Transit NZ

Pilot Study to Assess Passing/Overtaking Demand using TMS

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Quality Assurance Statement	
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A separate volume is to be produced containing the numerous graphical outputs.

EXECUTIVE SUMMARY

This report documents an investigative pilot study into the potential use of Transit's Traffic Monitoring System in assessing passing demand on rural two-lane State Highways. The pilot study area consisted of the Waikato and Bay of Plenty regions, for which MetroCount traffic data for one week in 2006 were analysed for over 90 sites and almost 180 directional files.

The study investigated the appropriate headway threshold for determining whether a vehicle was assumed to be following or travelling freely. Three alternative headway thresholds were investigated (3.5, 4.0, 4.5 seconds) based on the range of values used internationally. Examination of the cumulative frequency of headways indicated a noticeable change in profile below the 4 second threshold, and on this basis the study recommends that 4.0 seconds be chosen as the appropriate threshold for determining the percent following.

Having selected this threshold, graphs of the percent following distribution were undertaken for each site, of which there were two types namely, those surveyed using a MetroCount 'Regular' device for which only interval reports were available, and those surveyed with the MetroCount 'Plus' device which for individual vehicles could be reported. The size of the latter files and their structure proved demanding on computer processing and memory, but were easy and quick to create from the MetroCount reporting software, whereas for sites surveyed with a "Regular' device several reports were needed to be produced which was time consuming.

Two effects were precursory investigated that were outside the original study scope, namely the difference in results for surveys conducted at different time of the year for two sites, and the potential influence of the percentage of light vehicles towing for the telemetry 'Regular' sites. The results suggested that further investigation is warranted.

For comparison purposes, the percent following for the 24 average Monday to Friday hourly flows were output and aggregated into ten graphs, three of which comprised the higher flow sites predominantly on SH1 and SH2. Inspection of these graphs indicated that the percent following appears to be influenced more by the percentage of heavy vehicles than by speed, although there are correlative effects involved.

A cubic curve was found to fit the data reasonably well for one-way flows up to 600 vph, and for higher flows a linear fit appeared reasonable. For a given average weekday hourly flow, the variation in the observed percent following appeared to decrease with higher flows, with the associated observation that there were no very high flow (> 900 vph one-way) sites, which also had high percentages of heavy vehicles.

The results suggest that the data should now be subjected to statistical hierarchical clustering techniques to objectively determine site groupings, and the resulting dendogram(s) could then be further inspected with knowledge of the key characteristics of each site direction, such as proximity to upstream passing lanes, upstream terrain, and site geometry. The latter variables are suited to GIS applications, and it is recommended that the analysis key results be input into GIS.

A number of recommendations were made with respect to the potential changes to Transit's traffic monitoring strategy and the TMS data processing, recording, analysis and reporting system. One key recommendation is that the telemetry sites should be changed from recording the four length bins for all vehicles, to recording the four length bins for free and platooned vehicles separately – this has important implications for the extension of the telemetry sites presently being planned by Transit's national traffic monitoring team. Another key recommendation is that some of the MetroCount 'Regular' equipment should be upgraded to 'Plus' equipment to enable seven calendar days of individual vehicle recording to be undertaken at least once a year at each TMS site where practical. Likewise the equipment and storage capacity at continuous dual loop sites should be capable not only of recording length by headway data but also preferably individual vehicle data for one week.

In conclusion, the investigative study showed that there is great potential to expand on the effort to date, and to modify the TMS database slightly to accommodate the needs of the Transit national planning team with respect to meeting the road user needs in providing adequate passing opportunities to provide safe and convenient travel on the state highway network in the years to come.

1 Introduction

This study involves investigative research into passing demand as observed at sites selected from those with Transit New Zealand's (Transit NZ) Traffic Monitoring System (TMS). The key variables to be investigated included the percent following, the percentage of heavy vehicles and generic speed measures, with a key objective being to recommend an appropriate headway threshold for defining platooned or following vehicles.

This research will help to:

- Determine any modifications to Transit's current TMS procedures for data collection and storage so that traffic effects, such as percent following and speed can be measured.
- Provide guidance as to where the long-term framework within Transit's Passing and Overtaking Policy may or may not be appropriate for some state highways and in what situations another level of infrastructure would be more appropriate.
- Identify locations with high passing/overtaking demand that possibly lie outside of the long-term framework for Transit's Passing and Overtaking Policy and would be suitable for TDM measures.
- Understand the key influences behind passing/overtaking demand with a view towards optimising the general configuration of passing facilities along a road section.

As part of Transit's Passing and Overtaking Policy, Transit is investigating a methodology to measure passing/overtaking demand on its rural two-lane state highways. Transit already has a Traffic Monitoring System (TMS) in place, this research will look at the practicalities of utilising or modifying Transit's current TMS to measure passing/overtaking demand.

The availability of data and the suitability of Transit's Waikato and Bay of Plenty regions, as a pilot area, were investigated by MWH as part of a separate preliminary assessment.

In addition to this study, within the Waikato and Bay of Plenty regions, MWH and Maunsell are undertaking Transport Demand Management (TDM) studies on Transit's behalf.

Transit's Passing and Overtaking Policy has a long-term framework for determining passing lane length and spacings. To verify the framework and its supporting overseas research, Transit is carrying out a separate study into the optimum length of passing facility and the extent of downstream benefits with respect to traffic volumes.

2 Potential Use of TMS data

2.1 Background

Transit NZ operates a well-defined traffic monitoring strategy for the state highways and motorways, whereby every traffic monitoring link is regularly monitored. Most monitoring sites are monitored for one week, four times per year generally using a dual tube for lower volume highways and single (or dual) loop on higher volume highways. A small proportion of sites are continuously monitored generally using a dual loop classifier (telemetry sites) or a single loop system on the Auckland ATMS.

Apart from the motorways, a dual tube classifier survey is supposed to be undertaken once per year, using the Transit NZ classification scheme (1996). Presently these surveys are undertaken using the Metro Count classifier (from Perth), which essentially records individual detections with vehicle-by-vehicle data being available for outputting along with various aggregated (quarter hourly, hourly, daily) outputs. Currently only the quarter hour classified flows by direction are stored in TMS.

For the single loop sites the quarter hour directional flows are stored in TMS, while for the dual loop sites the quarter hour (or in a few cases hourly) flows, categorised into four vehicle length bins, are stored.

There are currently three types of equipment used at the dual loop sites, comprising the Golden River M660, AVC and TRS detector devices. The M660 has the capacity to record both vehicle by vehicle and interval data simultaneously, and internal data can comprise up to three parameters in matrix and/or vector format, with up to 15 bins specified for each parameter.

The AVC can currently only record vehicle by vehicle in online mode, requiring a laptop to be connected in order to capture the record. Besides the capability of recording vehicle length data the AVC can only record speed data for two different types of vehicle (cars and trucks). The TRS can currently only record vehicle length data and possibly also speed data (for all vehicles).

2.2 Potential Usefulness of TMS

Currently, for the purposes of measuring the proportion of following vehicles, only the (dual) tube sites have suitable data as have the loop sites at which a Metro Count Survey is undertaken once a year. Although the data are not available from TMS, the raw data (.ECO files) are stored on CDROMs (for the Waikato and Bay of Plenty regions at least).

In addition the M660 telemetry sites can easily be set up to download one day's vehicle by vehicle data, noting that 128kb internal memory (which most have) could record around 9000 vehicles along with the standard length internal data.

