THE MANAGEMENT OF SKID RESISTANCE ON A STATE HIGHWAY NETWORK

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ABSTRACT

Works Infrastructure Ltd manages the state highway network for Transit New Zealand in the Northland Region of New Zealand. The network is managed on a performance basis, using key performance measures to manage the delivery standards specified in the contract. Providing and maintaining an appropriate level of skid resistance is an important priority for network management.

The Northland network is some 750 km in length and passes through a wide variety of terrain types and degrees of geometric difficulty. Heavy goods vehicle traffic levels are high in some sections, leading to rapid polishing of surface aggregates and a consequent rapid loss of skidding resistance, particularly in sections of terrain with corners of low radii.

Experience has indicated that skid resistance levels on the network can not be assumed adequate simply based on a network survey performed once a year as the skid resistance, as measured by the SCRIM machine changes rapidly, depending on weather conditions and traffic loading. The recorded skid resistance is also affected by uncertainty associated with spatial referencing issues and the precision limits of measurement.

This paper is a review of the some of the various issues facing a network manager, such as

- The background and development of test procedures
- Aggregate quality and its polished stone value (PSV)
- The precision (repeatability and reproducibility) of the data
- The uncertainty and interpretation of data used to interpret key performance measures
- The locational accuracy of data collection

The review describes investigation and work, previously published and unpublished, relating to the network and illustrates the issues to be considered by a highway network manager when using key performance measure assessment techniques.

1. MANAGEMENT OF SKID RESISTANCE ON A STATE HIGHWAY NETWORK

1.1 INTRODUCTION

Works Infrastructure Ltd (Works) and Transit New Zealand (Transit) have joint-stewardship of the state highway network and assets in Northland, with Works responsible for routine management and physical works and Transit responsible for governance and ownership.

The network is managed under a performance specified maintenance contract (PSMC 002) (1) and uses key performance measures (KPM), such as skid resistance, roughness, texture and rutting to manage delivery. Measures, such as management performance and operational performance measures, govern other parts of the work.

The network is approximately 750 km long and passes through many terrain types. Heavy vehicle traffic levels are high in some sections, leading to rapid polishing of surface aggregates and rapid loss of skidding resistance, particularly in sections of terrain with low radii curves. These curves account for an equivalent lane length of over 200 km (2).

The KPM for skid resistance is based on Transit's T/10 standard (3). This defines levels of skid resistance in five categories of investigatory level (IL) using the Mean Summer SCRIM Coefficient (MSSC). SCRIM is an acronym for the "Sideways Force Road Investigation Machine," operated in New Zealand by WDM Ltd of the UK. Development of the SCRIM machine, its use and specifications are described elsewhere (4, 5, 6). Works contracts WDM Ltd to undertake its annual network KPM survey, where the KPM for skid resistance is taken as the mean SCRIM measurement over a ten metre length.

WDM Ltd also annually surveys the PSMC 002 network for Transit, as part of the national survey. Thus, the PSMC 002 team has access to two 1430 lane-km surveys every year to assist management activities. This is a significant benefit which has provided an in-depth knowledge of the vagary of measuring, assessing and managing skid resistance at a network level.

Experience shows skid resistance and network KPMs can not be assumed always safe and compliant simply based on network surveys as MSSC values change rapidly, dependent on weather conditions and traffic loading, often within short time frames and on a daily, weekly basis. This paper is a review of some SCRIM research and investigation work on the Northland network. It reviews some of the issues facing a network manager, such as

- The background and development of test procedures
- Aggregate quality and its polished stone value (PSV)
- The precision (repeatability and reproducibility) of the data
- The uncertainty and interpretation of data used to interpret key performance measures
- The locational accuracy of data collection

This paper revisits some previously published (7, 8) and unpublished investigation and research relating to the network and the issues to be considered by a highway network manager. Finally, this conference includes five other papers referring to the assessment and management of SCRIM on the PSMC 002 network so, given the review nature of this paper some overlap may occur. reference should also be made to these other papers for a full overview of variability and environmental effects. In this paper, *sealing chip* is often referred to generically as *aggregate*.

2. SKID RESISTANCE

2.1 BACKGROUND

The background to the measurement of skid resistance is described elsewhere (4). Transit has also held a number of seminars and workshops throughout New Zealand in recent years. However, some comment on the testing of aggregates used for surfacing in New Zealand and the UK Transport Research Laboratory (TRL) work, on the contribution to skidding resistance of a road surface, of the factors of macro- and micro-texture and polished stone value (PSV) of the surfacing aggregates, is still appropriate.

2.2 POLISHED STONE VALUE (PSV) AND AGGREGATE ABRASION VALUE (AAV)

The PSV test was developed to assess the susceptibility of aggregate to polishing and to study the relationship between surfacing materials and safety (4).

The procedure to determine the PSV of an aggregate is a 2-stage test, with the first stage comprising accelerated polishing, followed by determination of the resulting friction value using the British Pendulum tester, Fig. 1. The polishing machine and pendulum tester were both developed by the Road Research Laboratory (forerunner of TRL) to study the effect of pneumatic tyres on aggregate. The procedures are described in BS EN 1097-8 (9) and Road Note 27 (10).

