UK ROADS LIAISON GROUP

CASE STUDIES FOR THE HMEP LIFECYCLE PLANNING TOOLKITS

OCTOBER 2019

SCOPE

This document has been commissioned by the UK Roads Liaison Group Asset Management Board, with support from Transport for London and the Department for Transport and supports the use of the HMEP Lifecycle Planning Toolkits.

The Case Studies have been developed by Atkins with feedback incorporated from the UKRLG AM Board. The data is kindly provided by 2 Rural Highway Authorities.

This document intends to showcase the need to use the HMEP LCP Toolkits and to provide examples that the HMEP LCP Toolkits can support Highway Authorities by modelling their needs. For the data analysis, reasonable assumptions have been made when required.

ACKNOWLEDGEMENTS

Special thanks to 2 volunteers who kindly provided data and facilitated this endeavour.

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COMMENTS & FEEDBACK

The UK Roads Liaison Group would welcome any comments and feedback on these Case Studies for the Lifecycle Planning Toolkits, so that it may be reviewed, improved and refined to give the sector the best support possible. To do so, please email ukrlg@ciht.org.uk with the header, “Feedback on the Case Studies for the Lifecycle Planning Toolkits”.

1. WHY THE LIFECYCLE PLANNING TOOLKIT IS NEEDED

Good lifecycle planning supports strategic level planning and better decision making for future highway investment decisions. By considering an asset over a whole life cycle, it is possible to decide the optimum point of intervention with the optimum treatment.

Planning and estimating expenditure requirements alongside long-term asset performance is essential to improve the management of roads and services. These estimates can be used to determine the likely performance of the asset so that future budget can be prioritised accordingly.

The HMEP Lifecycle Planning Toolkit is:

- A strategic tool that can select the preferred maintenance solution and timing for intervention to suit the whole life cost of the asset;
- A network tool to enable Local Highway Authorities to make decisions regarding the timing of future maintenance decisions and their likely impact; and
- A costing tool to aid the selection of maintenance treatment options at a local level.

The HMEP Lifecycle Planning Toolkit and its deterioration models work as a package to enable local highway authorities to make strategic level planning decisions by helping to:

- Assess the impact that different levels of funding can make on future asset performance and asset maintenance requirements;
- Investigate the current and future levels of funding required to achieve more defined levels of service and condition; and
- Identify the levels of funding required to minimise whole life costs, helping to preserve assets in the most efficient way.

2. CARRIAGEWAYS

2.1 SCENARIO FOR CARRIAGEWAYS

The purpose of this case study is to show how Highway Authorities can use the HMEP LCP Carriageway Toolkit to support them in more proactively implementing preventative treatment strategies against severe winters, justifying different approaches to winter maintenance.

A Highway Authority would like to use the tool to model the effect that a severe winter has on the Authority's assets. The toolkit will be used to help the user answer the following question:

What is the effect of changing the treatment strategy on the asset's condition if a severe winter occurs?

The following 2 scenarios will be modelled to conduct this assessment:

Scenario 1: Severe winters occur every 3 years and "business as usual" treatment strategy is implemented; and

Scenario 2: Severe winters occurs every 3 years and "preventative" treatment strategy is implemented.

2.2 INPUTS AND ASSUMPTIONS

<u>The Authority has the following input data:</u>

- Homogeneous Asset Groups; Classified roads (A, B and C roads) and Unclassified roads.
- Condition Bands; Green, Amber and Red.
- The length for each Asset Group which is depicted in the following table:

Table 1: Length for each Asset Group

Asset Type	Length (km)
Classified Roads (A, B and C Roads)	4777
Unclassified Roads	4017
TOTAL	**8794**

- The Authority has condition data as shown in the table below. For the unclassified roads, only the % of the asset in red is known (currently 12.3%), as amber and green are not recorded in the surveys. Therefore, an assumption is made that the green and amber percentages for unclassified roads are in a similar proportion to those of the classified roads.

Table 2: Condition data for Classified roads in %

Year	Classified Roads Red	Classified Roads Amber	Classified Roads Green
2018/19	3.5	22.5	74

Table 3: Condition data for Unclassified roads in %

Year	U Road Red (measured)	U Road Amber (assumed)	U Road Green (assumed)
2018/19	12.3	22.5	66.2

- For the “business as usual treatments strategy” the deterioration profile used, was created using locally collected survey data. For the “preventative treatment strategy”, the deterioration profile used incorporates the effect of a severe winter (see assumptions section below).
- The budget for the carriageways for 2018/2019 is £35,850,508, but it should be noted that this changes every year. For the analysis, a budget constraint of £35.85m is used for all years, as changes to budget will not be modelled in this scenario.

Reasonable assumptions:

- Analysis period of 10 years and start year is 2018
- Width assumed is 3m.
- Lane length is assumed to be twice the actual length for rural UK authorities. The length of the network is therefore input into the toolkit as 2x the quantities in
- Table 1: Length for each Asset Group. The Authority has 7 Treatment Types in their maintenance contract with unit costs for materials and labour only. The actual treatment cost will include other items such as traffic management, materials disposal etc, hence an assumption is made to uplift the contract costs by 30% (using engineering judgement);

Table 4: Treatment types and unit costs for carriageways

Treatment	Unit	Materials and labour only cost (£)	Overall Cost (£) – for input to the toolkit
6mm Surface Dressing	m2	2.23	2.9
10mm Surface Dressing	m2	2.6	3.38
Resurfacing – 10mm CGSC	m2	8.6	11.18
Resurfacing – Hot Rolled Asphalt	m2	13.1	17.03
In - situ Recycling	m2	15.87	20.63

Reconstruction 40mm/60mm	m2	24.15	31.4
Reconstruction 40mm/100mm	m2	31.4	40.82

- A severe winter is assumed to cause 10% more deterioration to greens, 15% more deterioration to ambers and 20% more to reds. This is a very simplistic assumption; however, it is based on the understanding of the assets' deterioration and on engineering judgement.

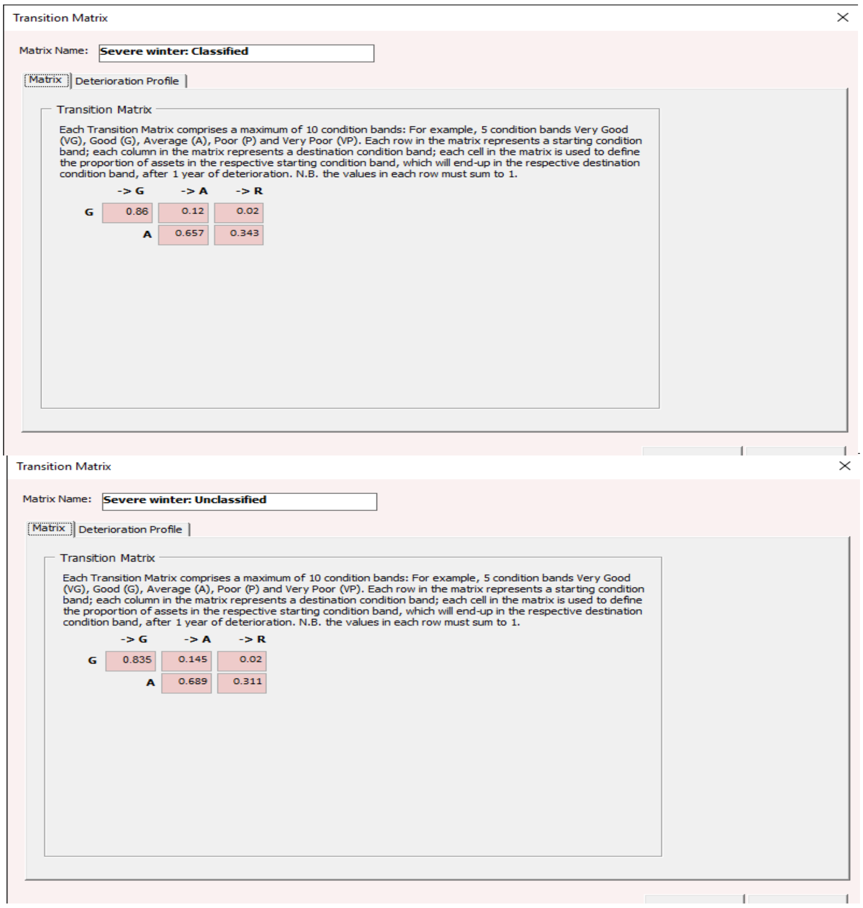

Figure 1: Severe winter deterioration matrices

- Two treatment strategies will be modelled: one for "Business as usual" and one for "Preventative Treatment Strategy".
    - Business as usual: the Authority's asset management strategy says that they will aim to reconstruct their reds until the budget is exhausted. If there is remaining budget, the authority will aim to surface dress the ambers. The treatment strategy has 2 steps when entered in the toolkit: Reconstruction 40mm/60mm on reds with 100% treated and 6mm Surface Dressing on amber with 100% treated.
    - Preventative treatment strategy: this strategy involves sealing the top layers of the pavement to prevent water ingress and protect the lower layers during a severe winter. Therefore, the aim will be to surface dress 90% of the ambers and use the remaining budget for reconstruction on reds. The treatment strategy has 2 steps

when entered in the toolkit: 6mm Surface Dressing on amber with 90% treated; and Reconstruction 40mm/60mm on red with 100% treated. The scenario tabs for Scenarios 1 and 2 are depicted below.

