NOTES TO THE SPECIFICATION FOR SKID RESISTANCE INVESTIGATION AND TREATMENT SELECTION

These notes are for guidance and are not to be included in the contract documents.

1. SCOPE

These notes are to provide background information for addressing sites where treatment to improve skid resistance may be justified and to assist with the understanding required for the prioritisation of treatment.

2. INVESTIGATORY LEVELS

The state highway network has been divided into 5 site categories that reflect the required level of friction at each location, with Investigatory Level (IL) expressed as ESC.

Several site definitions have been included within Table 1 of the specification to ensure that ‘at risk’ sites are given the appropriate level of Skid Resistance. For example, approaches to stop and give way intersections where the control occurs on the state highway and approaches to one lane bridges including the bridge deck, have been included in site category 1.

Motorway on and off ramps have been included in site category 3.

3. MODIFICATION OF THE INVESTIGATORY LEVELS (IL’s)

Sites that have a history of crashes are investigated as part of regular safety inspections. If these crashes involve “‘loss of control” or “skidding in the wet” and the road surface at the site has an ESC value at or above the IL, this would be a valid reason to review the IL. The guidelines for assigning skid resistance levels are attached as Appendix A.

4. ANALYSIS OF SKID RESISTANCE DATA

A Sideway-force Coefficient Routine Investigation Machine (SCRIM) machine travels on an annual basis over the highway network during the summer period to measure the in situ wet road surface friction. The processed data is reported as the Equilibrium Skid Resistance (ESC) which is averaged over 10 metre lengths.

Esc values are defined as falling within three ranges:

- High; Values of ESC above the IL
- Medium; Values of ESC between IL and the threshold level (TL)
- Low; All values of ESC below the TL.

The threshold level (TL) is currently set at 0.1 below the IL.

The RAMM database may be queried to sort skid resistance and texture data. RAMM averages the left and right wheelpaths to give skid resistance and texture data. A site with a Medium or Low ESC is identified in the RAMM report entitled "SCRIM Exceptions by Seal Length". The report processes the average ESC over:

- a complete site category
- a rolling average, or
- individual lengths measured in 10m intervals within a road section.

The resultant ESC data is compared against the IL in the report.

The IL is subtracted from the ESC value, therefore a negative value in the RAMM ESC report indicates a "medium" or "low" ESC value as defined above, while a positive value indicates a "high" ESC value.

5. TREATMENT SELECTION

5.1 General

There are several methods for programming treatment of sites with medium or low ESC:

• Resurfacing	Where significant lengths of medium or low ESC are included in the annual resurfacing programme.
• Area Wide Pavement Treatment	Where the length is rehabilitated using pavement smoothing methods, programmed on a length by length basis. (Typically used for areas where flushing and/or a build up of sealcoats is causing a continual problem.)
• Maintenance Treatment	Where smaller lengths are included for treatment during routine highway maintenance. As well as resurfacing, other treatments such as burning, waterblasting or the use of diluent and chip may be used to treat these lengths. For more details on possible treatments refer to the notes from the Transit New Zealand Skid Resistance, Bleeding and Flushing Workshops.

- Temporary Winter Treatment — In winter, or at other times when it may not be wise to resurface a road, temporary measures may be used. Signage or waterblasting are possible treatments to hold the site through to more optimum resurfacing conditions.

It is important to note that the first three treatments listed above may require a higher Polished Stone Value (PSV) chip than has been used in the past.

5.2 New Surfaces

The materials for the construction of all surfacings, new or resurfacing, shall be an aggregate which has a PSV as calculated using equation (1) in clause 6.2 of the specification, or as specified in the contract documents, whichever is higher.

The CVD used in equation (1) is the expected traffic flow at the end of the surfacing's life. If expected traffic growth rates are known, the following formula can be used:

$$CVD_F = \left(1 + \frac{i}{100}\right)^n \times CVD_P \qquad \text{Equation (2)}$$

Where:

i = Expected Percent Traffic Growth

n = Number of years expected life

CVD_F = Future CVD. The expected flow of commercial vehicles per lane per day at the end of the surfacing's life.

CVD_P = Present CVD. The current flow of commercial vehicles per lane per day where a commercial vehicle is an MCV or heavier.

The value of CVD_P can be calculated in the following way:

$$CVD_P = \frac{\%CVD}{100} \times AADT \qquad \text{Equation (3)}$$

Where:

%CVD = flow of commercial vehicles classified as MCV or heavier, per lane per day (using current data).