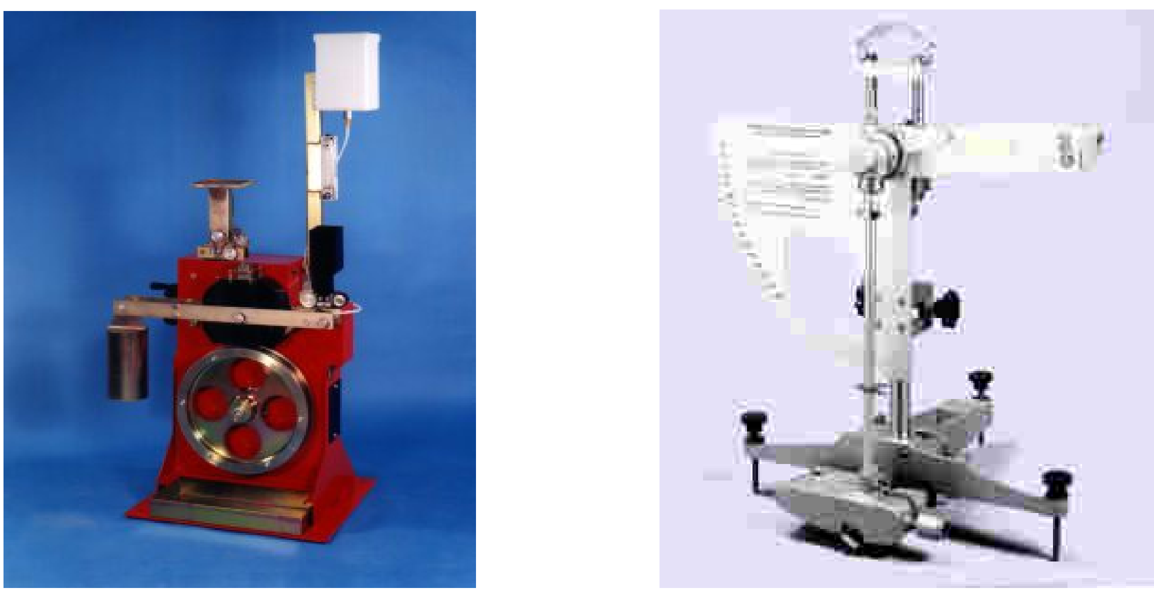


Fig. 1 Accelerated Polishing Machine (left) and the British Pendulum Tester (right)

The test procedures are very empirical with minor deviations from the standard having significant effect on the resulting PSV[1]. The polish resistance of any aggregate can be assessed and then ranked alongside other aggregates, with the polish rate being a function of its mineralogical properties. Some aggregates polish faster than others and deteriorate in

[1] The repeatability of the test is between 3-5 units of PSV.

service. So TRL also developed an aggregate abrasion value test (AAV), to measure and specify wear resistance. This test is described in Annex A to BS EN 1097-8 (9).

The AAV test measures resistance to surface wear by abrasion under traffic, with inadequate resistance to abrasion causing early loss of the texture required for high-speed skid resistance (11). The test measures different aggregate properties, compared to the Los Angeles Abrasion Value Test (LAAV) (ASTM C131 and C535) specified in our M6 and M21 chip specifications.

The LAAV test measures degradation of the aggregate upon impact of a 25 kg charge, although there is undoubtedly some abrasion loss due to grinding in the test, however, this does not adequately represent abrasion under tyre action, as simulated within the AAV test.

Significantly, the scope of the current edition of BS EN 1097-8 notes that the AAV Test should be used when assessing aggregates with a PSV of 60 or greater which can be susceptible to abrasion under traffic.

Investigations covering aggregate sourced around New Zealand were carried out many years ago at Canterbury University (12). Seddon reported a poor correlation between PSV and Los Angeles Abrasion Value and commented:

> *“This (*poor correlation*) is consistent with other findings overseas and illustrates one of the problems in specifying sealing chip, i.e. good LAAV tends to correspond with poor PSV and vice versa.”*

There was better correlation when the materials were grouped into either gritstones or basalts. Seddon also noted that AAV testing, rather than LAAV testing, was used in conjunction with PSV testing, when considering the quality of aggregate to use for skid resistant surfaces.

Considering that quantitative assessment of the wear characteristics of surfacing aggregates using the AAV test do not appear to have been done in New Zealand, perhaps the Aggregates Industry should urgently be looking at this test, as some aggregates currently used for their high PSV properties have been observed to wear quickly in service, losing both skid resistance and macro-texture and have provided short life.

Sealing chip used in some locations have been observed to quickly fail in service, to the extent that contractors have had to replace chip seal surfacings within the defect liability period. In other locations, the aggregates used have failed to meet the T/10 intervention levels in very short time, even though the material supplied and used met the requirements of T/10.

In Northland, some sites, situated on SC2 low radii corners, are resealed frequently to maintain skid resistance, with many sites appearing to require the use of a much higher PSV chip than indicated by the use of the T/10 approach (13). Recently, we imported an aggregate with PSV 65 from outside Northland for several locations. After 2 seasons, these sites, while having adequate texture, now fail SCRIM, with inspection revealing polished chip as the problem.