Vehicle-by-vehicle data could only be captured at the AVC or TRS sites by visiting each site and connecting a laptop and/or using another AVC or M660. Coincidently in the MWH 2006 review of TMS it was recommended that Transit conduct a vehicle by vehicle survey at the telemetry sites twice a year and store the data on a CDROM. This recommendation is still being considered by Transit.

To enhance the usefulness of TMS at certain M660 dual loop sites, instead of using the standard four length bin LEN configuration setting, LEN and HDW could be used with four length bins and two headway ranges distinguished by the following headway threshold.

The TMS database and procedures would need to be adjusted by adding four length bin fields, the existing four remaining the same (all headways) and the new ones for headways less than the critical threshold. In this manner the percent following could be monitored continuously providing the necessary data for a more rigorous statistical study in which case the addition of speed data should be useful.

While LEN and HDW would (almost) double the data collected which is unlikely to be an issue at the relatively few sites (currently there are M660 dual loop sites), adding a further 15 speed bins would result in downloading almost six times the data, thereby creating the likely need for more frequent downloads.

Prior to uploading into TMS the mean and 85th percentile speeds would need to be estimated, presumably based on the speed distribution, simply taking the midpoints of the speed bins (except for the end bins where a set value would be applied).

Currently within TMS, TNZ SPEED is already set up and is based on the ARRB defined VDAS format. This comprises {15 speed bins, mean, 85th} with the speed bins stated as 0-20, 20-30, 130-140, 140-160 and >160. To enable more precise estimate of the mean from speed bins, the default should more logically be for example which is biased towards the 70 to 100 km/h speed limit sites. A suitable default 15 bins could be
<35; 35-50; 50-60; 60-65; 65-70; 70-75; 75-80; 80-85; 85-90; 90-95; 95-100; 100-110; 110-120; 120-135; >135

A more refined approach would be to have a number of predefined speed ranges suited to different situations, with an additional field to capture which is the speed scheme in use, in which case 12 or 13 speed bins should be adequate for the purpose, although 15 speed bins could enable 5 bins at 3 km/h intervals over the critical 15 km/h centred on the expected mean speed rather than 3 bins at 5 km/h.

2.3 When and how often to collect percent following data?

The present system effectively ensures that percent following data can be reported for:

- one week every quarter at the lower flow tube sites, and
- once a year at high flow loop sites.

It might be expected that this is adequate. Without being able to analyse percent following data continuously collected, one would hope that prediction models of the percent following data coupled with site specification to determine the appropriate model subset should prove adequate for helping to identify individual locations or sections of road that may require passing facilities. Accordingly when the once a year survey is conducted should not matter too much (this is discussed further in section 3.5.3.

2.4 Where to collect percent following data?

This is a difficult question to ponder. However, preferred sites generally involve those:

- Not affected by T junctions i.e. 0.6 km for low flows and 1 km for high flows, away from the T junction.
- Not affected by queuing, lane changing and overtaking effects.
- Close to power sources and with potential for data download.
- Upstream of current or future passing facilities.
- Representative of the road section.

In many cases, traffic is monitored near the junction of intersecting stage highways as this is the most efficient data collection configuration. However the traffic volumes may not be truly representative of the link weighted average flow.

Examination of a limited number of such sites (refer section 3.5.4) suggests that the recorded speeds are affected by the proximity of the Tee intersection. For low traffic flows, it would be preferable to be at least 0.6 km away, while for high traffic flows 1.0 km would be better.

In terms of loop sites, these are typically constrained to be by available power sources and away from areas of queuing and/or frequent lane changing or overtaking; also for telemetry sites proximity of land lines or good cellphone reception are an issue.

Realistically only the location along the traffic monitoring link of tube sites could be altered for specific reasons. But for general purposes there is no real need for change. An exception would be for a project to investigate traffic effects upstream and downstream of passing lanes, which may require several monitoring stations along what currently may be one or two TMS traffic monitoring links, given that there are invariably no major intersections along a passing lane

A TMS site with a fixed distance from the beginning or end of a passing line could be considered. However, such a policy is likely to be impractical. Monitoring sites immediately downstream of passing lanes may record a similar percent following to upstream conditions. Although the order of the platoon could have changed, there may not have been enough distance since passing slower vehicles for speed differences to become noticeable. Upstream of existing or proposed passing lane sites would enable the effect of earlier network development to continue being be monitored.

Preferably, the site should be representative for the road section in both directions of traffic flow. Transit's Passng and Overtaking Policy has identified various sites as being typical of the road section for AADT and terrain. It is likely that some of these road sections would be further subdivided into more consistent road sections when Transit Regional Passing and Overtaking Plans are prepared. However, as discussed later within this report, the effect of discriminating variables should be established first so that road sections can be suitably differentiated.

3 Analysis

3.1 Background

For the purposes of this investigative study, Transit selected the Waikato and Bay of Plenty regions with the analysis sites to be from these two regions.

These two regions were chosen by Transit due to other associated projects being conducted in these regions.

Transit Hamilton supplied MetroCount ECO files for the past three calendar years 2004-2006 for each monitored site. For 2006 there were 543 ECO files; from these a sample was to be analysed.

The sample selection exclusion process was generally as follows:

- Exclude sites with unknown X, Y co-ordinates
- Exclude sites with AADT less than 550 vpd
- Exclude sites with more than one lane in either direction.

The inclusion process for the remaining sites was generally as follows:

- Include telemetry sites and any other dual loop sites
- Include single loop sites especially the higher volume [rural] sites
- Include as many of the remaining tube sites as scope allows

A review of the datasets found that the individual vehicles report option was only available where the code 'Type' (appears when the file is uploaded) was defined as 'Plus'. For some of the tube sites classified four times a year, only one of the 2006 surveys may have been undertaken with a newer MetroCount 'Plus' unit.

It is likely that Transit will be in future be referencing its data collection sites primarily by the GIS co-ordinates. Therefore, some more sites could be included for analysis purposes. However, there is sufficient volume of data under the current exclusion criteria, that sites with currently unknown co-ordinates do not have to be included.

3.2 Main Output

The output from the analysis spreadsheets comprised graphs for two key components, namely headway and platoon distributions, and percent following distribution, along with summary speed measures.

<u>a) Headway and Platoon Distributions</u>

The former two were output for the vehicle-by-vehicle sites, with the aim being to choose what is the appropriate headway threshold for distinguishing between vehicles that are travelling in a platoon.

To allow easy comparison between sites, the axes for the distribution of headways were fixed as being 0.0 to 10.0 seconds for the headway (x-axis) and 0.0 to 0.75 for the cumulative frequency (y-axis); the axes for the distribution of the number of platooned vehicles were fixed as 0 to 50 vehicles (x-axis) and 0 to 50 for the number of platoons (y-axis). For the latter, the number of platooned vehicles was output for four different headway thresholds, namely 3.5, 4.0, 4.5, and 5.0 seconds.

The graphs were for all the analysis days, typically one week, and output included the mean and 85th percentile speeds by direction for all vehicles, free vehicles, leading vehicles in a platoon, and following vehicles in a platoon based on a pre-defined headway threshold (4.0 seconds chosen). In addition the average daily traffic and percentage of heavy vehicles (%HV, comprising Transit NZ 1999 classification scheme classes 3 to 14).

b) Percent Following Distributions

For the 'Plus' vehicle-by-vehicle sites, a graph of the percent following distribution was produced for each site based on the pre-defined headway threshold, showing the distribution for the average (Mon-Fri) weekday, Saturday and Sunday. The linear and polynomial (cubic) best fit lines and the regression correlation coefficient were displayed for each of the three types of day of week, in order to give a better visual impression of any relationship and differences between the different types of day. For viewing clarity both the x and y axes were set to 'autoscale'.

