	0.350*Max Rut + 0.517*Pct HV$^{(3)}$ – 15.805	1.336
RA8	Wheatbelt	0.487*Max IRI + 0.002*Max D0 + 0.255*Max Rut – 6.243	1.227
RA11	Pilbara	0.008*Max D0 + 0.436*Max Rut + 0.040*Pct HV$^{(4)}$ – 11.670	3.694
RA14	Mid-West Gascoyne	0.010*Max D0 + 0.350*Max Rut – 10.968	2.282

Findings from the analysis

Significant predictors of rehab selection:

- Max rut depth (100 m segment)
- Max roughness (100 m segment)
- Max deflection Do (100 m segments)
- Some regional affects (not always)
- Percent HV

Factors with no significant affect on rehab selection

- MMIS defects
- Curvature (D0-D200)
- Pavement age
- Rainfall
- Surface age

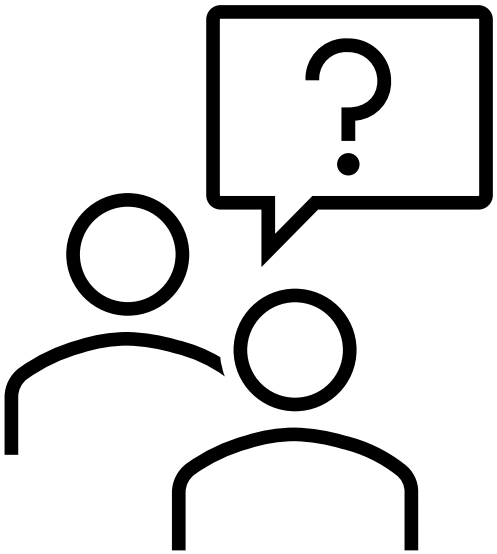
Implementation and benefits to MRWA

- Formulas validated in the field and very positive feedback was received
- Power BI App and ArcGIS online maps developed to assist regional adoption
- Used in supporting planning & delivery of rehabilitation works

Opportunities for further development

- Further refinement of equations allows differentiation between sites requiring rehab. for functional or structural reasons through extended MVLR analysis using
  - (slope velocity) & indirect outputs (D_0, D_{200}) from the TSD,
  - improved time-series MMIS data, treatment scope
  - available pavement materials and construction data
- Develop methodology classifying rutting type
- Development of WA based rut deterioration models

Questions?



Thank you

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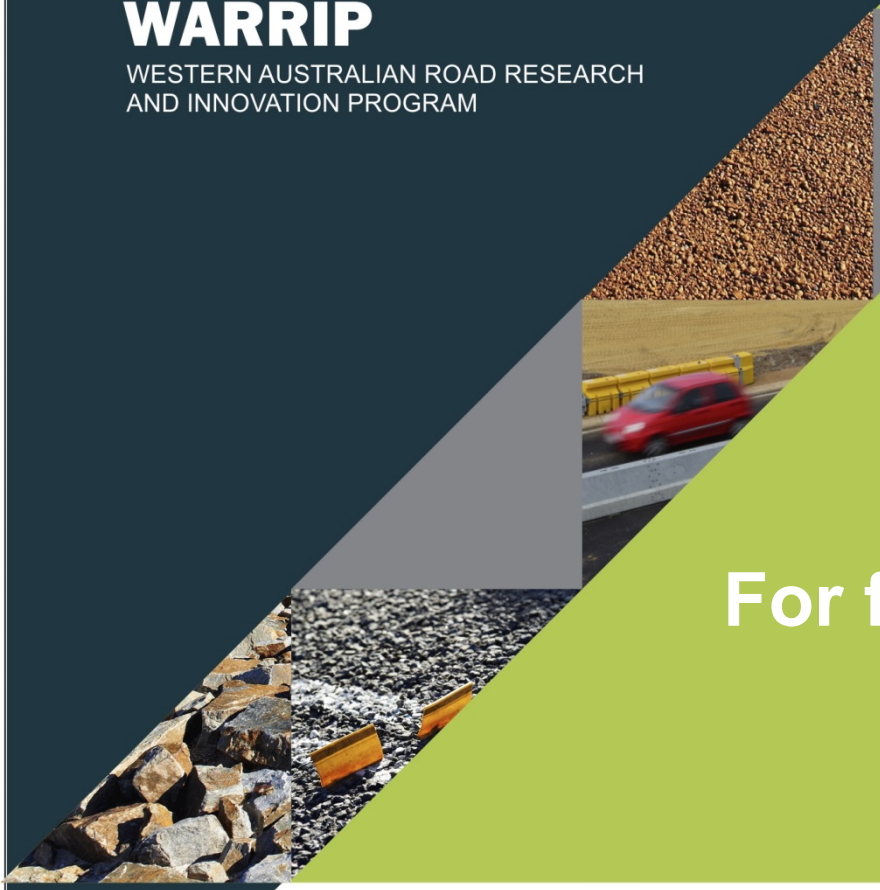

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