ASSET MANAGEMENT & SCRIM: A TARGETED APPROACH TO THE MANAGEMENT OF SKIDDING RESISTANCE

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ABSTRACT

This paper draws on the work undertaken by Cornwall Council in conjunction with W.D.M. Limited and presented at the previous conference in 2008 under the title *Using SCRIM investigatory levels to identify, manage and set priorities - the investigation process.* The paper outlines the methodology adopted by Cornwall in developing a targeted approach to the treatment of deficient sites and draws on further collaborative work between the Authority and W.D.M. Limited to develop a robust benefit / cost relationship which has allowed the targeted treatment of priority site categories such as high speed bends and junction approaches. The paper will further review the success of this strategy in reducing the level of deficiencies in skidding resistance and associated collisions on the Cornish network and will show the benefit of adopting a strategy which targets funds at the location where it can deliver the greatest benefit both for the highway authority and road user.

INTRODUCTION

This paper takes as its starting point the work carried out by Cornwall Council in conjunction with W.D.M. Limited which developed a methodology for identifying, setting and managing priorities for the investigation of skidding deficient sites highlighted by the annual survey programme. This protocol utilises investigatory levels set as a result of a detailed study into the relationship between recorded skidding resistance measurements as recorded by Sideway-force Coefficient Routine Investigatory Machine (SCRIM) and the incidence of collisions on the Cornish highway network over a period from January 1995 to December 2004 and was presented by Stephenson et al at the 2008 conference[1]. The methodology developed was itself the subject of a paper by the principal author at the 2008 conference[2]. The output of the process was a list of sites which were performing significantly worse than the background collision rates used to set the investigatory levels. These sites were then prioritised and a forward remedial treatment programme developed to raise the level of the skidding resistance to above the appropriate site category threshold. Application of this process in 2008 and 2009 quickly dealt with the very obvious “must do” sites, and ways of prioritising the remaining large number of sites where there was no obvious hierarchy of need, based on the criteria in the methodology, were being considered. In conjunction with this, a validation of the values and benefits of addressing low skidding resistance was considered as a potential mechanism for securing additional financial resources. In late 2008 W.D.M. Limited were commissioned to undertake a review of the benefit/cost relationships of treating deficiencies at various site categories, and it was this work which led to the refinement of the prioritisation process and the targeting of specific site categories for treatment and is detailed in the remainder of this paper.

ESTABLISHMENT OF BENEFIT/COST RELATIONSHIPS

As discussed above, the understanding of the relationship between skidding resistance and collisions is key to the establishment of robust benefit/cost information. The initial review of data had identified that there was a strong correlation between wet collision rates and skid resistance data for a number of site categories. It also demonstrated that some modifications to the UK national HD28/04[3] standard were justified and that a different categorisation of bends was appropriate for the county road network. The analysis also indicated that collision rates increased significantly as skidding resistance values decreased, for example on 'minor and major junctions' as shown in Figure 1.

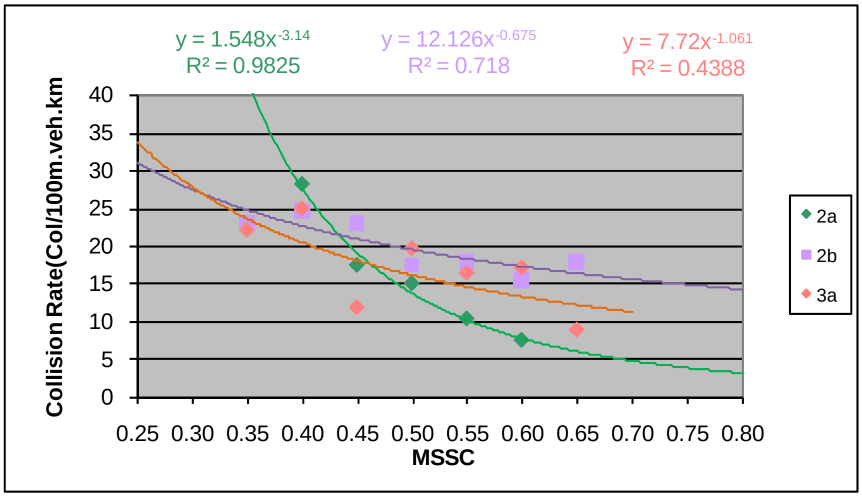

Figure 1: MSCC (SCRIM) and collision rates for minor and major junctions

Cornwall Council uses a maintenance hierarchy and carries out skidding resistance surveys on the following road categories:

- 2a – strategic routes
- 2b – principal A roads
- 3a – main distributor roads (made up of B and C roads).

Strong relationships, with high levels of confidence, between skidding and collision data were found for the following categories:

- Approach to minor / major junctions
- Single carriageway bends
- Approaches to roundabouts.