The same additional information as for the headway and platoon distributions was output. In addition for three different day of week types, the mean speed of free vehicles and lead vehicles, % HV, and average ADT were output.

For the 'Regular' interval sites, a similar graph was produced, but with some slight differences. Friday values were distinguished from the average weekday values; while the best linear fit lines were not shown apart for that for the average weekday. The average weekday was set as Monday to Thursday but could be altered to be Monday to Friday; the weekday best fit line was derived based on a user defined flow range, typically with a minimum flow of 20 vph (one-way) and an arbitrary maximum flow of 1200 vph (one-way).

For the vehicle-by-vehicle sites, a second graph of percent following was produced which showed the predicted values every 50 vph for the fitted Monday to Friday linear best fit line based on a user defined flow range, typically with a minimum flow of 40 vph (one-way) and an arbitrary maximum flow of 2000 vph (one-way). By altering the flow range in the absence of statistical software packages, one could investigate creating a best fit curve comprising of fitted linear lines for varying flow ranges.

Initial observation of the first few pilot sites revealed the following:

- It did not necessarily follow that days with higher %HV had slower speeds, nor that these days had higher percent following for the same volume.
- For the high flow pilot site, there was good agreement in the day of week curves up to 600 vph (one-way).
- For the high flow pilot site at the 700 vph (one-way) level, the percent following for Saturday or Sunday were about 5% higher than that for the two Mon-Fri curves.
- The highest observed percent following was slightly over 80 % for Mon-Fri curves

- For the high flow pilot site, a cubic curved fitted the data well up to about the 900 vph (one-way) level.
- For the high flow pilot site, use of linear regression to predict the relationship at the low flow range, and the results for Saturday were at odds with the other days.

c) Speed Measures

In addition, as noted above key measures of the speed distribution were derived and output with the graphs.

For the vehicle-by-vehicle sites, the mean speed was output below the percent following distribution graph for free vehicles and the leading vehicle of platoons (along with the %HV and daily flow), for the average Monday to Friday, and the (average) Saturday and Sunday. The mean and 85th percentile speeds were output on the graphs for all vehicles, free vehicles, lead vehicles and following vehicles based on the whole (usually 7 calendar days) survey period (along with the %HV and average daily flow).

For the interval sites, the mean speed and the mean plus the standard deviation speed were output on the graph for all vehicles, free vehicles and platooned (lead plus following) vehicles based on the whole survey period (which usually was slightly more than 7 days). In addition the %HV was output for the average Monday to Thursday, Friday, Saturday, Sunday and for the whole week for the same 7 calendar day period corresponding to the plotted graph values. The weekly average daily flow was also output, and also the corresponding value for vehicles recorded as travelling in the opposite direction (useful to distinguish which sites had directional surveys).

3.3 Analysis Aspects

A number of issues confounded the analysis:

- Vehicles with zero headway.
- Very busy sites had too many records to process easily.
- Opposing traffic using the lane to overtake.
- Duplicate files with different filenames.

a) Zero Headways

Occasionally the Metro Count ‘Plus’ outputs “coerced sequence” records for the individual vehicles report. These consist of a seemingly valid vehicle, albeit always classified as class 1, followed by one or more (usual maximum for four) identical records all with headway of zero seconds.

On the pilot site, a two-way site with WADT of about 3600 vpd (two-way), this situation arose for 3.2% of the records. Accordingly, it was necessary to modify the analysis spreadsheet to exclude the spurious records, which was not an easy task. To help gauge the extent of occurrence of this situation, two summary notes were output above the top two graphs; later inspection of the notes revealed that three sites (00200127-BA, 00200225-AB, 00300064-AB) had a substantially higher level of spurious records (more than 5.8% of the original total number of records or more than 2.3% after their removal), and a high %HV recorded, suggesting that the survey results should perhaps have been rejected and the survey repeated (and if the problem occurred again then the site should probably be relocated).

b) Busy Sites

It was discovered that some of the very busy sites had too many records for Excel to handle (maximum 65500). In such situation the "Mask" option was used in MetroCount processing and reporting software MCREPORT, to exclude one or more of the mid week days (Tues, Wed, Thurs) to ensure that at least the Friday to Monday (and other weekday) were captured for analysis. Even then the resulting spreadsheets could be 80Mb which created considerable CPU processing difficulties, and ultimately the analysis had to be undertaken on a directional site basis, and processing was slower than expected.

c) Effects from Opposing Traffic

For some of the directional sites, a small proportion of the records related to vehicles travelling in the opposite direction. These represent overtaking vehicles and the possibility of incorporating them into the data output for the opposite direction was examined.

It was evident however that the records for the different directions differed by time and/or space, such that the potential insertion of the overtaking records according to time and recomputing the headways (and thence platoon numbers) was not reliable (note that for some sites the loop for the different directions might not be opposite each other).

Accordingly there will be some inaccuracy introduced in the analysis (although one might have wished in any event to exclude such records), but this is of limited effect. The number of overtaking vehicles and their proportion compared to the analysed records were noted during the MetroCount processing.

d) Duplicate Files

A lot of the files supplied for 2006 were duplicates, having a subtle difference in the filenames (one had a renaming error of 15 September rather than 11 September). There was one special case whereby the labelled March and October files for 0020146 A/B or N/S comprised the same data although the start dates were different; how this occurred except by special editing of the .ECO files is unknown; as a result the files were checked sorting by file size but no other occurrence of this situation was noted.

3.4 Determining the appropriate following headway threshold

It is concluded that the choice of threshold per se is not as important as undertaking the passing/overtaking demand analysis on a constant threshold; in this respect a threshold of a whole number of seconds is considered better than one ending in half a second, for situations where the recording device only records to the nearest second. Accordingly, analysis of the percent following distribution was based on a headway threshold of 4.0 seconds. The reasons behind this conclusion are discussed below.

It is universally accepted that all vehicles travelling less than 3.0 seconds from the vehicle in front are deemed to be following, while all those more than 6 seconds behind are not but are considered to be travelling freely. However, the Land Transport NZ Economic Evaluation Manual Volume 1 uses a threshold of 5.0 seconds. The

VDAS dual tube classifiers developed in Victoria Australia for RTA used 4.0 seconds. A South African Study[1] recommended revising the 4.0 seconds previously user in South Africa to 3.5 seconds nearer to the 3.0 seconds it stated was used by the Highways Capacity Manual[2].

The South African figure of 3.5 seconds was derived from manual (visual) observations of about 2100 headways with 3.5 seconds representing the 43/57 split of when a vehicle was considered to be following or not (similar technique to that for determining the critical gap). The equivalent split for 3.0 seconds and 4.0 seconds was 15/85 and 73/27 respectively, which indicates that the practical choice was between 3.5 seconds and 4.0 seconds (given that one chooses to the nearest 0.5 seconds).

From initial observations of the pilot site, the headway distribution flattens off into a linear relationship from about 4.5 seconds. Examining the platoon distribution, the 4.0 second line is approximately midway between the 3.5 second and 5.0 second lines. Initially, then a threshold of 4.0 second seems appropriate, which matches the writer's limited personal observations.