AADT = Average Annual Daily Traffic, per lane per day (using current data).

Note: Due to the fact that the vehicle classification count is often unavailable, and that the expected percent traffic growth may be speculative, there can be a high factor of error in the above equations.

5.3 Existing Surfaces

Different actions are required depending on the reason for the medium or low ESC values.

The RAMM ESC report is characterised by seal length and identifies site categories within a seal length that have average high, medium and low ESC over the length of the site category

Analysis of the ESC data is summarised using 3 levels:

Low ESC: identifies site categories with an average ESC less than the required threshold value over the total length of the site category, for each seal length. An example of the SCRIM report identifying these type of sites is shown in the User Guidelines Manual along with information to help with analysing the detail within this report.

Low ESC also includes site categories with rolling averages of minimum lengths based on the site category e.g. minimum 50m rolling average for site categories 1 and 2 and 100m for site cateogories 3, 4 and 5. (The rolling average length is automatically increased in increments of 10m intervals) To assist with determining appropriate lengths to treat, the report has break points for each unique seal length.

Medium ESC: These should be noted and programmed for treatment under the routine maintenance programme or annual resurfacing programme.

High ESC: Sites with values of ESC above the IL; no action is required in terms of this specification.

A field visit is necessary to confirm the ESC value from the RAMM report. This site visit requires an inspection to determine whether or not the ESC value is representative and if not, why not. An assessment should be made as to reasons for the lower than expected level of skid resistance to assist with treatment selection. For example, at locations where severe braking, cornering or accelerating occur, the polishing action is greater and so skidding resistance reduces to a lower level than at less stressed sites where the same PSV aggregate may have been used. A higher PSV aggregate than has been previously used should be applied at such highly stressed sites.

If the ESC as indicated from the RAMM report is in doubt, or some exceptional circumstances exist, confirmation of the required skid resistance by physical measurement may be necessary. Skid resistance testers available in New Zealand that are suitable for performing this evaluation are the Griptester, the British Pendulum Tester, and the Norsemeter ROar (in 34% fixed slip mode).

The relationships for converting output from these testers to equivalent SCRIM ESC values are as follows:

GripTesterESC = 0.42GN + 0.20 where GripNumber (GN) is measured using 0.25mm water film depth at a 50 km/h survey speed. (Different formulae for griptesters may be accepted with robust scientific proof).

Norsemeter ROar
ESC = 0.55μ + 0.12 where mu (μ) is measured using 34% fixed slip and 0.5mm water film depth at a 50 km/h survey speed.

British Pendulum Tester
ESC = 0.0071BPN + 0.033 where the British Pendulum Number (BPN) is measured according to TRL Road Note 27: "Instructions for using the Portable Skid Resistance Tester" or TNZ Draft T/2 Standard Test Procedure For Measurement Of Skid Resistance Using The British Pendulum Tester.

Provided the skid testers are operated in strict accordance to the manufacturers' instructions, research indicates that correlation with SCRIM values is achievable. The "equivalent" ESC values are ± 0.08 ESC based on a 95 % confidence level. These complimentary measurements, if performed outside the SCRIM survey season (November to February) additionally suffer the full uncertainty of seasonal variation (see figure 1). Therefore, although out of season complimentary testing can be of some use to experienced personal who are fully aware of the limitations, its main application is to test road sections on a comparative basis. This is performed by comparing the skid resistance value of the site of interest with an adjacent road surface that has a known and acceptable level of skid resistance based on SCRIM ESC (see figures 2 and 3).