Collision analysis

Analysis of the same skidding and collision data used to set the revised Investigatory Levels enabled the determination of 'wet collision densities' for the lengths of the 2a, 2b & 3a network hierarchy. This then enabled an assessment of the numbers of collisions that had occurred and, therefore, an evaluation could be made of the economic benefits available through increasing the SCRIM values. Figure 2 illustrates this principle for bends with a radius less than 100m.

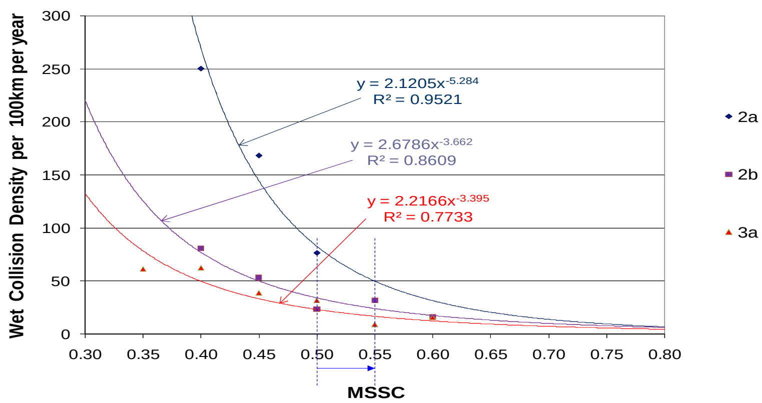

Figure 2: MSCC (SCRIM) v collision rates for <100m radius bends.

Achieving Higher Skid Resistance

In 2000, the Council undertook a trial of different aggregates on a section of the A390 on the approach to Truro with the purpose of demonstrating the long term equilibrium values of a range of commonly used aggregates. The conclusion of this trial was that local aggregates will reach equilibrium SCRIM values of no more than 0.45 and that other higher Polished Stone Value (PSV) aggregates will not necessarily achieve an in-service performance in line with that expected from the initial PSV. There was, therefore, a need for careful selection of high PSV aggregate if the required in-service performance was to be achieved.

The collision analysis had identified the theoretical reduction in collision rates that could be achieved through improving skidding resistance which in practical terms is usually achieved through the specification of higher Polished Stone Value (PSV) aggregates, particularly those shown to provide higher skidding resistance levels whilst in service on the Cornwall network. These higher PSV materials come at a premium of £1 and £5 per square metre for surface dressing and surfacing respectively, although to consistently achieve SCRIM > 0.55 calcined bauxite materials are required. The surface treatment options for specific sites depend on site constraints and other condition characteristics, but typically to improve skidding resistance in line with Figure 2, a system of double surface dressing would be used on rural roads and a thin surfacing on urban roads; these treatments are considered to provide the best performance in terms of durability, noise and other environmental constraints.

Assuming that the skidding life of a new surface is 10 years, it is therefore possible to determine the cost over 10 years of improving the skidding resistance of the network to meet the desired levels. The cost of such a programme over 10 years equates to £608,000 per year (in 2008 prices) and a Net Present Value (NPV) of £5.1M.

Economic Analysis

The Highway Economic Note no 1[4], published in 2007, sets out the cost of road collisions by severity in 2005 prices. Considering the entire A and B road network in Cornwall and taking into account the actual severity split, it was possible to assess the economic benefits of improving the skid resistance through the economic analysis used in local safety schemes; however as this programme is envisaged as a 10 year programme, investment over the 10 year period is used to demonstrate the rate of return, with discounting as appropriate. This was done for all the road categories as shown in Table 1.

Table 1: Analysis of cost and benefits through improving skidding resistance on road categories.

Road Category	Investigatory Level (IL)		Collision savings		Additional costs: PV(10 year)	Economic indicators	
Approaches to minor / major junctions	**Current**	**Proposed**	**Number (annual)**	**PV(10 year)**		**NPV(10years)**	**BCR(Benefit Cost Ratio)**
2a	0.45	0.50	6.1	£4.58m	£0.552m	£4.02m	8.3
2b	0.45	0.50	5.2	£3.91m	£1.187m	£2.72m	3.3
3a	0.45	0.50	3.3	£2.46m	£2.268m	£0.19m	1.1
Approaches to roundabouts							
2b	0.45	0.60	3.0	£1.77m	£0.097m	£1.668m	18.1
Single carriageway beds <100m radius							
2a	0.50	0.55	1.3	£1.221m	£0.114m	£1.107m	10.7
2b	0.50	0.55	1.5	£1.416m	£0.433m	£0.983m	3.3
3a	0.50	0.55	0.9	£0.852m	£0.403m	£0.448m	2.1
All networks			21.3	£16.198m	£5.055m	£11.142m	3.2

APPLICATION OF THE BCR APPROACH

Analysis of the data set out in Table 1 shows that of all the identified site categories which demonstrated a positive BCR, there were some obvious categories notably bends with a radius of less the 100m, approaches to junctions and the approaches to roundabouts on the 2a network.