It is considered that an objective way to test this is to examine the effect on the variation in the speed of following vehicles and the difference in the following speed to the lead vehicle speed for different following headway thresholds.

The theory behind this speed variation is that in some platoons it was observed that the first vehicles were travelling at about the same speed as the lead vehicles while the last vehicles were not, suggesting that perhaps it should have been two platoons. However other observations included slow vehicles travelling behind one fast vehicle, suggesting perhaps that it had just overtaken the slow vehicle as it passed the survey site.

An examination of the potential discriminatory measures was undertaken for some sample sites[3]. The results have not been tabulated as it was evident when comparing the results for thresholds of 3.5, 4.0 and 4.5 seconds, that the variation in the results was only plus or minus 0.1 km/h, that is within the rounding errors.

3.5 Examining the Percent Following Distribution

3.5.1 Introduction

Having chosen 4.0 seconds as the headway threshold for defining whether a vehicle was considered to be following or not, the process of deriving the percent following distribution for each of the sample site-directions was undertaken.

The process was laborious, with most sites only able to be analysed on an interval basis rather than individual vehicle basis as had originally been envisaged. For the former it was necessary to run nine or ten MetroCount 'Regular' reports for both directions rather than the one individual vehicles report for the MetroCount 'Plus' sites (or two if the directions were surveyed separately).

[1] South African National Roads Agency Ltd, "The development of an analysis method for the determination of level of service of two-lane undivided highways in South Africa" (undated – 2003 or later)
[2] Refer page 12-12 of the HCM 2000 Metric Edition (refer also pages 20-3, 20-4). Interestingly a British Columbia Ministry of Transport 1998 Technical Bulletin states that the percent following headway threshold in the 1994 HCM is 5.0 seconds (refer report section 4.2).
[3] The following sites were used: 1/594 n/b; 2/66 s/b & n/b; 2/127 s/b & n/b; 2/146 s/b & n/b; 2/160 s/b; 2/204 e/b & w/b; 41/49 s/b & n/b; and 25A/11 increasing route position

It transpired that when the former were processed, the default classification scheme changed from Transit 1999 to ARX, which is a variant on the Austroads classification scheme having another very short two axle class as class 1 and the last classes combined, and without the "???" class 14 incorporated.

Both the Austroads 1994 and ARX classification scheme have the same distinguishing threshold for two axle cars / two axle trucks of 3.2m, in common with the Transit 1999 classification scheme. Thus there was no need to reprocess the MetroCount data, the only need to modify the initial spreadsheet for the interval data to be based on the ARX classification scheme rather than the Transit 1999 classification scheme.

Actually the ARX classification scheme has the advantage of identifying cycles / motorcycles separately from cars. This sensitivity was advantageous within the results analysis for ascertaining an unusual traffic pattern at one of the telemetry sites.

3.5.2 Analysis spreadsheets

The initial analysis spreadsheet developed for the individual vehicle MetroCount 'Plus' sites was split into two so that each direction was analysed in separate spreadsheets. This was necessary since the files for the busy sites were large and impacted adversely on the PCU processing time. The MetroCount sites data were trimmed to comprise only whole day data, generally for seven complete days only, but if necessary (to ensure no more than 65,500 records) for fewer days (excluding or one or more midweek days). The created analysis spreadsheet defined weekday to include Friday, as previously envisaged. An example of the output is given in Appendix B.

The same PCU processing difficulties did not arise for the interval data sites (each just over 0.5Mb in size), and to improve the speed of creating the MetroCount reports all the data were chosen, but the percent following was based on whole days data only, again generally seven complete days. The decision was also made to modify the analysis spreadsheet to by default treat a weekday as Monday to Thursday with Friday shown separately on the single output graph; however the statistics for the average Monday to Friday were computed to enable comparison with the individual vehicle sites.

Both the individual vehicles and interval data worksheets contained a 'SiteFWD' worksheet with the predicted linear regression best fit line based on the Monday to Friday average hourly flows and percent following, for 50, 100, 150 vph (one-way). The default valid hourly flow range was initially set as 40-2000 vph (one-way), subsequently changed to 20-1200 vph (one-way). This could be changed so that for example, the best fit line was only applied for the highest flows.

An example of this is given in Appendix C, with the best fit line applied to average hourly weekday flows exceeding 600 vph (one-way), as from observations of the busiest sites the profile of the percent following distribution can be approximated reasonably well with a linear line for the high flows. For moderate flow sites with upper flows in the 250 -600 vph (one-way) range, the comparable threshold appeared to be about 300 vph (one-way), and below this level there is considerable scatter. In theory one could create a model of the percent following distribution comprising three straight lines, e.g. flows 20-300; 300-600 and > 600 vph (one-way).

However it was decided to add to the 'SiteFWD' worksheet for the interval data, the recorded percent following for the 24 average Monday to Friday hourly flows. Subsequently these were copied and pasted as values into a summary spreadsheet; in addition the corresponding data for the individual vehicles sites were copied across (from the Anal1 worksheet with the label from the 'SiteFWD' worksheet).

3.5.3 Special observations

a) Special Events

The 32/74 West Lake Taupo site had unusual characteristics for the first full day of recording, namely Saturday 25 November – it is surmised that there was a cycling event on the day affecting the increasing route position direction in particular. The start date for the output results was altered[4] to be Sunday 26 November; however the speed distribution results include the whole period surveyed and thus the mean speed was artificially lower, and the standard deviation substantially greater for the site.

Accordingly, the MetroCount software was re-run with the speed outputs recomputed excluding (masking) the Saturday in order to give revised speeds (for seven days only), noting that the percent following and traffic volumes were unaffected.

However, this does raise the issue that one-off events such as roadworks, could have an effect on results if not allowed for within the processing stage. It is preferable to avoid these situations by rescheduling the survey week but still staying close to the original scheduled period to avoid any possible seasonal effects.

b) Variations between Survey Month

Many sites had four MetroCount 'Regular' surveys for 2006, but no sites had more than one 'Plus' survey. By way of exploratory investigation, two surveys were processed for one site on SH 27, and all four surveys were processed for one site on SH 28, the results of which are summarised in the table below.

Table 1: Intra-Site Comparison

Site	27/82 AB	27/82 AB	28/9 AB	28/9 AB	28/9 AB	28/9 AB
Start Date for Week (2006)	**25 June**	**14 July**	**1 March**	**15 July**	**23 Aug.**	**7 Sept.**
Speed (km/h) comparison						
Mean speed, all vehicles	89.8	84.6	60.8	69.5	69.4	68.5
Mean speed, free vehicles	90.8	85.8	61.7	70.2	70.0	69.2
Mean speed, platooned vehicles	87.0	81.0	57.9	67.3	66.9	65.6
Mean + std dev^n, all vehicles	100.7	95.2	73.1	82.1	82.4	81.5
Mean + std dev^n, free vehicles	101.7	96.4	74.0	82.7	82.9	82.2
Mean + std dev^n, platooned vehs	97.6	91.7	70.3	79.9	80.5	79.0
Flow comparison						
Weekly ADT (7 days, one way)	1939	1857	1432	1423	1496	1434
%HV Monday to Thursday	24.0	23.4	23.3	22.3	20.5	22.7
%HV Friday	17.6	15.3	14.8	18.3	15.5	18.2
%HV Saturday	8.6	7.1	8.8	5.3	7.6	8.1
%HV Sunday	8.7	6.1	6.0	3.8	5.2	4.8
%HV Monday to Friday	18.9	17.5	16.7	15.3	14.7	16.8
Percent Following comparison						
Predicted M-F %following, 150 vph	29.4%	30.3%	37.5%	35.6%	29.7%	33.4%

[4] This was achieved by insert an "*" in the appropriate places in the MetroCount output to falsely indicate that the day was only partially surveyed, rather than the alternative approach of running the MetroCount software again with the Saturday excluded.