Figure 1: Skid Resistance Over 18 Months

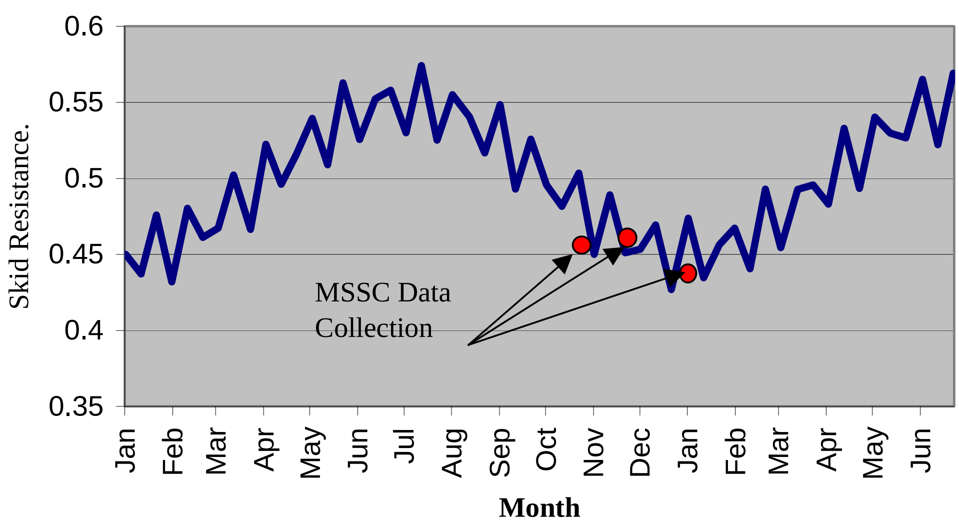


Figure 2: The importance of measuring skid resistance either side of an anomalous reading. This diagram shows ESC data (lower line) and griptester data (upper line) taken at different times of year on the same site. The anomaly between 90m and 140m displacement is real as measurements a, b, and c are identical.

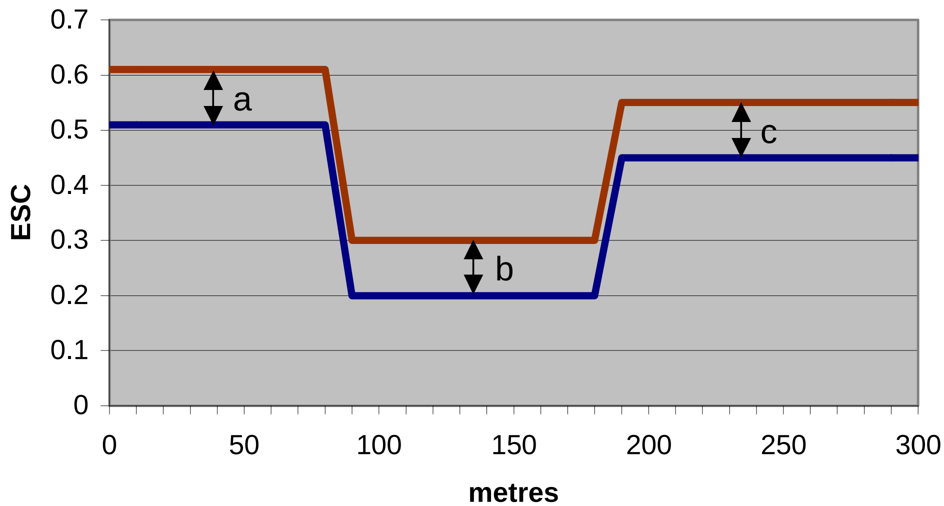
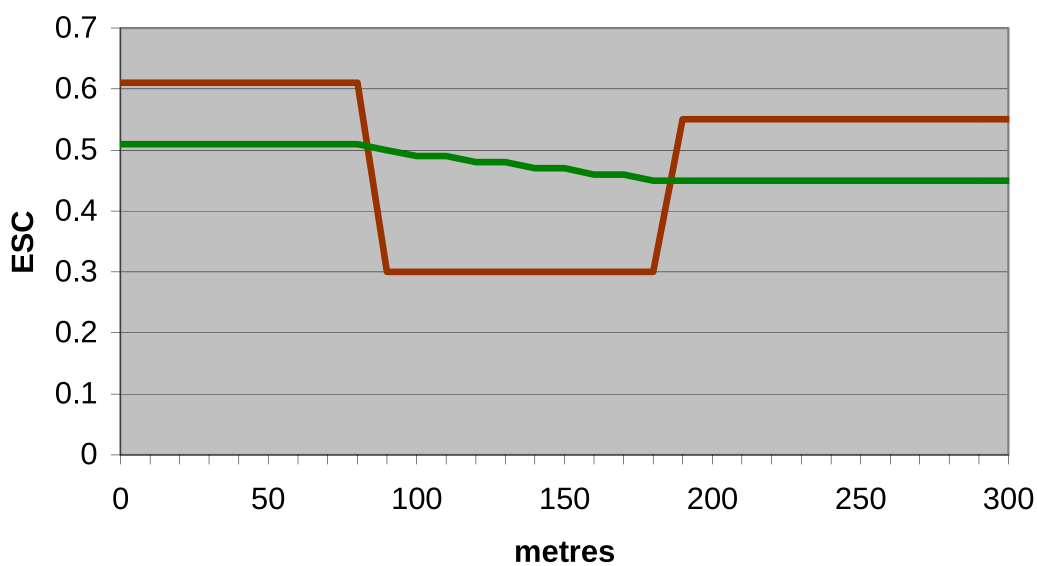