Following a review of the output from the BCR study, Cornwall Council decided to refine the way in which identified skidding resistant deficient sites where prioritised. The initial interrogation of the skidding resistance survey data and the incidence of collisions were still used to produce the list for initial and secondary investigations as set out in the paper delivered to the 2008 Conference[2]. Application of this methodology produced a list that was significant in length and would, given the available financial resources, take a significant number of years to treat. Utilising the output of the BCR study, we were able to refine our prioritisation process to identify those sites where there was a positive BCR and include this as a significant weighting factor in the prioritisation process. The prioritisation process also now includes sites which although no collision history exists, we can, by application of the relationships derived in the skidding resistance / collision analysis, predict the likelihood of a collision and therefore initiate preventative treatment before hand.

In implementing the approach we developed a ranking process which takes account of not only the collision rate but also the speed limit and the combination of site categories present. Following the BCR figures set out in Table 1, we now prioritise those sites which are on the high-speed network (defined as sites with a speed limit of 50mph or greater) and which feature bends of <100m radius and/or approaches to junctions. In line with the likely severity of any potential collision, we assigned the highest risk rating to those sites which had a speed limit of greater than 50mph, a bend of <100m radius or a junction; a medium risk rating to those sites with a speed limit of greater than 50mph and a bend with a radius of >100m and a low rating to any other combination. This process is illustrated in Figure 3 below.

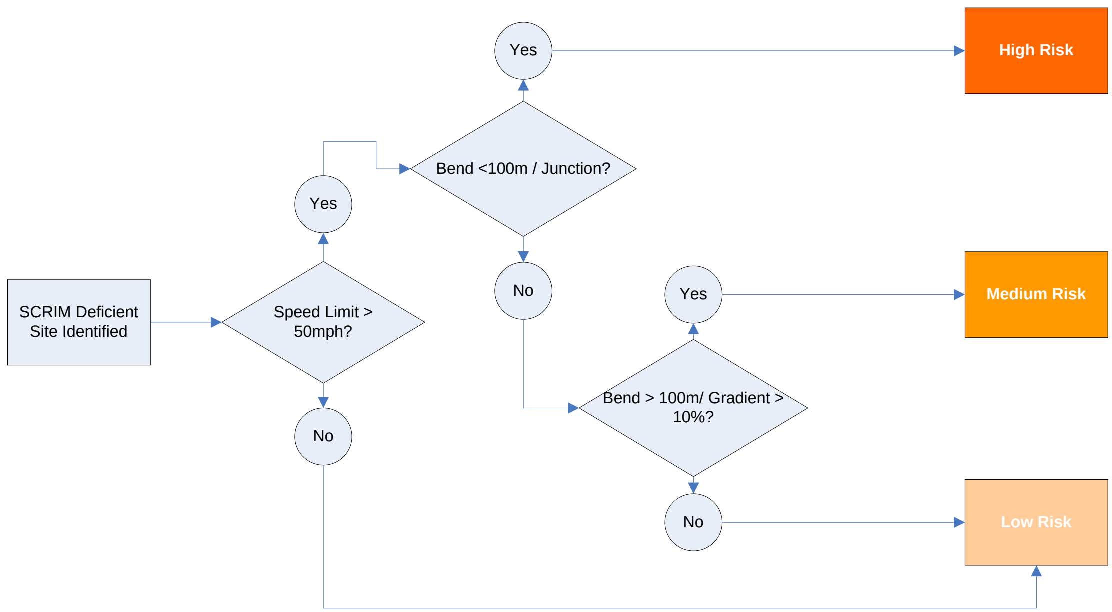

Figure 3: Prioritisation Process Chart.

Application of this methodology has allowed the targeting of treatments at those locations where it can have the biggest effect on wet skidding collisions and also those sites where a saving in economic terms can be made by treating the skidding deficiency before the occurrence of a collision. Following a full analysis of all the deficient sites on the 2a, 2b and 3a network, a 4 year remedial programme was developed, which sought to treat all sites with a High or Medium risk rating within two years. These sites were treated in the 2009/10 and 2010/11 surface treatment programmes, with the lower priority sites programmed for subsequent years. In order to facilitate this programme of work, the overall treatment strategy was reviewed and a decision was made to front load the skidding deficiency remedial programme and target finances accordingly. This approach was in part predicated on the fact that large lengths of the 2a and 2b road network were in need of remedial work and that the sub network was in a very good overall condition. Thus, from an asset management perspective, the overall condition could be allowed to deteriorate slightly and funds transferred from structural maintenance. It was recognised that this was a strategy which required some justification and so in conjunction with W.D.M. Limited, a review was initiated of both the Cornish skidding policy and the way in which it had been implemented.