SCENARIOS

Run Analysis ... | Clear selected row(s) | Copy selected cell(s) | Paste copied cell(s)

				1	2	3	4	5	6	7	8	9	10
No.	Homogeneous Group	Scenario Name	Criteria	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
1	Classified Roads (A,B and C)	Scenario 1	Transition matrix	Baseline Det for Classified	Baseline Det for Classified	Severe winter: Classified	Baseline Det for Classified	Baseline Det for Classified	Severe winter: Classified	Baseline Det for Classified	Baseline Det for Classified	Severe winter: Classified	Baseline Det for Classified
			Treatment strategy	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual
			Budget constraint	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall
			Performance target										
2	Unclassified Roads	Scenario 2	Transition matrix	Basline Det for Unclassified	Basline Det for Unclassified	Severe winter: Unclassified	Basline Det for Unclassified	Basline Det for Unclassified	Severe winter: Unclassified	Basline Det for Unclassified	Basline Det for Unclassified	Severe winter: Unclassified	Basline Det for Unclassified
			Treatment strategy	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual	Business as Usual
			Budget constraint	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall
			Performance target										

Figure 2: Scenario tab for Scenario 1

SCENARIOS

Run Analysis ... | Clear selected row(s) | Copy selected cell(s) | Paste copied cell(s)

				1	2	3	4	5	6	7	8	9	10
No.	Homogeneous Group	Scenario Name	Criteria	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
1	Classified Roads (A,B and C)	Scenario 1	Transition matrix	Baseline Det for Classified	Baseline Det for Classified	Severe winter: Classified	Baseline Det for Classified	Baseline Det for Classified	Severe winter: Classified	Baseline Det for Classified	Baseline Det for Classified	Severe winter: Classified	Baseline Det for Classified
			Treatment strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy
			Budget constraint	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall
			Performance target										
2	Unclassified Roads	Scenario 2	Transition matrix	Basline Det for Unclassified	Basline Det for Unclassified	Severe winter: Unclassified	Basline Det for Unclassified	Basline Det for Unclassified	Severe winter: Unclassified	Basline Det for Unclassified	Basline Det for Unclassified	Severe winter: Unclassified	Basline Det for Unclassified
			Treatment strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy	Preventative Treatment Strategy
			Budget constraint	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall	Overall
			Performance target										

Figure 3: Scenario tab for Scenario 2

2.3 OUTPUTS

The outputs are tabulated and graphically presented below.

Table 5: Outputs from HMEP Tool for carriageways

Asset Group	Condition Band	Initial Distribution	2018 - Business as Usual	2018 – Preventative Treatment Strategy	2027 Severe Winter, Business as usual (Scenario 1)	2027 Severe Winter, Preventative Treatment Strategy (Scenario 2)
Classified Roads	G	74.00%	69.72%	90.60%	46.81%	98.92%
Classified Roads	A	22.50%	24.50%	2.45%	20.70%	1.08%
Classified Roads	R	3.50%	5.79%	6.95%	32.50%	0.00%
Unclassified Road	G	66.20%	63.26%	62.23%	25.43%	66.77%
Unclassified Road	A	21.50%	20.96%	20.96%	14.07%	0.55%
Unclassified Road	R	12.30%	15.78%	16.82%	60.50%	32.68%