This is economically and environmentally unsustainable, with frequent resealing leading to unstable seal layers and flushing which then requires early pavement rehabilitation intervention to restore safety.

Investigation and research is required to overcome this problem which seems also to be affecting other networks about New Zealand, particularly in the North Island, where traffic volumes are heavier and aggregate resources with high PSV are not readily available. The T/10 approach also needs review to ensure the required outcomes can be delivered.

2.3 THE USE OF T/10 AND THE PREDICTION OF SFC

As well as investigating the required aggregate qualities that contribute to skidding resistance, TRL also investigated the relationship between the volumes of commercial vehicles, PSV and AAV of the surfacing aggregate and the relative risk of skidding on the highway (14). This work led to the relationship of PSV and skid resistance used to prepare the "relative risk rating charts" now used in the UK for the management of network skidding resistance (15), more recently updated by the Highways Agency (5). TRL's work gave rise to the well-known formula (1), Equation 1:

$$SR = 0.024 - 0.0000663*CVD + 0.010\ PSV \quad (r^2 = 0.85) \qquad \text{(Equation 1)}$$

which can be re-arranged to make PSV the dependent variable,

$$PSV = 100*SFC + 0.00663*CVD - 2.4 \qquad \text{(Equation 2)}$$

In these equations, CVD is the number of commercial vehicles exceeding 1.5 tonne/lane/day. In New Zealand, the T/10 equation has adapted this to

$$PSV = 100*SR + 0.00663CVD + 2.6 \qquad \text{(Equation 3)}$$

In New Zealand, a CVD is a vehicle with mass exceeding 3.5 tonne, so the difference has been accounted for by an additional 5 units in the constant in Equation 3. This is to allow for the different vehicle classifications and the polishing effects at locations where severe braking, cornering or accelerating occurs. However, this may not be enough. As observed above and elsewhere (13), rapid polishing and declining skid resistance has been noted in New Zealand.

In Northland, rapid loss of skid resistance typically occurs on SCRIM Category 2 chip seal sites, where short life cycles (< 2-3 years) are experienced. In recent years, the use of an additional stress constant within Equation 3 has been advocated in workshops. However, even this has proven inadequate, with the highest natural PSV aggregate in the North Island, shown to not retain skid resistance (13).

So, the important point to consider above, relating to network management, is that the use of a natural aggregate of high PSV does not always provide a long-life durable and skid resistant road surface, particularly in areas such as SC2 corners. Again, more research is required.

3. DATA COLLECTION ON THE PSMC 002 NETWORK

3.1 SCRIM DATA COLLECTION

SCRIM on PSMC 002 is specified by reference to key performance measures (KPM), differentiated by sub-network (1). A contractual requirement is the annual collection of condition data by a high-speed survey. The resulting data is analysed and compared to the contracted KPM requirements for rutting, roughness, texture, and skid resistance[2].

As at March 2005, Works has undertaken one KPM benchmark and two routine annual KPM surveys. The next survey is in April 2005. Four national surveys have been done over the same time frame, providing seven surveys for analysis. The equipment and operators, in each annual survey round, have been essentially the same each year.

[2] Only skid resistance data is discussed in this paper

In the first two years, the dual surveys presented an opportunity to gain an understanding of the repeatability and reproducibility of SCRIM measures, within our Northland environment, as described below. In Season 1, the benchmark survey was done in December 2000, at the same time as the national survey, with some sections of network re-surveyed within hours and, in other sections, later that day or the next.

At first, this duplication of measurement was considered a waste of effort. However, after data analysis, it was realised an insight into the uncertainties associated with SCRIM measurement had been gained. The uncertainty related to the SCRIM KPM refers to issues, such as:

- Data uncertainty and statistical variation
- Random and systematic errors
- KPM Model uncertainty
- Environmental effects (daily, weekly, seasonal variations)
- Spatial variability on the network (locational referencing and the tracked path)
- Precision of the data collection process

The potential uncertainties in SCRIM KPM models relate to two key areas:

- Input uncertainties: what is the precision, repeatability of the measure and how large are the possible uncertainties?
- Output uncertainties: how do we visualize and communicate uncertain results?

Perhaps we should also address the translation of the input uncertainties to the output?

Currently, we address the input issue by validation testing and calibration of the SCRIM machine and the use of a very robust SCRIM quality assurance plan, but precision issues still arise in data collection so statistical techniques (regression etc) are used for analysis.

On the output side, issues arise related to normalization for speed, correction factors such as the seasonal factor, calculation of MSSC and now ESC. MSSC adjusts the measure across the season and ESC across seasons, both being a form of ‘smoothing’ of the data. The uncertainties all add up to risk for the Network Manager and Contractor when they are transformed into KPM requirements.

Without a thorough understanding of uncertainty, difficulties will arise in demonstrating compliance, as described below. Limited review of the data below has been presented elsewhere (7). It is reviewed here to show the interpretation issues that can arise.