SKIDDING POLICY REVIEW

By the beginning of 2010 the revised skidding policy, together with the consequential treatment of deficient sites, had been operating for 3 years. In order to gain confidence on the continued operation of the policy and protocols developed, W.D.M. Limited was commissioned to undertake a review of the original work and to update the findings with a further three years skidding data. In addition, the assumptions made during the implementation of the targeted approach towards site prioritisation and the assumed financial benefits that flowed from this, were also tested

Review Methodology

The analysis process used in this review followed the same general principles as described in the original 2007 Review and presented at the 2008 conference. The data preparation required collation of Skidding data, Skid Resistance Site Categories, Maintenance Records, Collisions, and Traffic data. The review of skid resistance versus Collisions was based on a three-year collision history, hence, the latest skidding data collected between 01-01-2007 and 31-12-2009 was used in the analysis. Maintenance history and traffic data were also reviewed and updated to take account of any changes to the network and to ensure the removal from the analysis of any treated sites that had not reached equilibrium. The length of the network thus generated was 28% higher than that used in the original study, in addition the distribution of the site categories across the hierarchy was significantly different. This was due to the extensive reassignment of site categories which took place following the 2007 review.

Review findings

A comparison was made between the average values of the datasets used in the 2007 and the 2010 Reviews, in other words, a comparison of before and three years after the Skid Resistance Policy was implemented. This is presented in Table 2. The outcome of the review identified an apparent reduction in wet collision rates and wet collision densities from 2007 to 2010. The percentage reductions in Wet Killed or Seriously Injured (KSI) Collision Rates and Collision Densities were noticeably higher than the percentage reductions of All Wet Injury Collisions. This could be an indication that the skid resistance treatments have targeted areas that are high risk reducing the number of collisions with particular attention given to reducing KSI collisions.

Table 2: 2007 versus 2010: Collisions, Collision Rates, and Collision Densities Based only on Data used in the Reviews

Parameter	2007	2010	Change
Average MSSC in Study Data	0.51	0.49	-0.02
Total Length in Study (lane-km)	1755.320	2248.306	28.1%
Total Length Travelled in Study (100Mvehkm)	23.288	27.488	18.0%
2a Roads Length in Study (lane-km)	397.280	399.743	0.01%
2a Roads Length Travelled in Study (lane-km)	9.123	9.403	0.03%
2b Roads Length in Study (lane-km)	640.890	623.789	-2.7%
2b Roads Length Travelled in Study (lane-km)	8.093	8.380	3.5%
3a Roads Length in Study (lane-km)	717.160	1224.774	70.8%
3a Roads Length Travelled in Study (lane-km)	6.072	9.706	59.8%
# of Wet Injury Collisions (yearly average)	316	340	7.6%
Wet Injury Collision Rate (per 100Mvehkm)	13.6	12.4	-9.7%
Wet Injury Collision Density (per lane-km)	0.180	0.151	-16.1%
# of Wet KSI* Collisions (yearly average)	39.1	38.0	-2.8%
Wet KSI Collision Rate (per 100Mvehkm)	1.68	1.38	-17.9%
Wet KSI Collision Density (per lane-km)	0.0223	0.0169	-24.2%

* KSI – Killed or Seriously Injured

The data from the 2007 Review revealed that 3158 wet injury collisions occurred on the 2a, 2b and 3a roads during the 10-year period, whilst the 2010 review used 1021 wet injury collisions for a period of 3 years also on 2a, 2b, and 3a roads; these equate to approximately 316 and 340 collisions per year respectively.
The data clearly indicates that Collision Rates and Collision Densities have reduced during the intervening three years. Furthermore, due to the 28% increase in the study length in the 2010 study, the changes in Collision Rate and Collision Density figures can be used to indicate the impact of the skid resistance policy (as Collision Rate and Collision Density express collisions per 100M vehicle kilometres travelled or per network km respectively).

The reduction in collisions can be estimated using the collision rates presented in the table above.

Reduction in Wet Collision rate from 2007 to 2010	= 1.2 per 100Mvehkm
Total distance travelled in the study length	= 27.488 100Mvehkm/year
Wet Injury Collision Reduction	= 1.2 x 27.488
	= **33 collisions per year**
Wet KSI Collision Reduction	= 0.3 x 27.488
	= **8.25 collisions per year**

This indicates that approximately 99 wet injury collisions, out of which approximately 25 could have been KSI collisions, may have been saved during the last three years.

The 2007 Review used a 10-year collision history (01-01-1995 to 31-12-2004), whereas the subsequent review used a 3-year collision history (01-01-2007 to 31-12-2009). The average annual numbers of collisions based on the collision history used in the corresponding review are shown in table 3.