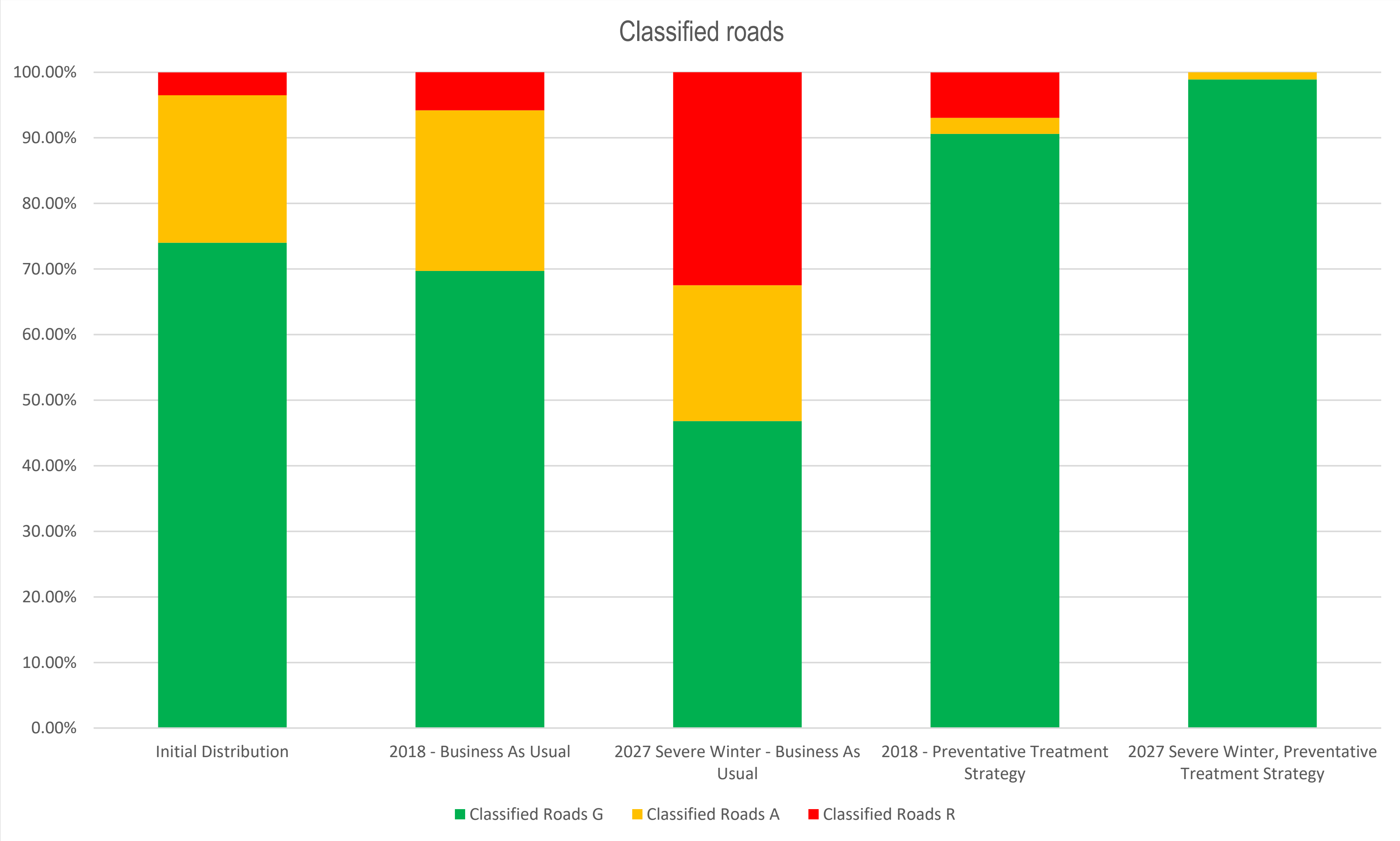

Figure 4: Visualisation of HMEP carriageways outputs for Classified roads

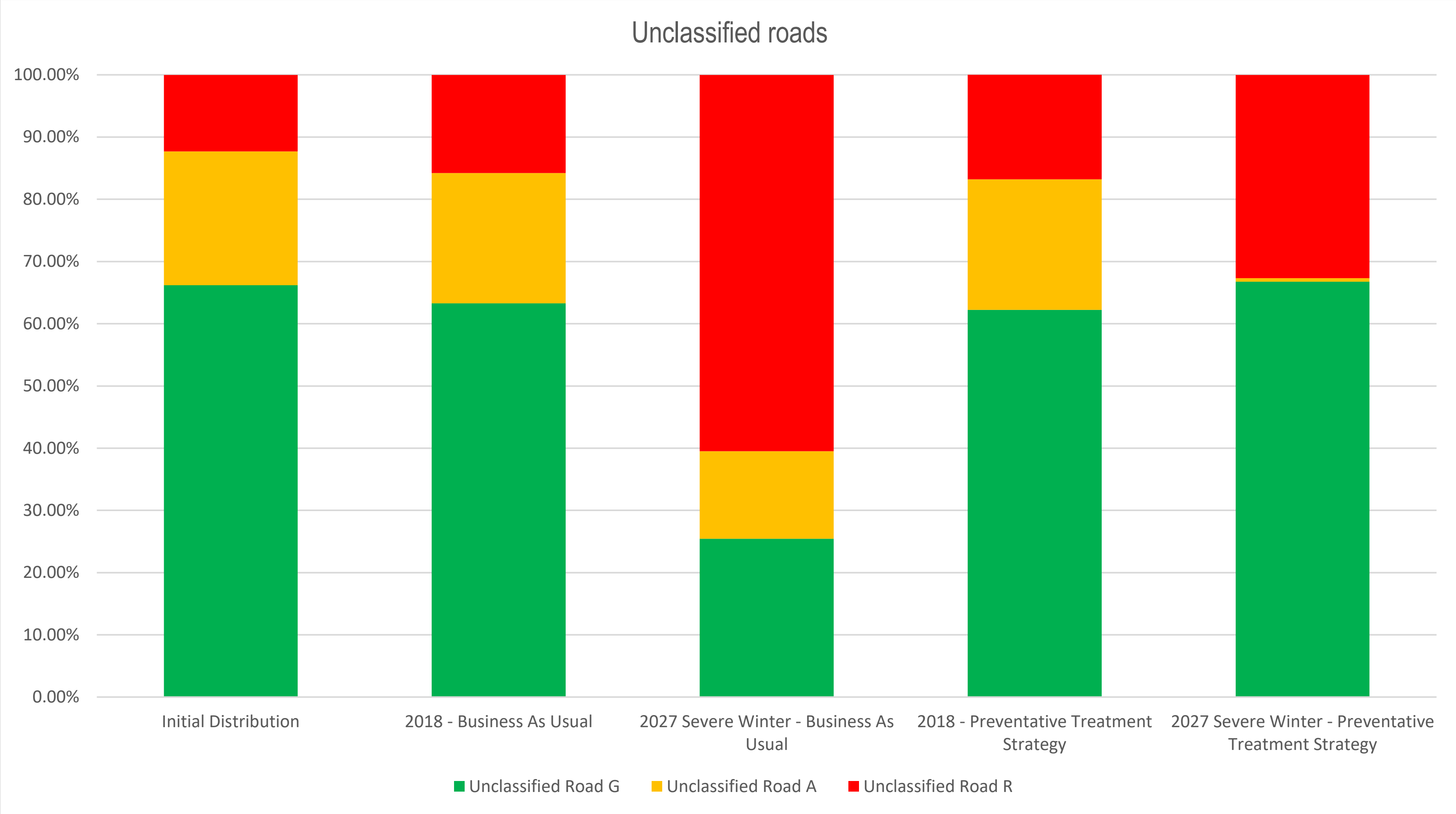

Figure 5: Visualisation of HMEP carriageways outputs for Unclassified roads

2.4 INTERPRETATION OF THE RESULTS

Year 1 and year 10 are depicted in the above graphs, to show the immediate and the long-term effect of the treatment.

To answer the question:

> *What is the effect of changing the treatment strategy on the asset's condition if a severe winter occurs?*

The authority should compare the results of the 2 scenarios. This is shown in Figure 6: Visualisation of HMEP carriageways outputs for Scenarios 1 and 2.below.

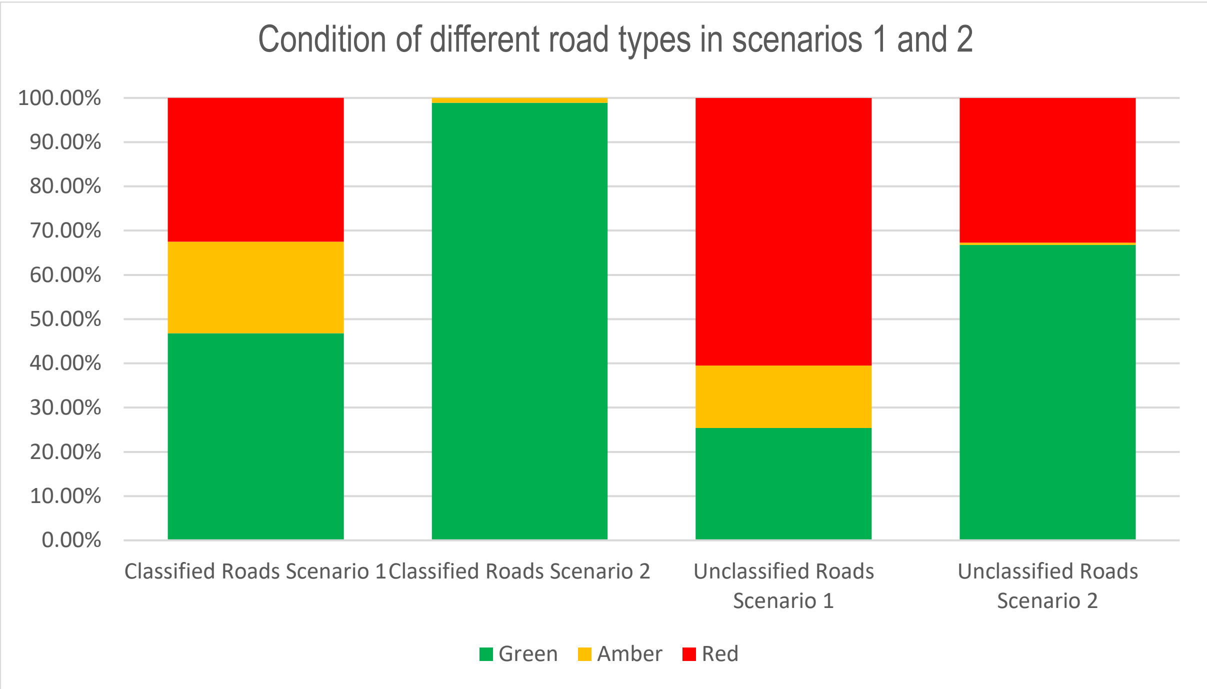

Figure 6: Visualisation of HMEP carriageways outputs for Scenarios 1 and 2.

The figure shows that changing the treatment strategy has considerable effect on both Classified and Unclassified roads. If there is a severe winter, the authority would benefit from performing preventative treatment strategy.

Overall, the case study shows that "preventative treatment strategy" is a prudential strategy to be implemented so that assets are protected against severe weather impacts.

3. OTHER ASSETS

3.1 SCENARIO FOR ROAD MARKINGS

The purpose of this case study is to show how Asset Management practitioners can use the HMEP LCP Other Assets Toolkit to support them in implementing proactive road marking maintenance.

A Highway Authority would like to explore whether their strategy for maintaining road markings should vary with the introduction of CAVs, which rely on the reflectivity of road markings (amongst other features) to navigate. The toolkit will be used to help answer the following questions:

What is the required budget so that all the road markings have the required reflectivity level so that Autonomous Vehicles can safely drive?

If this budget is not available immediately, how can investment be phased?

The following scenarios will be modelled to conduct this assessment:

Scenario 1: Do nothing scenario; replacement of assets just before failure

Scenario 2: Do something scenario; replace well before end of life to maintain reflectivity.

3.2 INPUTS AND ASSUMPTIONS

Known Input Data:

- Start Year: 2018.
- Condition of the road markings is provided as an RL measurement – this is the level of reflectivity obtained using the Ecodyne survey. Typically, the reflectivity of an extrusion through its lifecycle will be as follows:
  - RL 500 – 100 (green) - 0 - 5 years: Green
  - RL 100 – 80 (amber) - 6 - 7 years: Amber
  - RL less than 80 (red) - 8 years +: Red
- 1 Homogeneous Asset Group: Road Markings.
- Length: 352.3km.
- Condition data (81% of Greens, 8% of Ambers and 11% of Reds).
- Unit cost of £0.75/m.

Reasonable assumptions:

- Analysis period of 10 years.
- Condition of the road markings should be translated from a reflectivity level to a condition band (as the toolkit is limited in the number of condition bands which can be added, which is <500). Using the Green/Amber/Red splits as listed above could be an option but only if we were confident that the assets are evenly distributed within each band. For example, we could say that 20% of the green band transitions to amber each year, but if the data indicates that most lines are 2 years old and only a small percentage are 3-5 years old then assuming 20% would change band would result in too much deterioration initially.