Figure 3: An anomaly is shown to be a temporary reduction in skid resistance. The diagram shows ESC data and griptester data taken at different times of year on the same site. The ESC anomaly (series 1) between displacement 90m and 140m is proven to be a temporary reduction in skid resistance as it is not found by the griptester testing later at the same site (series 2). Note that if the griptester had only measured between the displacements of 90m and 140m the wrong conclusion could have been drawn.



Having confirmed that the site needs some form of treatment, consideration should then be given to the most appropriate treatment and appropriate length of treatment. These two factors can best be dealt with at the time of the site visit. The cause of the lower than expected levels of skid resistance may be an isolated "flushed" patch or numerous short intermittent lengths indicating the possibility of chip polishing for the length of the previous reseal. Therefore a site visit is essential to:

- confirm whether or not the measured ESC values are representative;
- establish exactly why the road surface is not performing as expected; and
- assist with determining the most appropriate treatment and treatment length.

Where low ESC is found and yet the previous surfacing aggregate meets the requirements for PSV as set out in the specification, reasons for the low ESC should be investigated and consideration given to using a higher PSV aggregate for the new surfacing.

Where aggregate from a quarry frequently results in an ESC less than indicated by the PSV equation, this should be reported to the Surfacings Engineer, Transit New Zealand Head Office.

5.4 Temporary Reductions in SCRIM Values

Low SCRIM values may be due to a temporary reduction in skid resistance. The most common reason for temporary reductions in skid resistance is surface contamination. Common contaminants include bitumen, oil, animal droppings, silt and clay. Bitumen coating may be from the original surfacing mix (e.g. hot mix asphalt or pre-coated chip) or tracking from a section of bleeding road.

Where a significant reduction in ESC values has occurred from one year to the next, and indications are that the chip has not polished, then treatment to remove the contaminant should be considered and the site monitored.

Where a sudden drop-off in ESC values occurs and it has been established that it is not due to the aggregate polishing, the cause of the loss of skid resistance should be established and the site treated appropriately. Typically an aggregate has initially high skid resistance and polishes over the first 2 or 3 years, and in some high stress areas, even more quickly, depending on trafficking and stress factors, until it reaches a state of equilibrium. After equilibrium is attained, temporary fluctuations in skid resistance occur due to seasonal changes (figure 1). To minimise the effect of these changes, the SCRIM SFC values are adjusted by a seasonal correction factor to yield Mean Summer SCRIM Coefficient values (MSSC) (previously called NZMSSC). MSSC is then processed into Equilibrium Skid Resistance (ESC), to smooth out year-to-year variations. If there is a significant change in the type of traffic, especially the volume of commercial vehicles, then the skid resistance will vary (it will either increase if commercial vehicle volumes decrease or decrease if commercial vehicle volumes increase) but will stabilise when traffic volumes stabilise. The PSV test reproduces this polishing effect under laboratory conditions and represents the ultimate state of polish of the aggregate.

ESC results have revealed that a cause of a sudden decrease in skid resistance is sites where bleeding bitumen has spread across the top of the chips as binder has been tracked along the road. Typically, this occurs where sites are flushed. Even where small patches (generally badly flushed) have bled during the hot summer months, the binder has been tracked for kilometres in the wheel paths and low ESC results have been recorded for these lengths. Generally, isolated flushed sites have low macrotexture and should be programmed for treatment to restore the texture depth, and hence reduce the effect of the bitumen.

Where the texture is above the required minimum and indications are that the site does not have low ESC through chip polishing, review the previous years SCRIM values for the site to confirm that the reduction in skid resistance values is sudden. A graph produced using the RAMM ESC report data showing the current year's SCRIM data can be used to compare the current and previous year's data.