3.2 SCRIM DATA ASSESSMENT

After SCRIM data is collected, it is normalized for collection speed and adjusted by applying a seasonal correction factor. In Season 1 (2000), the correction factor was the same for both benchmark and national survey as they were done in the same time frame. In Season 2, there was a 3 percent difference between the two data sets. The factor normalizes both surveys to permit comparison.

Benchmark v National Survey December 2000

Before describing the survey results, it is useful to describe the data handling and statistical technique used.

- Only data in SCRIM Categories 1 and 2 was considered.
- In each survey, data was collected as the mean SCRIM measure over the 10-m lengths, in each wheel path, in both lanes, and analysed within an EXCEL spreadsheet.

- The data pairs within each ‘survey’ (2 in December 2000 and December 2001 and April 2002) were compared using normal distribution frequency techniques.
- It was assumed the SCRIM truck traverses the same path, to be able to take the difference in readings in each 10-m length, to obtain the distribution of differences in skid resistance measured. This assumes the same spatial positioning of the SCRIM truck in each survey.
- If all is perfect, there will be no difference in the compared runs, returning a difference at each 10 m location of zero and 100 percent of results grouped about the central tendency. If there was any form of bias, the data spike would be displaced from the central position.
- It is impossible for the SCRIM truck to traverse the same path each run so differences will occur. The frequency distribution of differences permits an assessment of repeatability. Due to the volume of data points[3], the spread of the differences should approximate a normal distribution, with the same principle applying for all SCRIM categories.
- The data can be analysed two ways:
    - o Firstly, by ignoring the sign of movement, providing a simple frequency distribution
    - o Secondly, by taking account of the sign of movement of the measure. Intuitively, this is what happens in the field, with skid measures above or below what was measured on the first run. In this instance, we expect to see a normal distribution of values.

The first approach, given here for SH1N data for SCRIM Cat 1 and 2, ignoring the sign of difference, provides a conventional feel for the data. Table 1 shows nearly 80 percent of the data ‘changed’ within 0.05 SCRIM units between the two survey runs, even though this was only hours apart. While the degree of change is small, the quantum represents a potential problem of change and resulting compliance or non-compliance with the specified KPM.

MSSC Difference between runs	**Frequency in LWP**	**Frequency in RWP**	**Total in band**	**% in band**	**Cum. %**
>0.5	12	40	52	0.04	0.04
>0.4 to 0.5	142	172	314	0.27	0.31
> 0.3 to 0.4	313	355	668	0.57	0.88
> 0 2 to 0.3	564	562	1126	0.95	1.83
> 0.1 to 0.2	2074	2504	4578	3.88	5.71
> 0.05 to 0.1	8700	9760	18460	15.65	21.36
> 0 to 0.05	41575	41227	82802	70.18	91.54
0	4819	5167	9986	8.46	100
Total	58,199	59,787	117,986	-	-

Table 1 Difference in runs, SH1N December 2000

Nearly six percent of differences exceed 0.1 MSSC, the same as the interval (IL – TL), indicating high uncertainty levels for SH1N. A significant management risk is indicated. About 10,000 measurements (8.4 percent) didn’t change between runs.

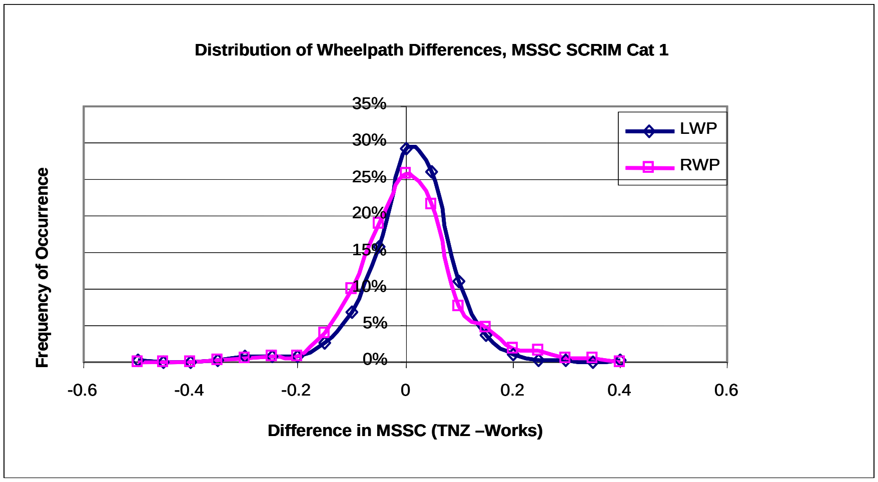
The mean difference, and standard deviation of the difference in runs, for this grouped data is 0.04 and 0.05 respectively. A mean difference approaching (IL-TL) and a standard deviation of difference, of the same magnitude, will cause problems when KPMs are based on levels of deficiency below the TL, unless the KPM is set to reflect the uncertainty indicated above.

[3] Over 92,000 points on SH1N alone

Figure 2 shows the difference in distribution by the second method. Ignoring the sign difference, the spread of results in the two runs vary significantly, 0.4 and 0.7 MSSC.