- An alternative method is to use age bands as condition bands. Since these condition bands are narrower, the assumption of an even distribution within the band is more plausible (i.e. a line laid in January is not too different to a line laid in December).
- Using yearly condition bands also simplifies the process of creating a deterioration matrix. In this scenario, it can be assumed that 100% of the assets will change condition band each year. For example, if an asset was in Year 1 of its life cycle, after a year has passed the asset will move to a new condition band (Year 2) for the second year of its lifecycle.
- In the CAVs scenario, retro reflectivity of road markings is only one of several parameters that affect the safe travel of automotive vehicles, but still constitutes a very important one. Based on research in international literature and on input provided by Atkins Intelligent Mobility team and technical CAVs experts, an assumption is made for the purposes of modelling that a CAV can safely drive if a road marking is up to 5 years old (RL > 100).
- The treatment strategy for Scenario 1 is to replace the assets when they are in red condition. This is when the asset is in Year 8 and Year 9 of its lifecycle. Hence, the treatment strategy tab is set to treat 100% of the assets in Year 8 and Year 9 of their lifecycle.
- For Scenario 2 a more proactive approach is taken, and the strategy is to treat all assets that are in red or amber condition. This is when the assets are in Years 6, 7, 8, and 9 of their lifecycles. We do not want the assets to go past Year 5 of their lifecycle, so the strategy tab is set to treat 100% of assets in Years 6, 7, 8 and 9 of their lifecycles.
- The performance target for Scenario 1 is to have 0% of the assets in red condition (Year 8 & 9). Therefore, the performance indicator is set to "Y9 & Y8" and the corresponding performance target equal to 0%.
- In Scenario 2 the target is to have 0% of the assets in red or amber condition (Year 6, 7, 8 & 9 of the model). A built-in limitation of the toolkit is that only the top/bottom 2 condition bands can be set as performance indicators. However, this issue can be bypassed by filling out the treatment strategy tab for Scenario 2 as discussed above and then setting a very high budget constraint and applying it to the scenarios tab.

3.3 OUTPUTS

Scenario 1

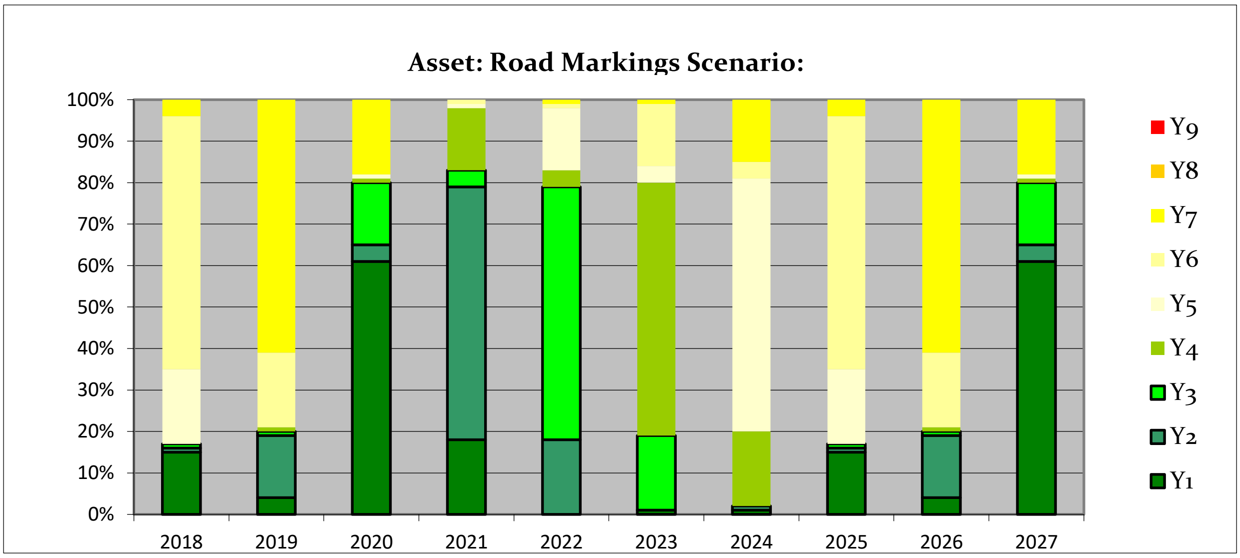

Figure 7: Condition Data output for the road markings from the HMEP LCP Tool (Scenario 1)

Table 6: Expenditure (in £000s) by Condition Band for the road markings (Scenario 1)

Asset Group	Condition Band	Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Total Expenditure	Y1	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y2	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y3	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y4	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y5	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y6	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y7	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y8	446.54	10.57	10.57	161.18	47.56	0	2.64	2.64	39.63	10.57	161.18
Total Expenditure	Y9	29.07	29.07	0	0	0	0	0	0	0	0	
Total Expenditure	**All**	475.61	39.63	10.57	161.18	47.56	0	2.64	2.64	39.63	10.57	161.18

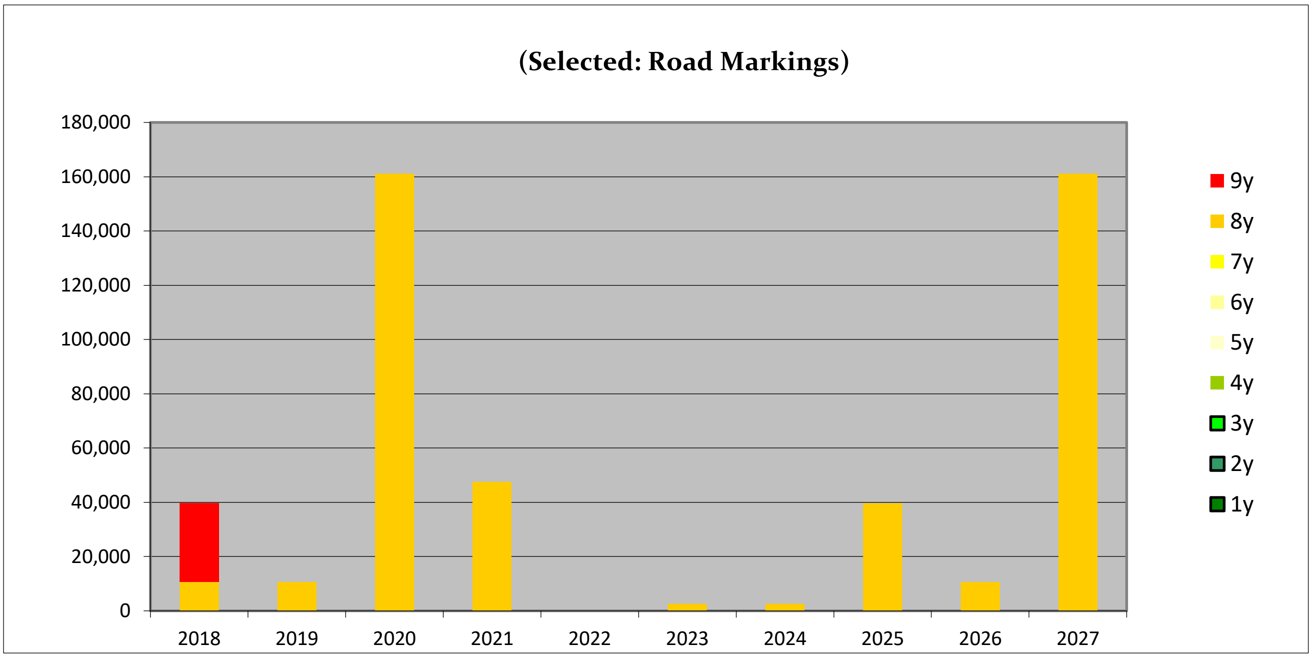

Figure 8: Expenditure Data output for the road markings from the HMEP LCP Tool (Scenario 1)

Scenario 2

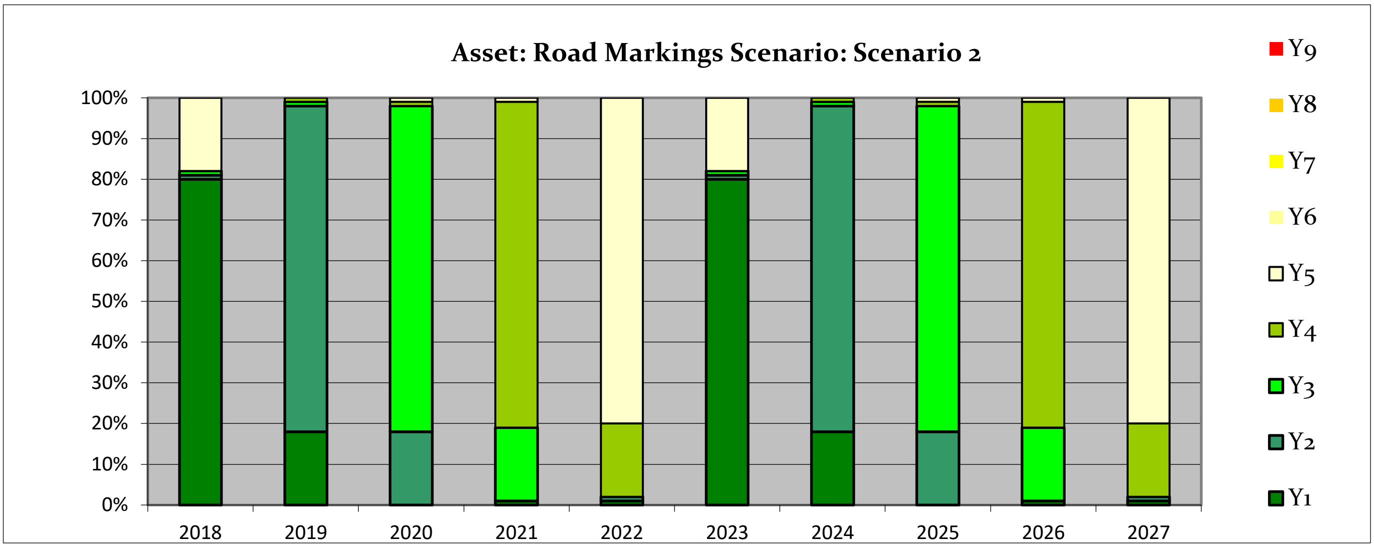

Figure 9: Condition Data output for the road markings from the HMEP LCP Tool (Scenario 2)