An example of this type of graph is shown in Appendix B. This example depicts a typical Route Station (RS) length and shows the average values from the RAMM ESC report using the Threshold Level of 0.1 below the Site Category Investigatory Levels measured as ESC values in one direction (one lane, the average of both wheelpaths). It is evident that there is a sudden reduction in values between 3.0 - 6.3 and 11.3 – 15.5 km. For this site, an inspection revealed that pavement repairs immediately prior to these lengths with excessive binder had bled and tracked along the wheelpaths for several kilometres, hence the sudden drop in ESC values recorded by SCRIM during the 1998 survey, compared to the 1997 survey. This decrease in skid resistance is far greater than would normally be associated with chip polishing.

Prior to a site inspection, analysis of video images taken at the time of the SCRIM survey and /or maintenance records should confirm whether or not the site experienced bleeding during the summer months, e.g. whether grit was applied or other maintenance treatments were undertaken.

A subsequent inspection of those sites where bleeding occurred during the summer months may not show obvious signs of bleeding after the event. For example by late autumn the tracked binder has generally been worn off by traffic action and consequently the skid resistance is restored. Some engineering judgement is required to determine the exact cause of ESC anomalies, particularly sudden inter-year reductions in ESC. If confirmation of the skid resistance level provided by the road surface is necessary, skid testers other than SCRIM may be used to evaluate road sections on a comparative basis as explained in Clause 5.3.

As even temporary low skid resistance may potentially jeopardise the safety of motorists, the first course of action must be to identify and eliminate the contributory causes. Secondly, the Engineer must consider all the historic data associated with the site and make a judgement as to the reason for the lower than expected ESC values, especially whether it is temporary or permanent. The ESC results should not be disregarded until completely satisfied that the cause has been identified.

In summary, where a significant reduction in ESC values has occurred from one year to the next, and indications are that the chip has not polished, then treatment to remove the contaminant should be considered and the site monitored.

5.5 Resurfacing Lengths

When determining the length to be resurfaced, surfacings must begin and end at the tangent point of the curve. This is especially important when the PSV of the new surface will be different to that of the surrounding surfaces. Concepts of horizontal alignment are discussed in chapter 3 of *Rural Road Design, Guide to the Geometric Design of Rural Roads,* Austroads 1989. Due consideration should be given to geometric traps (e.g. a sudden small radii curve amongst larger radii higher speed curves).

5.6 PSV

Clause 6.2 of the specification provides a formula to determine the appropriate PSV for the aggregate to be used, based on the commercial traffic volume at the end of the anticipated life of the surfacing. This formula applies to all surfacings on state highways, including but not limited to state highway reconstructions, area wide treatments, asphaltic surfacings, maintenance surfacings (e.g. chipseals, slurrys) and surfacings on new road sections.

In the case of hot mix asphalt, it is expected that the coarse aggregate fraction would be entirely composed of aggregate with the required PSV. The requirement that 85% of the coarse aggregate fraction must comply with the required PSV is not an excuse to provide non complying coarse aggregate, but rather is to allow for other aggregate components of the mix that may include particles of coarse aggregate size. The engineer may specify that a higher percentage of the coarse aggregate fraction must be composed of aggregate with the required PSV, but this could prove to be an expensive option.

A higher PSV for any surfacing may be specified in the contract documents, providing it is higher than the PSV that would be calculated from clause 6.2 of the specification.

Where a higher PSV chip is required than can be provided from natural aggregate, processed synthetic chip such as “calcined bauxite” may be appropriate. The requirement for high PSV aggregates may involve importing chip from outside the region. Despite the additional cost, this may still be a cost effective option because of the gain in the useful life of the high PSV chip surfacing over the lower PSV chip, which will be more prone to polishing action from traffic and so require more frequent renewal.

Where chip of the required PSV is unavailable locally and the cost of importing the appropriate chip is high, consideration should be given to alternative treatment solutions. These may include alignment or geometric improvements or more frequent resurfacing. The analysis may include benefit/cost comparisons for each option. Guidelines as to how to perform such a benefit/cost comparison are presented in Transfund New Zealand Research Report No 141, “Selection of Cost Effective Skid Resistance Restoration Treatments.” Caution may also need to be exercised so that the seal design is able to handle the stress on the aggregate. High PSV aggregates tend to be softer than lower PSV alternatives.

A new specification for high PSV aggregates, M/21 Specification for High Polished Value Sealing Chip, has been developed and is presently being trialed with 'pilot' status. The results from the M/21 trials will be incorporated into TNZ M/6 Specification for Sealing Aggregates. Changes to M/6 will be made to allow the use of marginal materials with PSV's typically 60+ which do not currently meet M/6 requirements.