The predicted percent following is that derived from the linear best fit line; as the observed values varied with the highest weekday flows being about 120 vph one-way, the best fit line (R square varying from 0.85 to 0.94 based on minimum 20 vph) was chosen.

Inspection of **Table 1** reveals that for the SH 27 site, there is a difference of about 5 km/h in the speed statistics and about 1-2% in the %HV, which is probably not atypical. In terms of the linear prediction of the weekday percent following for 150 vph one-way (based on flows >20 vph one-way), there was little difference, averaging at 29.9%.

For the SH 28 site, there is little difference in the speed statistics for three of the surveys but for the March survey the observed speeds were slower by about 8-9 km/h. There was quite a bit of variation in the linear prediction of the weekday percent following for 150 vph one-way (based on flows >20 vph one-way), averaging at 34.0% for all sites or 33.0% excluding the March survey.

The SH 28 site recorded higher % HVs over the whole weekend during March 2006 (early autumn with daylight saving) than for other periods of the year. This possible seasonal effect seems to be more marked over the weekends. Unfortunately, seasonal effects could not be compared for the SH 27 site.

Also, SH 28 is a minor regional state highway compared to SH 27, which is part of a long-haul route. Therefore, the function of the route and seasonal/weekend effects could partly explain the variation in percent following on some state highways, particularly at lower AADTs.

3.5.4 Sites near major junctions

A number of sites were analysed that were on the approach to an intersection whereby the state highway traffic had to slow, or were by a major intersection with the state highway though traffic potentially influenced by slow moving traffic joining the state highway. Some of these sites are colour-coded in the list of sites provided within Appendix A.

For example the three sites on SH 28 are all located near the intersection with another major State Highway and the recorded average speeds for 02800000 and 0280009 appear to reflect this (average speeds less than 70 km/h), but not site 2800024. Accordingly it would seem that in some cases the MetroCount may be undertaken not where inferred from the site description, which potentially might not have been updated.

The two sites on SH 21 by SH 1 and SH 3 also show the effect of proximity to the major State Highway intersection when compared with site 2100004, for which the speeds are higher although the topography and road alignment are not too dissimilar.

3.5.5 Aggregation of the site data

A summary spreadsheet (weekplot_DKW2) was created with the weekday percent following distributions for all the processed sites (apart for the 5/57 Waipa telemetry site which was evidently faulty and for which a complete day's data was only available for the Saturday and Sunday). The data were aggregated together into different graphs, which were examined as discussed in the following section.

3.6 Discriminatory Variables for the Percent Following

a) Percent HVs

A total of ten graphs were prepared based on the interval and vbv site output for the percent following for a weekday (defined as Monday to Friday) (Appendix D). The sites were generally grouped by State Highway with some rearrangement so that the busier sites were aggregated together. Three of the ten graphs related to the busier sites, for which the Hourly Flow scale was set as 0-1400 vph, and the Percent Following as 0-90%. For the remaining seven graphs the respective scales were 0-500 vph and 0-60%, in order to provide greater clarity.

The sites could in future be rearranged in another manner. To facilitate this and to assist conducting statistical hierarchical clustering, the data from the site spreadsheets were pasted as values, rather than as links. Because the sites were of two different types, the site labels differ somewhat as now described.

For the interval sites, the average daily traffic, the weekday (Monday to Friday) %HV, and the mean speed of all vehicles were output, followed by the site ID. Whereas for the individual data sites, the site ID was output followed by the mean speed for free vehicles and for lead vehicles and the %HV for the whole survey (usually after trimming the day to comprise 7 calendar days).

For both sites the label started with a single capital letter, indicatively showing the speed range (A < 68 km/h, B: 68-78; C: 78-88; D: 88-98 km/h and above) although the letter could instead be used to indicate for example the % HV, terrain, speed environment, or other characteristic.

From examination of the aggregated graphs, it appears that the percent following is generally influenced more by the percentage of heavy vehicles than by the mean speed of the vehicles. For example, for the first graph shown in Appendix D, there are three directional sites (1/729-AB,1/729-BA, 1/763-BA) with particularly high percent following; these have reported %HV of 20%, 22% and 23% (the latter for average weekday is actually 26%). The three directional sites with low percent following (1/559-AB, 1/559-BA, 1/563-AB) have reported %HV of 7%, 8%, and 9%. Three of the in-between directional sites with higher flows (1/526-AB, 1/526-BA, 1/580-BA) all have reported % HV of 15%.

Looking at the moderate flow sites, the percent following at the 300 vph (in one direction) volume level, is about 35% for sites with weekday %HV of 6-9%, with the highest percent following of about 52% at 300 vph for a site (27/65 AB) with 19% HV.

Looking at the higher flow sites, the percent following at the 600 vph (in one direction) volume level, is about 55% for sites with weekday %HV of 7-9%, with the highest percent following of about 70% at 600 vph for a site (1/519 BA) with 16% HV. For 900 vph, the percent following is about 68-77% (the lower limit applies to 3 sites on SH 1 and site 2/176-BA, 6 sites are in the 69-74% range and the upper limit applies to sites 1/526-AB and 2/143-AB), and for 1200 vph about 76-81% (2 sites on SH 1, 5 sites on SH 2). Thus as the traffic volume increases, the variability in the observed percent following is less, although there are fewer two lane rural sites with such high one-way directional flows.

The effect of % HVs as discussed above is summarised in the table below.

Table 2: Comparision Between Percent Following and Percentage Heavy Vehicles

One-Way Flow (vph)	< 10 % HV	% Following	10-20 % HV	% Following	> 20 % HV	% Following
300	6-9	35	19	52	20-23	46, 52
600	7-9	55	16	70	21	65
900	7-9	68	15	77	n/a	n/a
1200	7	76	11	81	n/a	n/a

b) Consideration of light vehicles towing.

A further observation relates to the potential use of %non-car rather than %HV the difference being that the former would include the light vehicle towing category (Transit 1999 class 2). This category was investigated for the telemetry sites, which were assumed to be on routes with a greater number of cars towing boats than is usual. The results are presented in the table below.