Table 3: 2007 versus 2010: Average Yearly Number of Collisions in 2a, 2b, and 3a Networks

Parameter	2007 (10-Year Average)	2010 (3-Year Average)	Change
# of Wet + Dry Injury Collisions per year	1210	1003	-17.1%
# of Wet Injury Collisions per year	497	406	-18.3%
# of Dry Injury Collisions per year	712	596	-16.3%
# of Wet + Dry KSI per year	167	114	-31.7%
# of Wet KSI per year	61	47	-23.0%
# of Dry KSI per year	106	67	-36.8%

The above statistics are based on all collisions occurred in the 2a, 2b, and 3a networks prior to the date of review.

There is approximately a 16-18% reduction in all Wet, Dry, and Wet + Dry injury collisions, and more significantly, the reductions in KSI's are higher in all surface conditions.

All wet injury collisions reduced by approximately 18%, with Wet KSI's by 23% from 2007 to 2010. Dry injury collisions reduced by approximately 16%, with Dry KSI's by 37%. The total Wet + Dry collisions in all 2a, 2b, and 3a networks reduced by approximately 17%, with the KSI collisions reducing by approximately 32%. As no other interventions had been carried out on the vast majority of the sites in the study, the data indicates that the surface treatment work carried out as part of the Skid Resistance Policy have contributed to a reduction in the number of dry collisions as well.

Comparative Findings

Further work was then carried out to verify the effect of the implementation of the Skidding Policy at individual site category and hierarchy levels. The output of this work, summarised for all hierarchies, is shown in table 4.

The conclusion that can be drawn from the table 4 is that there is clear evidence from the data that the Skid Resistance Policy has contributed to a reduction in collision rates and collision densities, and more importantly a higher percentage of KSI collisions have reduced. In comparison of the 2007 data to the 2010 data, the Wet Injury Collisions per 100Mvehkm reduced by 9.7%, and more interestingly, the Wet KSI Collisions per 100Mvehkm reduced by 17.9%. Further, it was calculated that approximately 33 ‘Wet Injury’ collisions (out of which 8.25 could be Wet KSI Collisions) have been saved per year on the 2a, 2b and 3a roads subject to the study. Using the ‘Transport Analysis Guidance: Collisions Sub-Objective’ published by the DfT in 2009, this equates to a saving of £2.495M per year on Wet Injury Collisions only, based on the 2007 prices.

Table 4: Comparative Collision Rates and Densities by Category 2007 v 2010

SKIDDING Site Category	All Hierarchies					
	2007			2010		
	Average MSSC	Collision Rate*	Collision Density†	Average MSSC	Collision Rate*	Collision Density†
Non-Event Single	0.51	5.4	0.068	0.49	5.7	0.068
Non-Event Dual	0.49	4.5	0.166	0.48	10.7	0.425
Junction Approach	0.51	17.2	0.266	0.49	26.7	0.355
Roundabout Approach	0.53	22.1	0.503	0.53	14.7	0.328
Crossings Etc Approach	0.53	28.4	0.756	0.54	45.8	1.127
Roundabout	0.50	44.1	1.261	0.50	33.3	0.813
Gradient 5-10%	0.51	7.2	0.107	0.50	7.3	0.089
Gradient >10%	0.51	19.4	0.241	0.51	10.6	0.094
Bend Dual <500m	0.52	12.7	0.523	0.50	8.8	0.452
Bend Single <100m	0.52	40.4	0.354	0.48	41.5	0.331
Bend Single >100m <250m	0.51	19.0	0.201	0.49	12.4	0.123
Bend Single >250m <500m	0.51	15.5	0.184	0.50	9.1	0.109

* in units of collisions per 100M vehicle kilometres
† in units of collisions per lane kilometre

BEFORE AND AFTER STUDIES

In order to further verify the perceived benefits from the implementation of the Skidding Policy, we undertook further analysis in the form of a series of ‘before’ and ‘after’ studies. The schemes selected for this study were treated at least one year prior to the collection of Skidding resistance and Collision data. To better understand the potential financial benefits, the First Year Rate of Return (FYRR) was calculated for all schemes combined and for individual schemes. Calculations were based on the average values of prevention of road accidents reported by the Department of Transport, Transport Analysis Guidance[5].

FYRR is a simple way of determining whether a scheme (or set of schemes) can be justified in economic terms. An FYRR of over 100% indicates that the benefits (or savings) from the scheme outweigh the cost of the scheme within the first year. If the FYRR is less than 100%, this indicates the scheme may still be economically beneficial, but the full benefits may take more than a year to outweigh the scheme costs.

Two alternative FYRR were calculated for the combined impact of all nine schemes. The first is where the value of each collision saved was based on whether it was an Injury Collision or a Damage Only Collision. The average value of an Injury Collision is £75,610, and a Damage Only Collision is £1,970. The second alternative is where the value of the collisions saved was based on the severity; a Fatal Collision is valued at £1,876,830, a Serious Collision at £215,170, a Slight Collision at £22,230, and a Damage Only Collision at £1,970. These values, as indicated in the Transport Analysis Guidance cited above, are based on 2007 road collision data and are at 2007 market prices and values.