A significant number of results lie in the interval ∀0.05 MSSC (0.1 MSSC) about the central limit tendency, which equates to the interval between threshold and intervention (IL-TL). But, alarmingly, a lot of data sets fall above ∀0.05 MSSC. It is encouraging to see the data here is approximately normally distributed and falls about the mean (zero) difference position.

The difference in the two surveys is a reasonable indicator of measurement repeatability (same conditions, crew and equipment). Consideration of the average wheel path differences indicates MSSC results vary significantly, more than the difference between adjacent site categories in TNZ T/10 (0.05 SFC), and is a process issue related to measurement uncertainties.



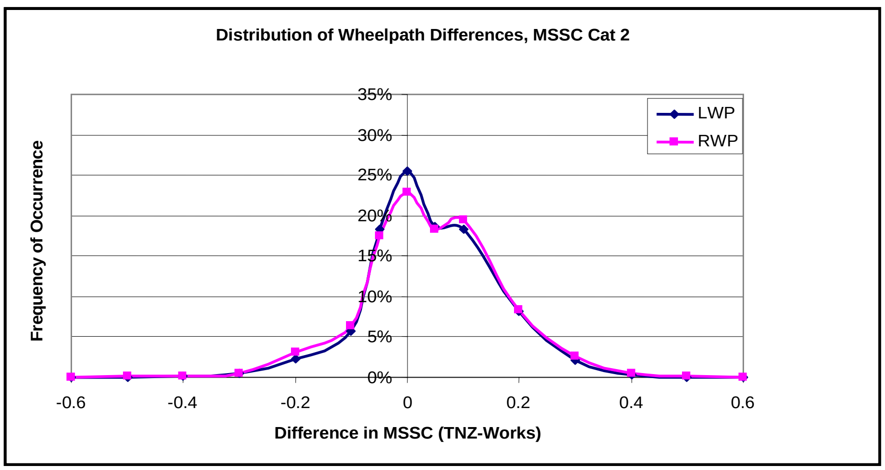
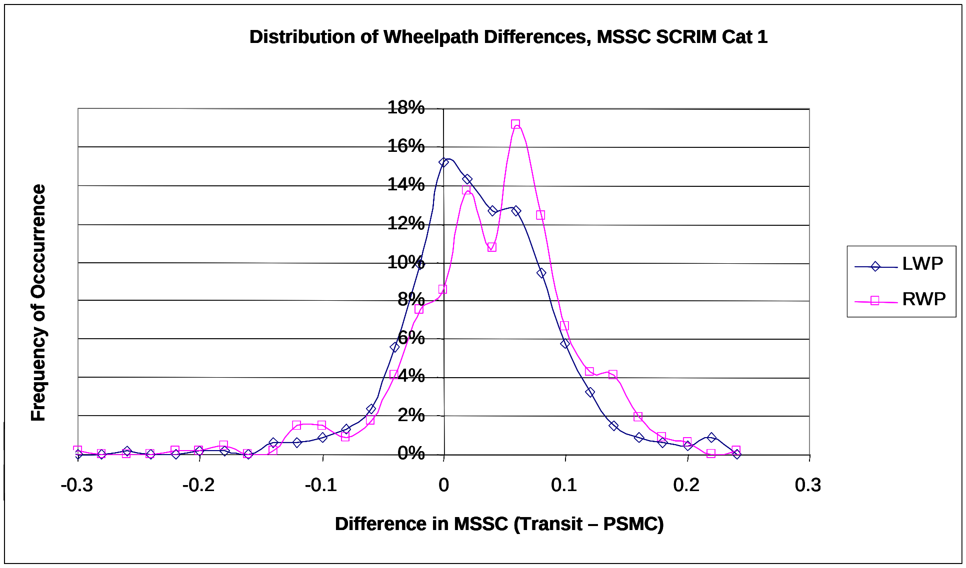


Figure 2 Skid Site Categories 1 and 2, Dec 2000 Surveys Distribution of Wheel Path Differences

This is a measure of the limit to comparison, and this becomes important when evaluating a Contractor's performance against KPMs. The results demonstrate how the repeatability measure and the indicated standard deviation of measurement need to be considered when using a KPM based on the difference of IL and TL and is something that needs to be considered.

National Survey v KPM Survey (Dec 2001 and April 2002)

The 2001 KPM survey was done at the end of the season, with the national survey done in December. The objective was to see if the effect noted the previous season was replicated.