Table 7: Expenditure (in £000s) by Condition Band for the road markings (Scenario 2)

Asset Group	Condition Band	Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Total Expenditure	Y1	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y2	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y3	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y4	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y5	0	0	0	0	0	0	0	0	0	0	0
Total Expenditure	Y6	478.25	161.18	47.56	0	2.64	2.64	211.38	47.56	0	2.64	2.64
Total Expenditure	Y7	10.57	10.57	0	0	0	0	0	0	0	0	0
Total Expenditure	Y8	10.57	10.57	0	0	0	0	0	0	0	0	0
Total Expenditure	Y9	29.07	29.07	0	0	0	0	0	0	0	0	
Total Expenditure	All	528.45	211.38	47.56	0	2.64	2.64	211.38	47.56	0	2.64	2.64

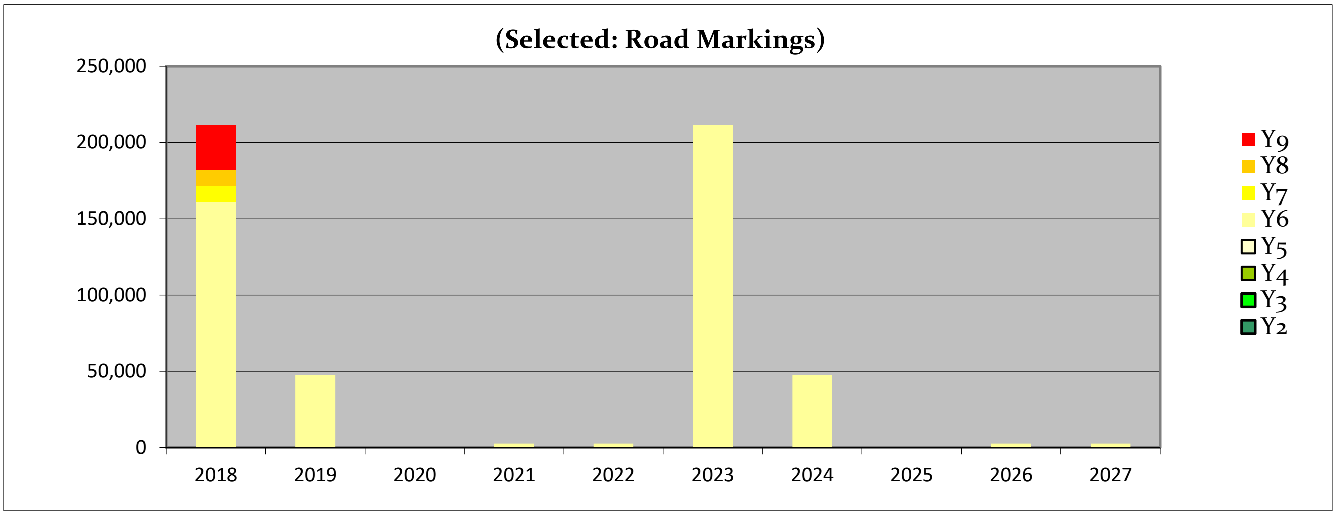

Figure 10: Expenditure Data output for the road markings from the HMEP LCP Tool (Scenario 2)

3.4 INTERPRETATION OF THE RESULTS

The distribution of Assets in each Condition Band is shown in the graphs above to visualise the effects of the treatment in both scenarios.

To answer the question:

What is the required budget so that all road markings have the required reflectivity level so that Autonomous Vehicles can safely drive?

The Authority should examine the results of Scenario 2 (replace early to maintain reflectivity). For this scenario, the assets are repaired just before "reaching" the amber condition in Year 6. Hence, assets in Years 6, 7, 8 and 9 of their lifecycles will be replaced and will return to "as new" condition in the first year of the analysis. Figure 9 shows us that the strategy will maintain all the assets in green condition (Year 1 to Year 5 of their lifeline), whilst none of the assets are in their year 6/7 amber condition, therefore, all the assets are safe for the use of CAVs

The total expenditure for this scenario is £528.45k with approximately £211k spending in the first year (and again in the year 2023) -this is because all assets that were in Years 6-9 of their lifecycles (80% of the total asset) have been intervened on at the same time, therefore transferring them all into Year 1 at the same time. This is also the reason why spending in intermediate years is relatively low (between £0 and £50k).

Comparing the expenditure of Scenario 2 (do something) versus Scenario 1 (do nothing) shows a large difference in expenditure in Year 1 (£211k for Scenario 2 vs £40k for Scenario 1), but the overall expenditure over the 10-year period is not too dissimilar (£528k for Scenario 2 vs £476k for Scenario 1). This indicates that the higher level of service of Scenario 2 might be affordable, even if the initial investment is not. Therefore, the question arises:

If this budget is not available immediately, how can investment be phased?

To answer this question, we would need to run a third scenario, setting the same maintenance strategy as in Scenario 2, but with budget limitations in the initial investment period. An authority may wish to model what would happen if this investment is spread over (for example) 5 years initially. In this scenario, the budget constraint for the first five years could be set at 211k/5 (i.e. £42k/yr) and the toolkit run to examine the implications of this. It is likely that several iterations would be required to achieve the desired condition at the start of Year 6, but the previous analysis provides a good starting point to set the initial budget limitation.

4. FOOTWAYS

4.1 SCENARIO FOR FOOTWAYS

The purpose of this case study is to justify how the HMEP LCP Footways Toolkit can support Highway Authorities to decide a potential material change in an asset type.

A Highway Authority would like to use the tool to model the following:

How much do we need to clear the backlog and achieve a steady state?

Scenario 1: Unconstrained budget and performance target, implementing the current treatment strategy.

What is the economic benefit from the implementation of the treatment strategy used in scenario 2 for the next 20-year period?

Scenario 2: All Footways in Red condition band are reconstructed and change to Bituminous, under the current budget constraint £4.5m.

Scenario 3: Unconstrained budget and performance target with the treatment strategy used for Scenario 2.

4.2 INPUTS AND ASSUMPTIONS

Known Input Data:

- Start year: 2016.
- Condition Bands; Green, Yellow, Amber and Red.
- Homogeneous Asset Groups: Footway Bituminous, Block Paved, Concrete and Flagged.
- Treatment Types with known unit costs as depicted in the following table:

Table 8: Treatment types and unit costs for footways

Treatment	Unit	Cost (£)
Reconstruction (Double Edging)	m^2	54
Reconstruction	m^2	34
Resurfacing (25mm/50mm)	m^2	17
Slurry Seal (with pre-patching)	m^2	4.5
Lift and Relay	m^2	21
Lift and Replace	m^2	24
Clean and Relay	m^2	18.5

- Inventory area and length is provided:

Table 9: Inventory Data for Footways

Asset Type	Length (km)	Area (m^2)
Bituminous	2842.1	4811675
Blocked Paved	760.56	1368247
Concrete	368.09	541092
Flagged	228.79	487071
TOTAL	**4199.54**	**7208085**

- % of Asset Groups in each condition band:

Table 10: % of assets in each condition band

Asset Type	Initial Condition			
	G	Y	A	R
Bituminous	6%	45%	44%	5%
Blocked Paved	3%	67%	17%	13%
Concrete	1%	31%	54%	14%
Flagged	2%	58%	35%	5%

- The authority indicated that their current strategy involves treating bituminous assets in amber condition with Slurry Seal with patching and assets in red condition with reconstruction. The treatment strategy for the rest of the non-bituminous assets will be assumed.

Reasonable assumptions:

- Analysis period of 20 years.
- Lane length is assumed the same as the actual length.
- Since the footway assets have been entered into the homogenous group tabs without a hierarchy (just categorised based on material), the % treated in the treatment strategies tab should be restricted to ensure that not all the budget is used up by the first group in the list.
- The % treated for each asset group could be determined using trial and error, running the toolkit several times until the distribution of funds is broadly uniform and proportional to the quantity of asset in each asset group.
- Alternatively, the % of assets that can be treated equally can be calculated using the following formula:

$$\frac{Available\ budget}{(Sum(\%\ amber\ of\ each\ asset\ group\ area)\times cost)+(Sum(\%\ red\ of\ each\ asset\ group)\times cost)}$$

Formula 1: % of Assets Equally Treated

(Where "Sum" refers to adding up each individual percentage for every asset group area relative to the stated colour, and cost refers to the cost of treating amber and red assets respectively)

This gives us results for bituminous footways of:

- 16.12% for Scenario 1
- 18.8% for Scenario 2

- The deterioration profile used is presented below; and was agreed during a meeting of the UKRLG AM Board for a related project.