The FYRR for individual schemes was based on the average for all Injury Collisions and Damage Only collisions (valued at £75,610 and £1,970 respectively). It was considered that there were too few collisions at scheme level to consider collision severity in determining an alternative FYRR.

Selected Schemes

Nine sites where skid resistance improvements had been undertaken were randomly selected for the study. SCRIM Summary, Construction, and Collision data for the length of individual schemes were extracted from the latest copy of the Cornwall PMS. Details of these schemes are included in Table 5.

The total carriageway length of all nine schemes was 15.843km, with a total treatment cost of £707,488. The majority of the schemes were implemented in 2008, hence the scheme costs used in the analysis are based on the values for the 2008/09 financial year.

Table 5: Scheme Details

Scheme Number (length)	Road Name	Section Code	Start m	End m	XSP	Major Treatment	Date of Maintenance	Cost (£)
Scheme 26 (3790m)	A0390	051	0	790	CL1/CR1	Overlay	14/06/2008	100,434
	A0390	053	0	575	CL1/CR1	Overlay	14/06/2008	
	A0390	055	0	2425	CL1/CR1	CL1 Surface Dressing CR1 Overlay	14/06/2008	
Scheme 138 (1700m)	A0392	025	0	1700	CL1/CR1	Surface Dressing	05/09/2008	80,837*
Scheme 139	A0392	023	0	570	CL1/CR1	Inlay	12/02/2009	111,290*

(1170m)								
	A0392	027	0	600	CL1/CR1	Overlay	05/03/2009	
Scheme 178 (1927m)	A0390	003	0	1430	CL1/CR1	Surface Dressing	05/06/2008	45,257
	A0390	006	0	497	CL1/CR1	Surface Dressing	05/06/2008	
Scheme 2579 (1068m)	A3071	010	374	1442	CL1/CR1	Surface Dressing	05/07/2008	69,452
Scheme 3218 (2889m)	B3275	015	0	2889	CL1/CR1	Surface Dressing	23/06/2008	105,842
Scheme 3261 (1750m)	B3274	030	0	370	CL1/CR1	Surface Dressing	26/09/2008	79,789
	B3274	035	0	1380	CL1/CR1	Surface Dressing	26/09/2008	
Scheme 4243 (1017m)	A3059	012	960	1977	CL1/CR1	Overlay	05/03/2009	89,587
Scheme A39/205 ** (266m)	A0039 Falmouth Carland	205	980	1250	CL1/CR1	Overlay	14/10/2007	25,000†

* *Individual scheme cost was not available. The combined cost of Schemes 138 and 139 was available. Cost of individual schemes estimated proportionately to the length of scheme and a 1:2 cost ratio for Surface Dressing to Overlay or Inlay treatment.*

** *This is not the actual scheme name used by Cornwall*

† *Cost of this scheme is an estimate based on the cost of the other schemes as the actual cost was not available at the time of the analysis*

Figure 4 demonstrates the number of yearly collisions (by severity and road surface condition) before the maintenance took place, versus the number of collisions occurring in the first year following the maintenance.

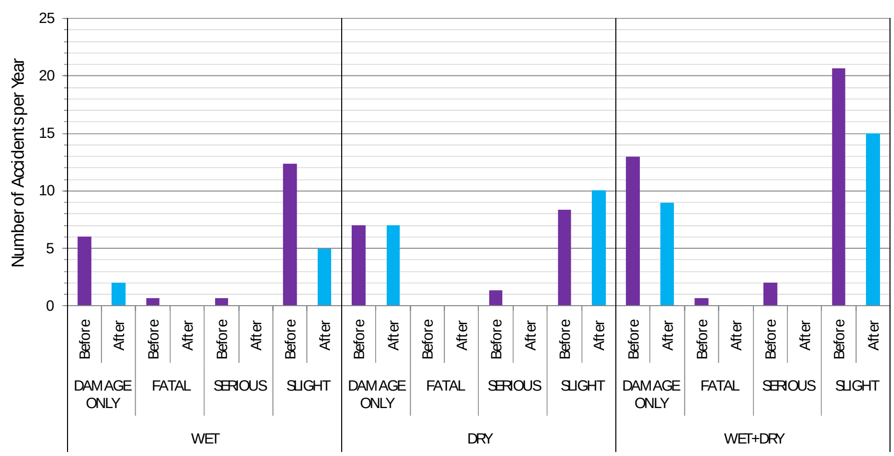

Figure 4: Collisions 'Before' and 'After' Maintenance for all Sites Combined

It can be seen from Figure 4 that Wet collisions of all severities have reduced following the maintenance work. Wet KSI's were eliminated (note only 1.3 Wet KSI's per year was observed before maintenance). In terms of Dry collisions, there was a slight increase, however, it was only a marginal increase. Dry KSI's were also eliminated (again only 1.3 Dry KSI's per year observed before maintenance). The combined Wet + Dry collisions per year have been reduced in all severities. The Wet + Dry KSI's were eliminated (from 2.7 per year before maintenance).