Table 3: % Heavy Vehicle and % Light Vehicle Towing For The Telemetry Interval Sites

SITE	% HV				% LVT				% Following		Week.	Comment
Average	Mon-Sun		Mon-Fri		Mon-Sun		Mon-Fri		vph		Begin.	
Direction	AB	BA	AB	BA	AB	BA	AB	BA	150	300	2006	
1/526 Taupiri	12.5	12.4	15.0	15.1	2.6	2.3	2.3	2.1	31	46-	27,11Oct	S/b / N/b separate
1/580 Karapiro	11.5	12.2	14.0	14.9	3.0	3.0	2.7	2.7	27	42	6 Dec	
1/620 Lichfield	20.0	18.9	23.0	21.9	3.2	3.2	2.8	2.6	34*	49*	14 Dec	Directions differ
1/729 Halletts Bay	15.8	19.0	22.2	20.5	2.7	3.0	2.7	2.7	52		26 Nov	Windy terrain
2/2 Maungatawhiri	16.9	15.3	21.0	20.1	3.8	3.7	3.3	3.2	32*	48*-	10 Dec	Directions differ
2/91 Waihi west	11.8	12.7	14.6	16.4	3.6	3.4	3.4	3.0	22*	54*	5 Dec	Directions differ
3/85 Te Kuiti south	24.7	18.1	27.6	21.1	2.2	3.1	2.1	3.0	31	-	12 Dec	S/b high %HV
5/34 Tarukenga	14.9	12.6	17.1	16.2	1.6	2.1	1.4	1.9	37	-	17 Jun	
25A/11 Neevesville	9.4	8.4	11.1	11.6	5.1	5.3	5.1	4.4	44	-	28 Nov	High %LVT
30/188 Lake Rotoma	13.6	13.3	14.6	14.2	3.0	3.2	2.7	3.0	37	-	16 May	Fri low, Sun high %HV
32/74 W Lake Taupo	8.4	10.2	12.4	13.5	4.8	5.3	5.2	4.7	-	-	26 Nov	High %LVT, low flow
33/30 Paengaroa	14.3	16.9	15.6	17.9	3.2	2.8	2.9	2.8	31	-	16 May	Fri low, Sun high %HV
* indicates that the percent following were substantially different for the two directions												

Inspection of Table 3 reveals that for two of the sites (25A/11 Neevesville and 32/74 West Lake Taupo), there were a comparatively high percentage of vehicles classified in the light vehicle towing class (%LVT) and both sites had the lowest percentage of heavy vehicles (%HV).

Four of the sites had % HV for a weekday (Monday to Friday) exceeding 20 %, with one site having a very high %HV for the southbound direction, possibly suggesting that the tube detections were affected by the high speed (this site – Te Kuiti – had one of the two highest recorded mean speed) and high percentage of heavy vehicles.

When the percent following for the two sites (SH 25A Neevesville and SH 32 West Lake Taupo) with the low %HV and high %LVT were compared with the other sites on the relevant aggregated plots, it was observed that they were some of the sites with the highest percent following for their flow range, yet other sites had higher %HV. Both telemetry sites are also on winding curved alignments with steep vertical gradient. However, some of the other sites are also in difficult terrain e.g. SH 30 Lake Rotoma and SH 1 Halletts Bay.

These results suggest that %HV plus %LCV and possibly in conjunction with road alignment and gradient might be better explanatory variables for percent following than % HV alone.

c) Upstream Road and Traffic Conditions

As is noted for the table above, and as is evident from examination of the graphs, a number of sites had significantly different speeds and percent following for different directions, even though the directional traffic volumes and %HV were similar at the survey site(s) for each of the increasing and decreasing route position directions.

Possible variables contributing to the differences are:

- The proportion of available vertical and horizontal sight distance
- The volume of opposing traffic in advance of each site
- The volume of following traffic.
- The speed environment or terrain type
- Proximity to a major intersection.

These possible variables would enable comparison with various overseas studies that have used the Australian software TRARR, for example the British Columbia Ministry of Transportation and Highways, May 1998 Passing Lane Warrants and Design Technical Bulletin[5].

The British Columbian charts illustrate, that for different upstream terrain at about 35% available upstream overtaking opportunities, mountainous terrain has lower percent following. This lower percent following arises from the greater speed differential such that overtaking traffic requires a shorter overtaking length. However, as the availability of upstream overtaking opportunities reduce (i.e. longer sight distances were required to allow for overtaking in the presence of opposing traffic), the percent following increases at a faster rate for mountainous terrain than for flat or rolling terrain.

Therefore, it would appear that road sections in mountainous terrain are more sensitive to the percentage of time spent following than road sections in flat and rolling terrain. Whereas, road sections in flat and rolling terrain seem to have similar (but slightly different) percentage of time spent following under the same percentage of upstream overtaking opportunities, and a slower rate of change in the percentage of time spent following.

Inspecting the Figure 4 and 5 graphs for level and rolling terrain (refer Appendix E), for an advancing traffic volume of 600 vph, 55% following corresponds with about 23% assured passing opportunity (APO), while 70% following corresponds with about 10% APO. As a comparison, for an advancing traffic volume of 600 vph in mountainous terrain, 55% following corresponds with about 15 % APO and 70% following corresponds with about 10% APO. (For higher flows the APO consistent with the results outlined above is about 15% APO). (Not sure what you mean by this last sentence). This gives some confidence that further more detailed investigations should prove fruitful.

[5] Available for downloading from http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC_Sections/09_Tab_9.pdf

3.7 Examination of Speed Measures

a) Intra-Site Comparison

Table 4 shows a comparison of speed measures between two sites for various weekly survey periods. Except for the SH 28 March values, there are relatively small differences between speed measures for each site. Also as traffic volumes increase speed does not necessarily reduce. Both speed values and traffic volumes are higher on SH 27 than for SH 28.

Within the same season, there is greater variation in speeds on SH 27, which is a higher volume road. This variation does not seem to relate to increased traffic flows or percent HVs. However, higher percent HVs over the whole of the week may be part of seasonal effects on lower flow state highways, such as SH 28.

Table 4: Intra-Site Comparison for Speed

Site	27/82 AB	27/82 AB	28/9 AB	28/9 AB	28/9 AB	28/9 AB
Start Date for Week (2006)	**25 June**	**14 July**	**1 March**	**15 July**	**23 Aug.**	**7 Sept.**
Weekly ADT (7 days, one way)	1939	1857	1432	1423	1496	1434
Mean speed, all vehicles (km/h)	89.8	84.6	60.8	69.5	69.4	68.5
Mean speed, free vehicles	90.8	85.8	61.7	70.2	70.0	69.2
Mean speed, platooned vehicles	87.0	81.0	57.9	67.3	66.9	65.6
Mean + std dev^n, all vehicles	100.7	95.2	73.1	82.1	82.4	81.5
Mean + std dev^n, free vehicles	101.7	96.4	74.0	82.7	82.9	82.2
Mean + std dev^n, platooned vehs	97.6	91.7	70.3	79.9	80.5	79.0

Comparing speed values between sites for weeks with similar one-way traffic flows, there were different speeds. This suggests other factors, such as road geometry may be influencing speed. However, while this may explain the difference between SH 27 and SH 28, there must be other influences causing variation over time for the same state highway.

For SH 28, the variation between early autumn (March) and early spring (Sept) shows that these months had slightly slower speeds compared to the winter months of July & August. The lower speed value for March may be due to daylight saving still applying in March compared to the other months. For SH 28, speeds were higher with wider variation between the winter months of June and July compared to SH 27's July and August.

b) Mean Speed of all vehicles

The mean speed of all vehicles does not distinguish between free and platooned traffic, and accordingly is not particularly useful in investigating parameters influencing the percent following.

c) Free Speed

The determination of 'free' speed should not be biased by the number of slower vehicles leading each platoon, particularly when there is a high proportion of platooning. Possibly, the speed of vehicles, that have more than a 4 second gap between vehicles both in front and behind, is a more appropriate measure of 'free' speed. This measure should increase the 'free' speed value and hence increase the sensitivity for comparing with 'platooned' speed.

d) Platooned Speed

Using the 4 second threshold, examination of speed data showed little variation between speeds of vehicles within a platoon. Therefore, the 4 second threshold did not appear to be capturing situations to any great extent where a slightly faster platoon was catching up to a slower moving platoon.

e) Relative Difference between Free and Platooned Speeds

From Table 1, observations of monthly variations for two sites suggest that the free speed of vehicles can vary markedly but there was little change in the relative difference between the following speed and the free speed. Therefore, any measurement of the relative difference between these free and platooned speeds also has to identify changes in free speed.

f) Average Travel Speed

The average travel speed is a better measure for road sections but the survey method to measure travel time is not suited to TMS, requiring a ITS application or manual survey. The average travel speed could be roughly approximated by averaging all operating speeds for TMS stations along a particular road section, depending on the number of TMS stations.

g) Anomalies at Other Sites

There was also one site (SH 41/49 increasing route position direction) where both the interval data for the week (7 full days) beginning 21 February 2006 and the individual data for week (9 full days) beginning 5 August 2006 were processed. The results are radically different with the February means speeds around 90 km/h, and the August mean speeds around 64 km/h (68 km/h in the opposite direction).