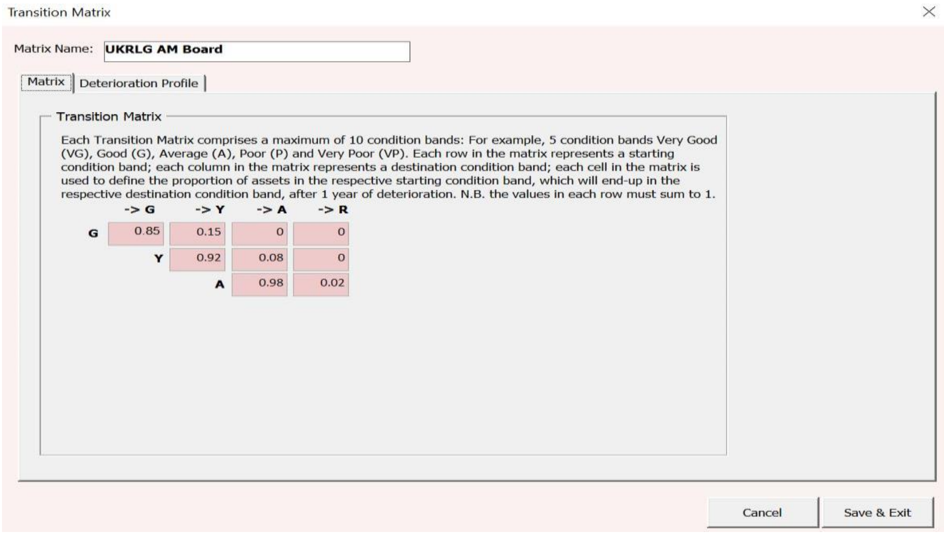

Figure 11: Deterioration profile used

- For the effects of treatments, we can assume that "slurry seal will seal cracks" restores lost flexibility and helps preserve the underlying pavement structure. The asset will therefore recover to yellow condition from amber. For reconstruction we are assuming the asset has been completely rebuilt after being damaged/destroyed (red), thus returning the asset to the green condition band.
- For blocked paved and flagged footways, the treatments used will be "Lift and relay" for ambers (turn into yellow). For the reds (turn into green), "Reconstruction" will be implemented for Scenario 1 and "Lift and replace" for Scenario 2. For concrete footways the same treatment strategy as for bituminous ones will be implemented.
- For Scenario 1 (clearing the backlog an achieving a steady state) a simple assumption has been made that in order to clear the backlog, no asset should be in red condition. The toolkit is run with this performance target and no budget in the Scenario tab. In the treatment strategy tab, the first treatment step is to treat 100% of the reds.
- To achieve the "steady state", the aim is to balance the % of the asset which deteriorates to amber each year, with the % of ambers which are treated each year, therefore maintaining no overall increase in the amber assets. This is done by using trial an error in the % of ambers treated each year. For this particular scenario, treating 7% of the ambers results in the steady state shown in Figure 16 and Figure 17 below.

- For Scenario 2, if the Authority wants to replace all its footways once they are ready for reconstruction (in red condition) and turn them into bituminous, the following treatment have been used:
    - Clean and Relay (Bituminous to Bituminous);
    - Lift and Replace (Block Paved to Bituminous);
    - Clean and Relay (Concrete to Bituminous); and
    - Lift and Replace (Flagged to Bituminous).

4.3 OUTPUTS

The output data required to answer the second question is tabulated and graphically illustrated below.

Table 11: Output Condition from the HMEP LCP Tool

Asset Group	Condition Band	Initial Distribution	2016 (current treatment strategy)	2035 (current treatment strategy)	2016 (treatment strategy "Change Reds to "Bituminous")	2035 (treatment strategy "Change Reds to "Bituminous")
Bituminous	G	6.00%	6.05%	4.03%	6.55%	5.63%
Bituminous	Y	45.00%	49.83%	67.78%	50.90%	70.57%
Bituminous	A	44.00%	39.19%	25.42%	37.80%	21.88%
Bituminous	R	5.00%	4.93%	2.78%	4.76%	1.92%
Block Paved	G	3.00%	3.19%	4.89%	2.58%	0.14%
Block Paved	Y	67.00%	65.64%	67.34%	67.10%	73.59%
Block Paved	A	17.00%	18.47%	24.80%	18.11%	23.91%
Block Paved	R	13.00%	12.70%	2.97%	12.20%	2.35%
Concrete	G	1.00%	0.85%	9.33%	0.85%	0.05%
Concrete	Y	31.00%	28.67%	62.45%	28.67%	72.95%
Concrete	A	54.00%	55.40%	22.96%	55.40%	24.03%
Concrete	R	14.00%	15.08%	5.26%	15.08%	2.96%
Flagged	G	2.00%	1.70%	0.08%	1.70%	0.09%
Flagged	Y	58.00%	53.66%	42.33%	53.66%	71.95%
Flagged	A	35.00%	38.94%	32.71%	38.94%	24.17%
Flagged	R	5.00%	5.70%	24.88%	5.70%	3.78%