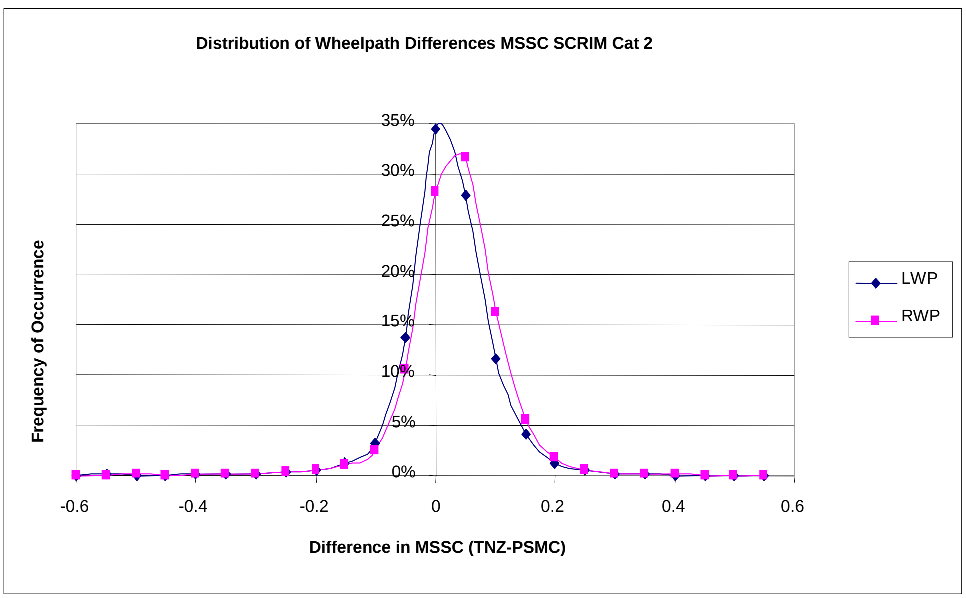


Figure 3 Skid Site Categories 1 and 2, Dec 2001 and April 2002 Surveys Distribution of Wheel Path Differences

The calculation procedure used to prepare Figure 3 was identical to that performed for Fig. 2. The same tendencies noted occur but we now see considerable differences in the SCRIM Cat 1 data, with some bias away from the central tendency, illustrating the volatility of this category. The data for SCRIM Cat 2 is more stable and illustrates the same tendency as seen in 2000. The wheel path differences vary between 0.04 and 0.06, with a considerable spread of data and there is some bias. Other issues became evident with this survey data, notably the effect of locational referencing errors, more pronounced for SC1 sites. There were also seasonal and environmental factors indicated. These are not discussed here.

3.3 LOCATIONAL REFERENCING PROBLEMS

The data volatility in SC1 prompted a review of what might cause this problem.

The amount of SC1 data collected on the sub-networks is very small. At these locations, 50 metres either side of the event is classified as the SC1 site. In measuring these sites, it is essential the measured SCRIM value is in “the correct location,” particularly if you have invested in high PSV chip or calcined bauxite treatments. The situation of a high PSV bauxite crossing, indicated as failing SCRIM, prompted a review. On examination of the SCRIM data, the measures related to the crossing had been displaced “down the road!” How does this occur?

To illustrate this problem, the longitudinal route position accuracy of the SCRIM measure needs to be taken into consideration. The tolerance permitted by the Distance Marking Standard is

$$\forall(10\text{m} + 0.3\% \text{ of the length surveyed}) \qquad \text{Equation 4}$$

Over a 15-20 km route station, this is 45-70m. Although this is ‘rubber-banded’ over the survey length, it introduces uncertainty. Even if the location is within the tolerance, the site can be displaced by the constant, up to 10 m, before an exception is prompted in the process.

‘Rubber banding’ distributes locational errors and is an acceptable approach. It generally works well; however, problems do occur, particularly for SC1 sites. These are only 50 m long, each side of an event site. For example, in Northland Network N2, there are two SC1 sites, representing a length of 200 lane-metres in 216 lane-km.

With a KPM limit of two percent deficiency, only one 10-m section in N2 needs to fail to miss the KPM. As indicated above, this can occur, within the tolerance of the measurement. Similar SC1 problems exist in all Northland networks. We have not yet come up with a suitable solution other than locating these sites by laborious manual search of the data - but we still record failures.

To consider locational uncertainty in another context,’ consider the effect of displacement on the nominal site category at any given location. Currently, all locations measured in a survey are assigned a category that is electronically determined during the survey according to the geometry of the survey run itself. This means the particular track followed by the SCRIM truck is crucial. In particular, SC2 sites are fixed by the curvature and gradient[4].

The data for December 2000 SH 1F was reviewed and the site categories assigned in each survey run for each 10-m band was checked. This indicated 440 x 10-m lengths ‘changed’ Site Category between runs on the same day. Most of these changes occur at the start or finish of a site category, indicating locational error and ‘rubber-banding’ related to the adjustment formula. The main areas affected are SC2 and SC3 sites.

The ‘work-around’ we have adopted to overcome this problem involves validating a longitudinal route position file every year. The standard file used in the national survey is the RAMM file for each route station. In Northland, there are 51 route stations ranging from 4 km to about 25 km long. The LRP file now used has split the network into 146 sections about 5 km long, based on fixed points on the network, such as intersections and bridge ends. The longitudinal accuracy involved in using short lengths has greatly improved the accuracy of our surveys, to the extent that we no longer encounter much movement between categories – but some still occurs!

[4] It is understood SC1 sites are fixed by the survey personnel during the survey

4. DISCUSSION

Above, some issues to consider when managing SCRIM have been discussed. Aggregate issues were highlighted, indicating concerns with respect to the wear characteristics of some materials which need to be resolved, perhaps by a round of testing using the AAV process.

It is also clear that uncertainty exists with respect to the measures obtained and also that the use of what appears to be a readily achievable KPM, based on the difference in (IL-TL) may in fact be difficult to consistently achieve.