A detailed analysis of these findings is presented below. The yearly number of collisions for all schemes before and after maintenance are summarised in table 6. This presents essentially the same data portrayed in figure 4.

Table 6: Collisions 'Before' and 'After' Maintenance

All Schemes	Damage Only Collisions per Year			Injury Collisions per Year		
	Before	After	Reduction	Before	After	Reduction
Wet Only	6	2	4	13.7	5	8.7
Dry Only	7	7	0	9.7	10	-0.3
Wet + Dry	13	9	4	23.3	15	8.3

Prior to the maintenance activities, all nine schemes together had an average of 36.3 collisions per year in both Wet + Dry conditions. In the first year since the maintenance schemes, the number of collisions reduced to 24. This is a 34% reduction in the total yearly collisions for all sites. Injury Collisions fell by 36%.

In terms of Wet Collisions Only, before maintenance, the sites had 19.7 Wet Collisions per year, whereas after maintenance it reduced to 7. That is a significant 64% reduction in Wet Collisions. Wet Injury Collisions also reduced by 64%.

Dry Collisions appear to have stayed almost the same. The yearly total Dry Collisions before maintenance was 16.7, and after maintenance marginally increased to 17.

The FYRR for Wet + Dry Collisions and Wet Collisions Only options are shown in Table 7

Table 7: Overall FYRR

All Schemes	Wet + Dry Collisions		Wet Collisions Only	
Cost	Value of Collision Reduction	FYRR	Value of Collision Reduction	FYRR
£707,488	£635,443	90%	£665,687	94%

The FYRR's indicate that all nine schemes combined delivered 90-94% return on the investment after the first year.

The Transport Analysis Guidelines for collisions specifies that the average value of prevention of road collisions varies depending on the severity of collisions. Therefore, an alternative total value of the collisions prevented at these sites was calculated based on collision severity. The yearly number of collisions by severity for all schemes, before and after the maintenance, are summarised in Table 8. Again, this is the same data portrayed in figure 5.

Table 8: Collisions by Severity

All Schemes	Damage Only			Slight			Serious			Fatal		
	B	A	R	B	A	R	B	A	R	B	A	R
Wet Only	6	2	4	12.3	5	7.3	0.7	0	0.7	0.7	0	0.7
Dry Only	7	7	0	8.3	10	-1.7	1.3	0	1.3	0	0	0
Wet + Dry	13	9	4	20.7	15	5.7	2	0	2	0.7	0	0.7

***B**-Before, **A**-After, **R**-Reduction*

In terms of Wet + Dry collisions, Damage Only reduced by 4, Slight reduced by 5.7, Serious reduced by 2, and Fatal reduced by 0.7. In terms of Wet Collisions Only, Damage Only reduced by 4, Slight reduced by 7.3, Serious reduced by 0.7, and Fatal reduced by 0.7. Two fatalities were recorded in these sites in the last 3 years, equating to the reduction of 0.7 fatal collisions per year. None of the sites experienced a fatality since maintenance.

The FYRR for Wet + Dry Collisions and Wet Collisions Only options are shown in table 9.

Table 9: Alternative FYRR

All Schemes Cost	Wet + Dry Collisions		Wet Collisions Only	
	Value of Collision Reduction	FYRR	Value of Collision Reduction	FYRR
£707,488	£1,878,712	266%	£1,634,559	231%

The increase in FYRR (compared to the earlier FYRR option) is mainly due to the influence of introducing collision severity, especially as the value of fatal collisions is significantly higher than other severities. The FYRR's indicate that all nine schemes combined, delivered excellent return on investment.

The study indicated that the benefits (collision savings) of all nine schemes combined would outweigh the cost of the treatments within a very short period (approximately 13 months). The alternative FYRR based on collision severity indicated that the collisions saved in the first year outweighed the costs in a matter of about 5 months.

Due to the improved skid resistance, more collisions are expected to be prevented in future years. The typical life of a surfacing is in excess of 10 years and the returns or benefits will accrue over that period with no further expenditure. This demonstrates that skid resistance improvements in the network result in high value for money in the long-term, and improve road safety.

Summary of Skidding Deficiency and FYRR of All Schemes

Table 10 below lists the seven schemes that have skidding data for before and after maintenance. It shows the percentage of skidding deficient length before and after the maintenance, the percentage length of skidding deficiency eliminated, and the Wet Collisions Only FYRR of the schemes.