It is important to consider the use of correct PSV aggregates for maintenance repairs, which sometimes cause localised areas of low skid resistance inconsistent with the rest of the road surface. In addition, excessive widths of smooth, low skid resistant material, such as overspray that occurs as part of patch repairs and seal widening, can be a particularly serious hazard to motorbikes and may cause four-wheeled vehicles to lose control momentarily.

5.7 Flushing

Flushing results in low macrotexture.

A road surface that has its microtexture masked by bitumen will usually have a lower ESC. Bitumen may mask microtexture because of:

- A flushed surface, or
- Tracking of binder from an adjacent section of road that has bled.
- New hot-mix asphalt surfaces.
- New surfaces incorporating pre-coated chip.

If flushing is evident, prompt action should be taken to restore the macrotexture of the road surface.

It is desirable to treat flushed surfaces before the annual SCRIM survey, as the techniques used can then be assessed for effectiveness using the SCRIM survey results.

5.8 Protocol for SCRIM Data Release

Care is required when releasing RAMM and particularly SCRIM data to outside parties. The correct procedure shall be followed for SCRIM data release, as set out in the State Highway Control Manual.

APPENDIX A

GUIDELINES FOR ASSIGNING SKID RESISTANCE LEVELS

Skid resistance Investigatory Levels (IL) are warning levels. If a section of road is below the IL shown in Table 1 of the specification, an investigation of the site is required to establish whether remedial work should be undertaken. IL are not minimum standards or intervention levels. Using the IL as the initial basis sets the actual skid resistance level of any site and the specific site characteristics can be used to raise, lower or maintain this level.

Reason for Reducing the Investigatory Level

The following site characteristics may indicate that the IL could be lowered.

Low Traffic Volumes

Low traffic volumes reduce the risk of accidents simply by reducing the number of times a manoeuvre is required. New South Wales and Victoria in Australia reduce the IL by 0.05 for roads carrying less than 2500 vehicles per lane per day (v/l/d). Insufficient research has been carried out to confirm this reduction, consequently it is suggested that a conservative view be taken and a reduction of 0.05 off the IL is only considered acceptable when the traffic volumes are lower than 500 v/l/d.

Up Hill Gradients

It requires less skid resistance to stop within the same distance going up a hill than it does on the flat. The IL may be reduced by 0.05 if the site is on an up hill gradient of >10%.
However, it is also important to consider vehicles travelling downhill who may use the up hill lane to overtake. If this is the case this may negate the justification for an IL reduction.

Reasons for Increasing the Investigatory Level

The following site characteristics may indicate that the IL could be raised.

Multiple events

If a site has more than one event (see Table 1 of the specification) and the combined events place an additional requirement on the skidding resistance of the surface, there may be justification to increase the IL of the site. For example, if a curve is on a downhill gradient, or an approach to traffic lights is on a curve, it is recommended that the IL be increased by 0.05 to 0.1 depending on the demands of the combined events.

Superelevation on Curves

In the case of a negative superelevation (the road is lower on the outside of the curve) of greater than 5% the IL should be increased by 0.05 or more, while consideration is given to geometric improvements.

Road Roughness

Normally road roughness is not related to skid resistance. However, on very rough roads greater skid resistance is required to be able to manoeuvre successfully. Therefore, it is suggested that an increase in the IL of 0.05 be considered for roads with NAASRA counts of greater than 120.

Isolated Events Causing Driver Surprise

Any area where a surprise manoeuvre may be necessary should be considered for increased IL. This could include an isolated curve on a high speed and otherwise event free road. Or event free roads that are prone to sudden braking due to congestion, such as certain motorways in peak periods. In these areas the IL may be increased by 0.05 to 0.1.

Some examples include:

- The start of a long downhill section where trucks slow down, despite the speed environment being high.
- Areas where slow vehicles are obscured.

Crashes

Another factor, which may affect the required IL value, is the frequency of "loss of control" and "wet skidding" crashes where loss of skid resistance was a contributing factor at the site with low or medium ESC. These sites are generally identified through regular Safety Inspections and the problem highlighted for further investigation.