The mean variation in SCRIM, within hours, was found to be 0.04 MSSC units. It was also noted that the standard deviation of test measurement was 0.05 MSSC units. It was only considered here that this difference might be caused by test processes. Not discussed above, but also of concern are the environmental uncertainties. These can also significantly affect the result.

Because the distribution of mean differences in the SCRIM results approximates a normal distribution, we can expect about 95 percent of our test results to fall within a range of ∀0.1 MSSC units, i.e. 2 standard deviation intervals above and below the mean.

The KPM is based on a minimum value (a one-tail test) so if the IL was to then approximate the central tendency of the normal distribution (the average or mean value), and the aggregate used was to target this point, as expected using the T/10 Equation (which uses the IL or minimum sfc value for the category) then, statistically we can always expect deficiencies to be recorded. To overcome this, a provider would have to use an aggregate of quality such that the mean SCRIM value is then displaced, as shown below (Figure 4, left).

This may mean using aggregate of higher PSV than that traditionally used on some networks and may be economically unsustainable. Alternatively, we could seek to improve the precision of measurement and reduce the spread of results (Figure 4, right).

Figure 4 below illustrates both these two scenarios. An alternative, not discussed here, is to accept the current SCRIM measurement as the best that can be achieved at the current time and lift the level of deficiency to an achievable level. This would require a KPM review and improvement process before any change could be agreed and implemented.

Another course of action is a variable IL, based on a review of a particular site. The T/10 process is a risk-based approach that assumes the same consequence arises at all sites within a site SCRIM category throughout New Zealand. Although the T/10 Notes suggest it is possible to re-assign an IL, there is no investigation or risk management process suggested, such as that in the Highway Agency Guidelines (5), a flow chart of which is reproduced below as Figure 5. The purpose of including this chart to offer suggestions of some points we could consider when reviewing a site IL. Another paper presented here (13) makes some suggestions also.

The use of improved LRP files can certainly improve KPM assessment, as described above, however, the assessment of compliance for SC1 sites is difficult and at the moment needs to be done manually rather than just assessing this within spreadsheets, to ensure the correct 'site' is identified. This can be very difficult if conventional PSV aggregates are used.

The locational referencing accuracy currently achievable also indicates a compliance error of up to 20 percent per site can easily be recorded (10 m error in 50 metres).

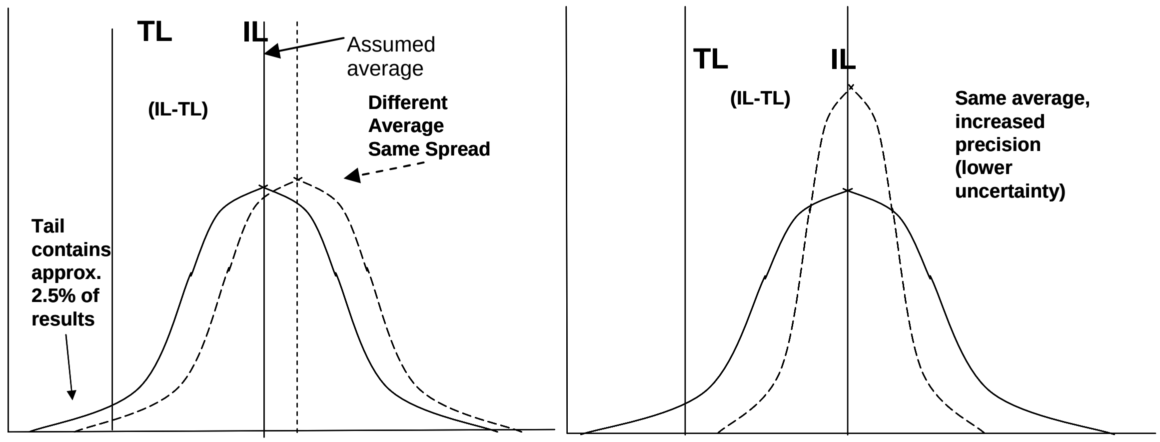


Figure 4 KPM Statistics

Assessment of SC2 sites is problematic, with rapid polishing of aggregate on high-stress sites. Experience indicates the T/10 approach is not delivering the right result as described elsewhere (113) and some high PSV aggregate is not delivering the in service life predicted by T/10. This causes issues with asset management for value, often driving unsustainable work. Discussions with other contractors suggest this problem is not uncommon on a number of networks.

Finally, it is not all doom and gloom; Table 2 below indicates the current situation in Northland (16). Although there are compliance issues with SCRIM in Northland, which we are currently working to close, the table, based on a simple linear regression of the compliance level in each network over 5 years, indicates an improving situation across the network. The SC1 deficiency in N5 relates to two one-way bridge decks.