The schemes are listed in the descending order of the Wet Collisions only FYRR. It is noticed that high FYRR is achieved from sites that had a large proportion of skidding deficient length before maintenance. In the examination of individual schemes, it was observed that sites with a large proportion of skidding deficiency commonly also contained a notable amount of high skidding deficiencies (i.e. considerably below the IL). After the maintenance works have been carried out on such sites, it appears that most of the worst skidding deficiencies have been eliminated. This indicates that higher FYRR's were achieved from sites that initially contained a large proportion of skidding deficient length where the scheme eliminated the worst deficient areas and significantly improved the skid resistance at the site.

Table 10: Summary of Skidding Deficiency and FYRR of All Schemes

Scheme	% of Scheme Length			FYRR (Wet Acc Only)
	Skid Deficient Before	Skid Deficient After	Reduction in Skid Deficiency	
A39/205	91%	64%	27%	507%
2579	78%	46%	32%	328%
3261	95%	36%	59%	226%
139	61%	41%	21%	115%
178	23%	15%	8%	54%
26	53%	21%	32%	1%
138	30%	14%	16%	-30%

From the foregoing, it can be noted that all sites treated showed some degree of skidding deficiency even after treatment. The vast majority of the schemes were implemented in mid 2008 or early 2009 and the skidding resistance survey was undertaken at all sites in July 2009 with the exception of one site, where the work was carried out in October 2007 and the skidding resistance survey in June 2008. In all instances, the survey of the post treatment skidding resistance was carried out after about a year in service. It is, therefore, perfectly possible that the values measured may not have reached equilibrium due to 'early life' effects. In terms of FYRR, the summary data in Table 10 shows a wide spread; in part this can be attributed to the fact that some sites have been extended to include lengths which, whilst not hugely deficient or problematic, have nevertheless been treated on an asset management basis to prevent deterioration or a second visit within a relatively short timescale.

CONCLUSION

The studies outlined in this paper have demonstrated the value both in human and economic terms of the implementation of a skidding policy in Cornwall. Further, the work clearly demonstrates the benefits of targeting treatments at sites where it is known that a significant risk of a wet skidding related collision exists by virtue of collision history, traffic speeds and / or site configuration. The methodology also allows the Asset Manager to make an assessment of the risk presented by similar sites where, although there is no collision history, it can reasonably be inferred that such a collision is highly likely, and furthermore, its consequences are potentially severe both in terms of lives and life changing injuries.

Clearly, we live in challenging economic times; the need to demonstrate value for money and the delivery of challenging casualty reduction targets are ever present. The work carried out by Cornwall Council and W.D.M. Limited demonstrates that a rational analysis of skid resistance and collision data can take historic, network-wide data and develop a methodology which allows limited financial resources to be targeted at those sites where the greatest beneficial effect can be achieved and in doing so, achieve real demonstrable savings in terms of injuries and the associated financial costs to the wider society.

REFERENCES

The management of Skidding using SCRIM Investigatory levels to identify, manage and set priorities. – Safe Roads 2008, Mark Stephenson, Robert Epps and Kevin Bryant.

Using SCRIM investigatory levels to identify, manage and set priorities - the investigation process - Safe Roads 2008, Andy Stevenson, Matt Philips and Steve Trotman.

Design Manual for Roads and Bridges, Volume 7, Section 3, part 1, HD28/04: Skid Resistance, Highways Agency, 2004.

Highways Economics Note No 1, 2005 Valuation of the Benefits of Prevention of Road Accidents and Casualties -Department for Transport January 2007.

Transport Analysis Guidance Unit 3.4.1, Accidents Sub-Objective, Department of Transport, April 2009

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Anuradha Premathilaka

Anuradha Premathilaka is a Senior Project Engineer in the Consultancy Division at W.D.M. Limited in Bristol in the UK. He is currently involved in a variety of asset management consultancy projects with a number of highway authorities in the UK. Prior to coming to the UK in 2008, he worked in New Zealand at Fulton Hogan Limited as a Regional Technical Engineer, and at Downer EDI Works Limited as a Project Engineer. Anuradha has a Bachelor of Engineering (Civil), a Master of Engineering Studies (Transportation), and a PhD in Civil Engineering from the University of Auckland, New Zealand. Anuradha is a Chartered Engineer and an International Professional Engineer (NZ), and is a Corporate Member of both the Institution of Civil Engineers (UK) and Institution of Professional Engineers New Zealand.

John Donbavand

John began work in NZ after completing his PhD in the UK in 1983. John worked in NZ for 18 years and has held a number of positions including research scientist studying bitumen for the New Zealand Ministry of Works, Surfacing Scientist for the National Roads Board and Transit New Zealand and Engineering Policy Manager for Transit New Zealand. John returned to the UK in 2001 to take up the position as Project Development Manager at W.D.M. Limited. In this position, John has been involved with a wide range of projects, including: developing procedures to estimate the national maintenance budgets for Highway Agencies, asset valuation for local roads, providing scheme prioritisation techniques for Highway Authorities, providing skid policies and training for site investigation. John was also a member of the TRL group that assisted the Highway Agency to develop the latest HD28, to be published in 2011.