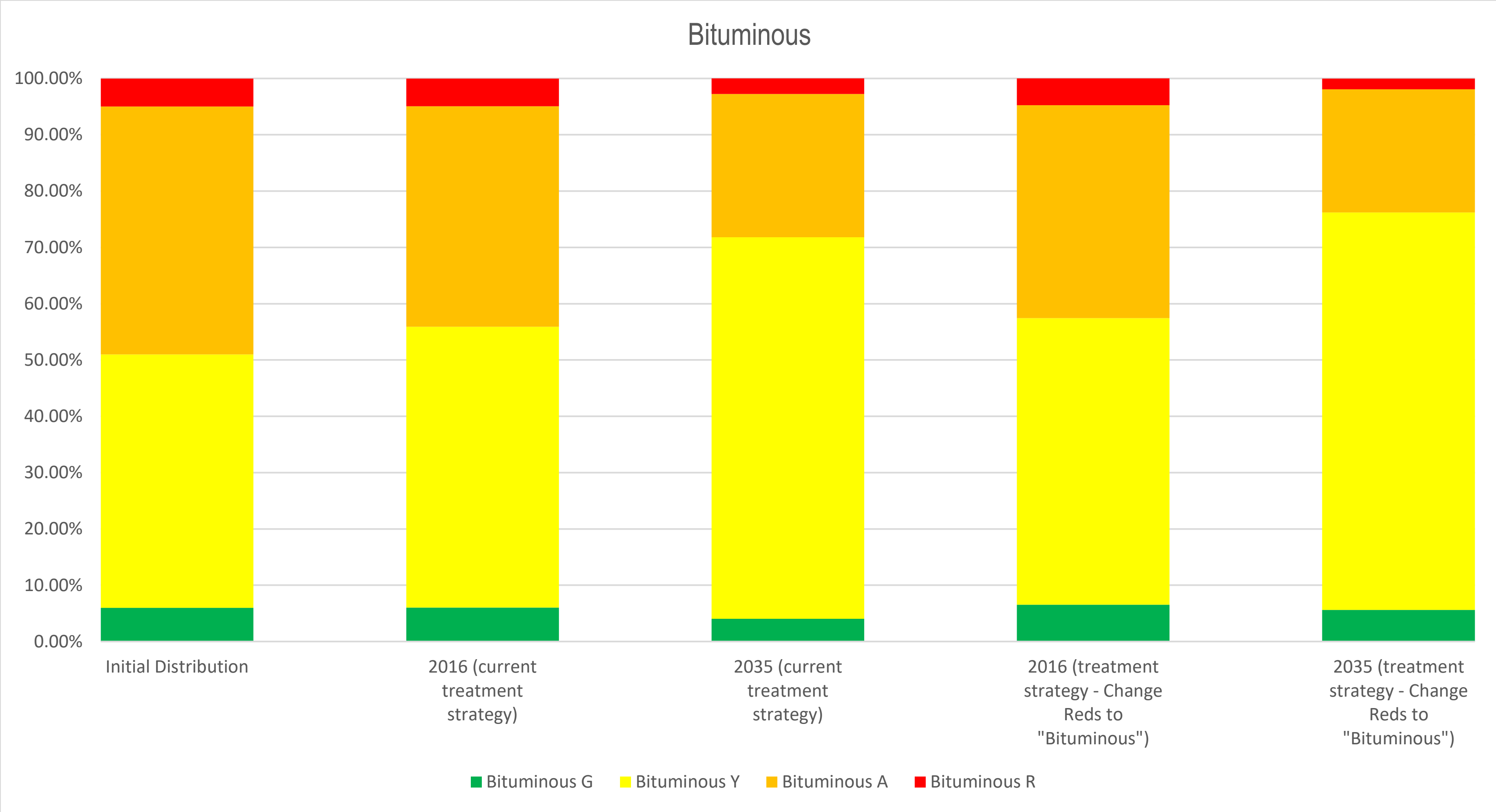

Figure 12: Output Condition data graph for Bituminous Footways

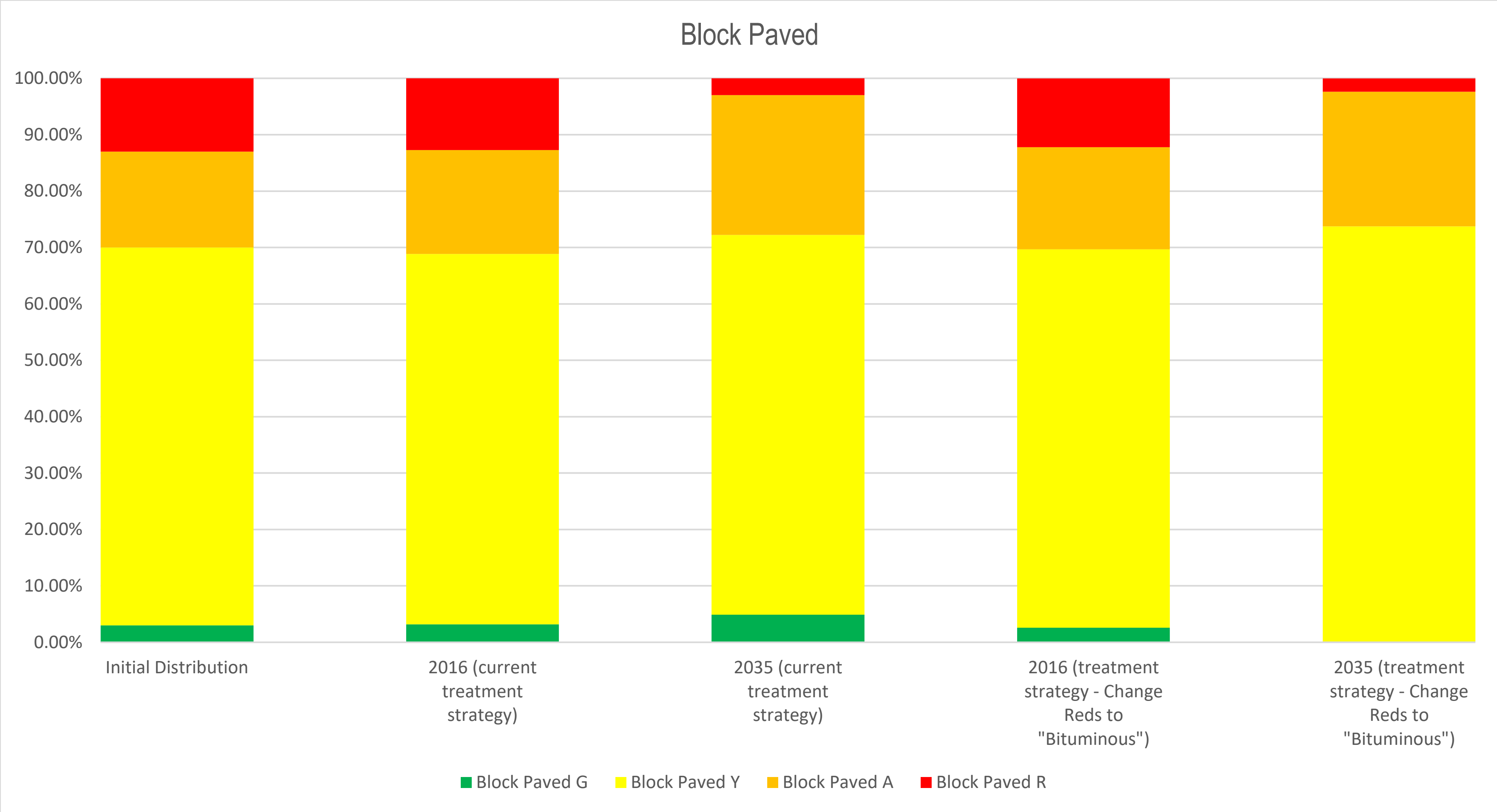

Figure 13: Output Condition data graph for Blocked Paved Footways

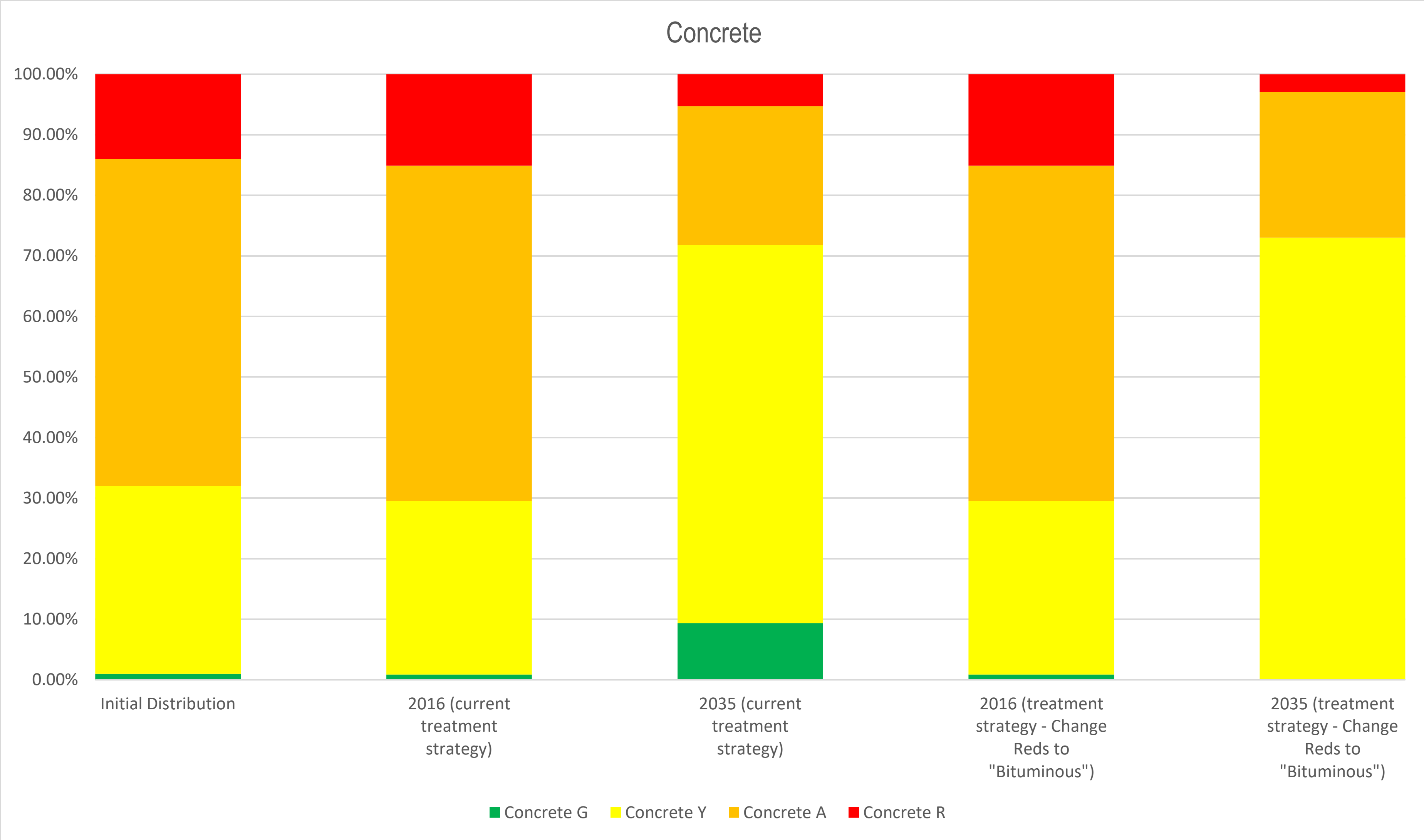

Figure 14: Output Condition data graph for Concrete Footways

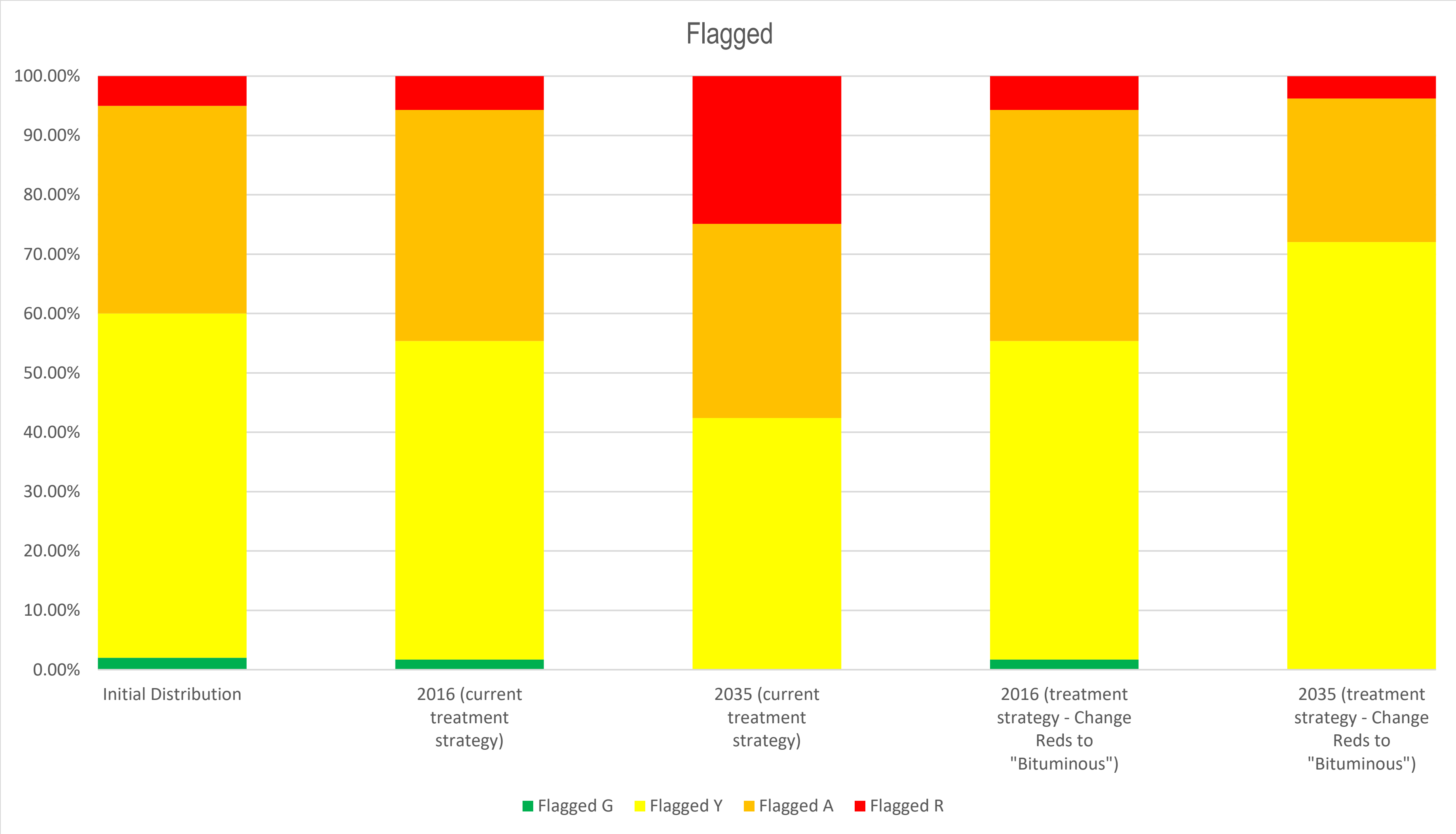

Figure 15: Output Condition data graph for Flagged Footways

4.4 INTERPRETATION OF RESULTS

Year 1 and year 20 are depicted in the graphs above, to show the short term and long-term condition of the assets.

To answer the first question:
How much do we need to clear the backlog and achieve a steady state?

The Authority should consider the results of Scenario 1 (unconstrained budget and performance target).

The expenditure in Year 1 equates to the backlog, as all the red assets are eliminated at this point – this amounts to £21.07m for year 1 (see Figure 17).

The average yearly expenditure in the following 19 years is the budget required to maintain a steady state (circa 43% of bituminous footways are amber) – this amounts to £3.88m/yr. Steady state is achieved when 7% of the Ambers are treated. An average is taken as small fluctuations in asset amounts lead to small fluctuations in the amount of works each year.