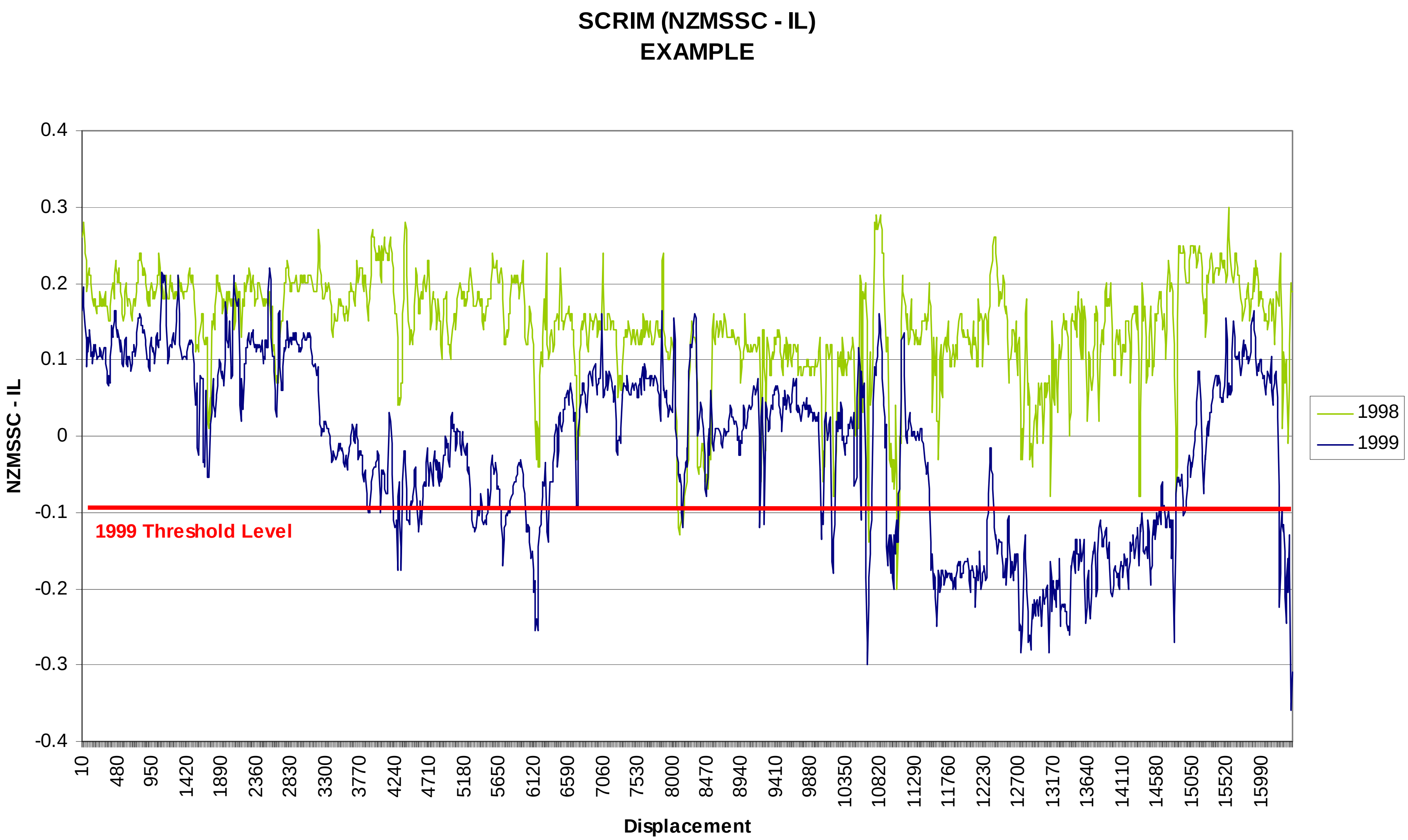
If 2 or more crashes (generally over a maximum 5 year period) have occurred at the site, which may be associated with the level of skid resistance, then the skid resistance may be increased by 0.05 while consideration is given to other safety initiatives.

Responsibility of the Assessor

The reductions and increases in the IL outlined above are only indicative and it is the responsibility of the Network Consultant to consider all the characteristics of the site to assign the optimum IL values to a site.

The newly assigned IL value is termed the **Modified Investigatory Level** Value.

APPENDIX B



SCRIM (NZMSSC - IL)
EXAMPLE
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
NZMSSC - IL
1999 Threshold Level
1998
1999
10
480
950
1420
1890
2360
2830
3300
3770
4240
4710
5180
5650
6120
6590
7060
7530
8000
8470
8940
9410
9880
10350
10820
11290
11760
12230
12700
13170
13640
14110
14580
15050
15520
15990
Displacement