KPM	**Sub Network**				
	N1	**N2**	**N3**	**N4**	**N5**
Skid Resistance (Category 1) % Deficient	**Improving**	**Improving**	**Improving**	**Improving**	Deteriorating
Skid Resistance (Category 2) % Deficient	**Improving**	**Improving**	**Improving**	Deteriorating	**Improving**
Skid Resistance (Category 3) % Deficient	Deteriorating	Deteriorating	**Improving**	Deteriorating	**Improving**
Skid Resistance (Category 4) % Deficient	Deteriorating	**Improving**	Deteriorating	Stable	Stable

Table 2 – SCRIM KPM Trends on PSMC 002 Network

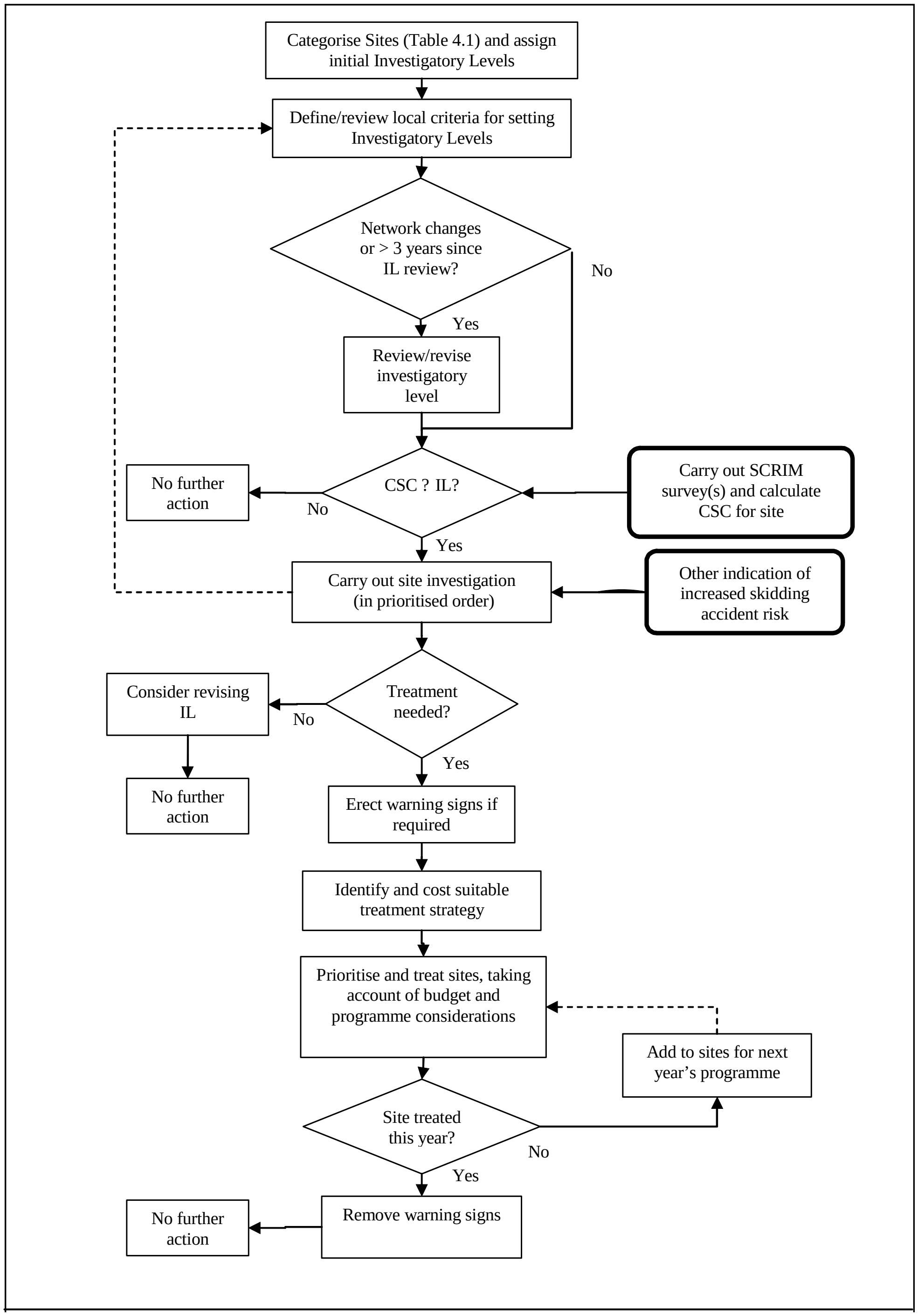


Figure 5 Investigatory Limit Review Flow Chart (ref. Highways Agency HD 28/04)

5. ACKNOWLEDGEMENTS

This paper is based on a review of work related to PSMC 002 network over the period 2000 to 2005. It draws on contributions from colleagues, in particular, Peter Houba, David Hutchison and Glen Kirk of Works Infrastructure,Chris Kennedy and John Donvaband of WDM Ltd and Richard Green of Transit New Zealand.

Vicki Daley of MWH Ltd, currently seconded to the Superintendent's Office, timely contributed with the trend analysis presented at Table 2.

The information and advice provided within the Advice Notes published by the Highways Agency in the UK is also acknowledged.

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7. DISCLAIMER

The opinions expressed above are those of the author. They should not be taken as those of Works Infrastructure Ltd, WDM Ltd (Sub-Contractor to Works) or of the Principal, Transit New Zealand.

The review and discussion is offered in the context of improving the state of art in New Zealand and the application of SCRIM as a process within the wider context of network management.