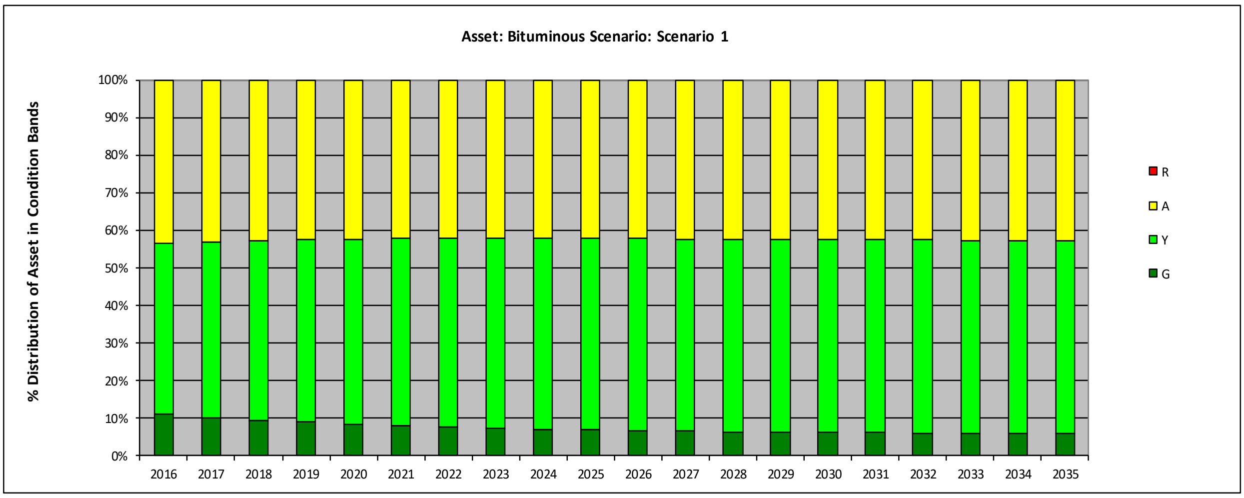

Figure 16: Condition Graph for Steady State for Bituminous Footways

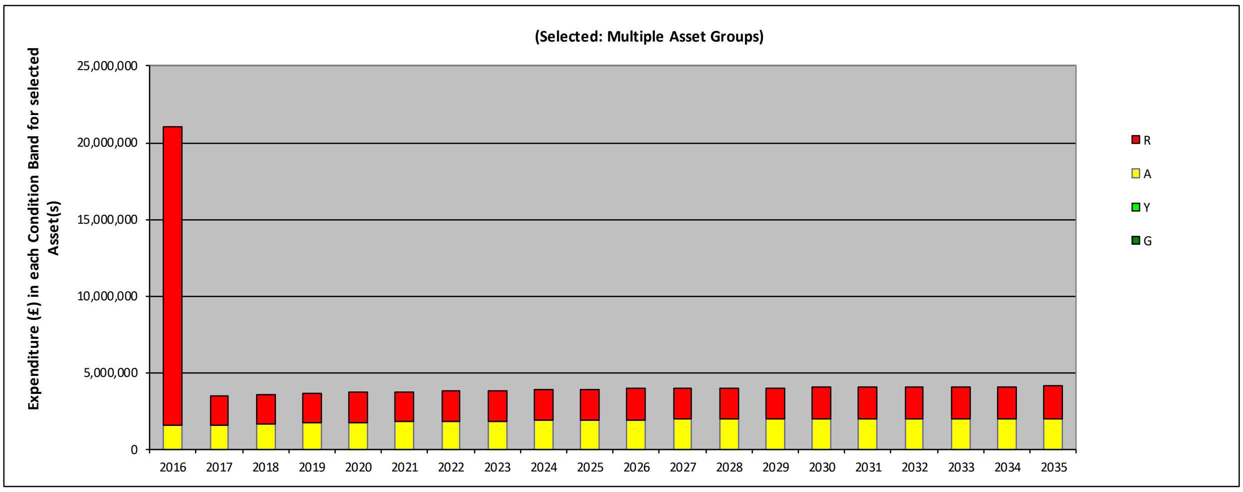

Figure 17: Expenditure by condition band for Steady state for Multiple Asset Groups

To answer the second question:
What effect does the replacement of all the red footways have if they turn them into bituminous?

In Scenario 2, as depicted in Figure 12 - Figure 15, 2.68% more assets are treated (18.8%-16.12%=2.68%) while the assets are in slightly better condition. By modelling Scenario 3 (performance target: R<=0), the total expenditure which occurs for the next 20 years is £86.48m while if the assets are treated remaining on the same asset type the total expenditure is £94.83m. So, replacing footway assets which are in red condition and changing them to bituminous presents £8.35m efficiencies in a 20-year time and the assets are also in better condition.

In Scenario 3, the expenditure in Year 1 equates to the backlog, as all the red assets are eliminated at this point – this amounts to £17.7m for year 1. The average yearly expenditure in the following 19 years is the budget required to maintain a steady state (circa 41% amber of bituminous) – this amounts to £3.62m/yr.

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