This large difference has not been investigated, although it is surmised that the difference is probably due to the February 2006 survey being undertaken at a different location, further from Tokaanu than the August 2006 surveys. Another distinct possibly is that roadworks were undertaken near to the site during the same week in August 2006.

h) Discriminating Variables

More research is needed into discriminating variables for speed as well as the selection of an appropriate speed measure. The table below shows the downstream length of roadway affected by a passing lane in flat and rolling terrain[6].

Table 5: Downstream Length of Roadway Affected for Passing Lane*

One-Way Flows (passenger cars per hour)	**Downstream Length of Affected Roadway (km)**	
	Percentage of Time Spent Following (PTSF)	**Average Travel Speed (ATS)**
Less than 200	20.9 km	2.8 km
400	13.0 km	2.8 km
700	9.1 km	2.8 km
1,000 or more	5.8 km	2.8 km
Note: * In treated direction, in flat and rolling terrain		

The length of downstream highway likely to be affected in terms of the average travel speed interestingly does not vary with volume. The effect on average travel speed is reduced at a faster rate than percent following for all flows. This greater reduction in downstream influence suggests that the average travel speed is more easily influenced by downstream road and traffic conditions than percent following and is not markedly influenced by one-way flows.

Possibly road gradient and alignment are contributing to speed variations between sites but these variables do not explain speed variations at the same site. For SH 28 speed data in Table 4, weekend heavy vehicle volumes were increased, as part of March seasonal effects, which may account for the slower speeds during this survey period. However, for some road sections, seasonal effects could mean slower speeds in the winter months due to weather conditions, such as snow.

Whereas, other roads may be busier during the summer with peak recreational traffic and more HV use occurring over the whole of the week. Also speed measures may be more sensitive to the relocation of survey sites than other traffic parameters such as the AADT and percent HV.

[6] Reference - Harwood D.W., May A.D., Anderson I.B. Liemann L. & Archilla A.R., 1999 Capacity and quality of service of two-lane highways *Final report 3-55(3)* prepared for National Co-operative Highway Research Program, Transportation Research Board, US National Research Council. Cited in Koorey G.F. and Gu J. 2001 Assessing Passing Opportunities Stage 3. Transfund NZ Research Report No. 220)

4 Discussion

4.1 Implications for the Traffic Monitoring System

There are a number of implications for Transit's traffic monitoring system (TMS) arising from utilising the TMS survey information to estimate passing demand. The following comments should be read in conjunction with those already mentioned in Section 2

a) Modifying Regular MetroCount Equipment

It would be useful if not only was a MetroCount survey required at least once a year at each TMS site, but also that it was specified to be a 'Plus' rather than a 'Regular' MetroCount survey. Apparently the difference between the two is that the individual vehicles and other reports have been unlocked in the 'Plus' units by inputting a special code, that can be purchased from the suppliers. Thus upgrading from 'Regular' to 'Plus' units would be straightforward but would have some cost implications; nevertheless it is easier to process individual vehicle data than to combine several interval reports.

b) Dual Loop Sites

At the dual loop sites (both telemetry and local sites) it would be sensible to have devices capable of recording not only vehicles categorised into the four standard length bins, but also the four length bins for free and platooned vehicles separately. Again this would have some cost implication with at present only the Golden River Marksman M660 capable of recording length by headway.

Furthermore having installed such devices at the dual loop sites the default recording specification should be length by headway in order to monitor the percent following. Data conforming to this specification cannot presently be captured in TMS, so the TMS system would need adjusting to include four additional fields, namely the four length bins for either free or platooned vehicles (with the current four length bins pertaining to all vehicles). Accommodating this should be straightforward, and it is considered that the implications would not be great.

c) Vehicle-by-Vehicle Data

At the dual loop sites, it would be useful to have at least one day's individual vehicle (vbv) data collected once or twice a year. This has previously been proposed for the TMS telemetry sites, but essentially again only the Golden River Marksman M660 is capable of recording by telemetry vbv data. A mechanism could be derived whereby suitable devices[7] are rotated around dual loop sites and manually installed; although hopefully any

[7] Some devices besides the M660 are (for example AVC in theory, Golden River Classifier), or in the future may be, capable of recording vbv data in live mode with a connected laptop capturing the data records. Refer emails from Siegfried Gassner, Traffic Systems & Surveys, dated 8/2/2007 (and earlier) to David Wanty.

new devices installed with length by headway capability as aforementioned, will also have vbv capability. However, it should be noted that fulfilling the first comment above, effectively satisfies this situation.

d) Central Storage Repository

It would be useful for Transit National Office to hold a central repository of the raw MetroCount 'Plus' .ECO files and vbv files for other devices. As mentioned in correspondence between David Wanty and Neil Beckett, TMS Administrator, the repository would most likely be in the form of CDROMs or DVDs, rather than stored within TMS which would otherwise necessitate some fundamental changes.

e) Appropriate Location

It appears that on mountainous sections of highway with little variation in the traffic flow, the TMS sites are located, not surprisingly at the bottom of the mountain rather than on the gradients. It could be useful for the various studies related to passing demand and overtaking opportunity, if survey sites could be specifically created or relocated in mountainous sections, for example at or near the summit or on both sides of the summit at the 'one-third' points, to better gauge the variation in percent following within the mountainous sections.

f) Intersection Effects

It would appear that not all the site descriptions are current and/or the surveys are not necessarily undertaken where they are supposed to be located. It would be preferable to locate sites away from the direct influence of major intersections. It is suggested that the TMS administrators investigate this matter further, recognising that it might increase collection costs marginally and would be subject to safety considerations for the contractor.

4.2 Consideration for further work

The creation of the single summary spreadsheet with pasted values as previously stated, is amenable to analysis using hierarchical clustering techniques to produce a dendogram(s) from which both suitable discriminatory variables can be derived and the appropriate number of site groups established.

A logical step is to present the analysis results in GIS, and in so doing the location of existing passing lanes (and slow vehicle bays) and the horizontal alignment upstream of each site can be assessed visually. The RAMM terrain type can also be readily shown, along with sealed carriageway widths, all of which influence the percent following and speed at each (directional) site. The level of available overtaking sight distance for sections of state highway could also be input (as determined from the High Speed Data, adopting an assumed amount of lateral clearance or as measured from surveys).

In due course the seasonal variation of the percent following could be examined for those telemetry sites where the configuration has been changed to recording length by headway (and possibly also by speed).

5 Conclusions

This pilot study involving exploratory investigation of the passing/overtaking demand using data for the Waikato and Bay of Plenty Regions for 2006, has been successful in many ways.

a) Relationship between the Percent Following and One-Way Flows

Three separate cubic curves were fitted to percent following values relating to one-way hourly flows for Monday – Friday, Saturday and Sunday. The cubic curves were a better fit to the data than a linear function.

Different levels of percent following could be loosely grouped into one-way hourly flows of less than 300 vph, 300-600 vph and greater than 600 vph. However, within each of these groups of one-way flow, the amount of percent following was influenced by various discriminatory variables, particularly the percentage of heavy vehicles.

b) Percent Following Threshold

In terms of the definition of the percent following, a headway threshold of 4.0 seconds would be appropriate and matches the former NAASRA criterion for measuring the percent following. However, it would appear that the threshold per se is not as important as the relativity between sites by using the same threshold.

c) Equipment

Currently, many MetroCount counters have an electronic lock that prevents vehicle-by-vehicle counts being obtained. It should be a relatively simple and cheap process to unlock this feature. Therefore, by moving around "unlocked" MetroCount equipment, it should be possible to undertake a vehicle-by-vehicle survey at each site.

At time of tendering for data collection contracts, the equipment characteristics could be specified to include collection of both vehicle-by-vehicle headway and speed data.

d) Survey Frequency and Period

At each site, ensure that a MetroCount 'Plus' vehicle-by-vehicle survey or similar is undertaken at least once per year to enable determination of percent following and speed.

If further statistical analysis confirms a causal relationship, investigation of seasonal or weekend effects should be undertaken. The programming for data collection should avoid road sections undergoing roadworks or requiring vehicles to queue and wait.

As the percent HVs and percent light towing vehicles can vary between the weekend and weekday, it is suggested to analyse the data for a 7 calendar day basis count, trimming the data from a larger count period.

e) Data Storage

The raw MetroCount.ECO and any vehicle-by-vehicle data for other equipment, such as telemetry sites should be kept in a central repository by National Office (CDROMs or DVDs).

At rural dual loop sites always record the four length bins separately for 'total' and 'platooned' vehicles (the difference between 'total' and 'platooned' vehicles is the 'free' vehicles). This can be implemented by recording length by headway (and possibly also by speed).

f) Site Location

Additional data collection sites have been suggested under a previous study by MWH. As well as these locations being typical of the road section's AADT, consideration should also be given to sites in locations that are typical of the road gradient and horizontal alignment (e.g. within mountainous sections rather than at the start or end).
Where practical, sites should be located away from the direct influence of major intersections i.e 0.6 km for minor intersections and 1 km where there is a high % HVs.

g) Representative Sites

It is likely that with the eventual development of Transit Regional Passing and Overtaking Plans, that there may be further sub-division of road sections into more consistent characteristics of road gradient, horizontal alignment, AADT, percent HVs and percent light towing vehicles.

Further statistical work on the preceding road geometry might be needed to identify confirm the influence of the above-mentioned discriminating variables and which ones should be used to help differentiate between road sections.

It would be useful in undertaking further work, if the posted speed limit at each site was stored within TMS, in order to reliably cull out urban (posted speed limit of 70 km/h or less) sites, noting that a few selected sites had observed average speeds of less than 65 km/h (refer the third graph in Appendix D).

Furthermore additional validation checks could be incorporated into TMS including checking the proportion of the unknown class 14 vehicles (considered to be HCV-II heavy vehicles) and the proportion of "sequence" records with headway output as 0.0 seconds. If such problems persist at a site, then the site should be relocated.

h) Influences on the Percent Following

For the one-way average hourly flows for Monday-Friday, Saturday and Sunday, cubic curves have been fitted to values of the percent following. As well as the amount of one-way traffic flow, it is evident that the percentage of heavy vehicles is an influencing factor on the amount of percent following. There are clearly other variables that could influence the percentage of time spent following. These variables should be subjected to statistical testing to determine the extent of their influence, namely:

- The sum of % heavy vehicles and % light vehicles towing.
- Seasonal and weekend effects (which influence the %heavy vehicles and flows).
- Upstream road characteristics in each direction.

While the seasonal effects could be investigated based on the current data for those interval sites counted four times per year, it would be easier in due course to analyse the data for those telemetry sites that have been set to record length by headway. Therefore, analysis of data from telemetry sites would be a better way of determining seasonal effects.

i) Influences on Speed

Speed may be linked to the type of state highway, which is a combination of road geometrics and traffic composition. In addition, seasonal and weather effects may affect all types of state highway depending on location. However, no obvious relationship was found between speed and the above-mentioned possible discriminating variables for the percent following. Further statistical analysis is suggested.

Part of the problem with determining speed relationships may lie in the choice of speed measure. Many speed measurements relate to the specific location rather than reflecting the road section as a whole. Further investigation into an appropriate speed measure is required.

Average travel speed would seem a better speed measure for determining road section effects but would be more difficult to measure. Possibly, a series of spot measurements may be adequate. For spot measurements of speed, relative speed helps to differentiate between ‘free’ and ‘platooned’ vehicles.

Recording individual vehicles that have a four second gap between vehicles in front and behind should remove any possible bias from including platoon leaders. Also, the four second threshold appears to avoid the situation of faster platoons catching up to slower platoons, making for a more accurate determination between lead and following vehicles.

j) Further Work

A satisfactory speed measure is required that accurately reflects the road section. Suggested measures include:

- the average travel speed through a road section.
- a series of spot measurements along the road section for the relative difference between ‘free’ and ‘platooned’ vehicle speeds.

Further statistical analysis is suggested to determine the influence of discriminatory variables on percent following and speed.

It would be logical to present the percent following and speed data in a GIS format, with the location of existing passing lanes (and slow vehicle bays), the terrain type, the sealed carriageway width and other available characteristics from RAMM (or elsewhere) shown that influence the percent following and speed. However, there would need to be careful thought into which analysis data to incorporate as layers.

6 Recommendations

It is recommended that Transit consider:

i) A four second threshold to be used for data collection of percent following, to separate free or lead vehicles from following vehicles.

ii) Data collection for Transit's TMS to be modified to allow for data collection of the percent following and speed, as described within the Conclusions section of this report in terms of:

- Equipment
- Survey Frequency and Period
- Data Storage
- Site Location
- Representative Sites

iii) Statistical follow-up work to be undertaken to further develop the casual relationships between percent following and its discriminatory variables

iv) Further work to determine an appropriate speed measure and measurement procedure that reflects the road section.

v) Following satisfactory selection of a speed measure(s), statistical follow up work to develop casual relationships between speed and its discriminatory variables.

vi) After statistical follow-up work, the results in the summary spreadsheet to be captured into GIS, using the coordinates for each sampled TMS site as the location reference.

Appendix A Rural two-lane highway analysed sites

Table 6: List of sites (two lane, rural)

Reg	Site Ref	Description	Site Type	Type	AADT	Wk	Wk	vbv	vbv
03	00100517	North of Bell Crossing St. opposite house #222	non-continuous	Single Loop	17380				
03	00100518	120m past Bells Crossing St (Huntly)	non-continuous	Single Loop	20942				
03	00100519	400m North of Tainui Bridge Road	non-continuous	Dual Loop	17961	1	1		
03	00100526	TAUPIRI - North of Gordonton Road [#19]	continuous	**Telemetry**	19600	1	1		
03	00100529	100m South of Hopu Hopu Rail Bridge	non-continuous	Single Loop	14878				
03	00100537	Opposite Ngaruawahia Golf Club sign	non-continuous	Single Loop	17090				
03	00100540	100m South of Horotiu Bridge Rd	non-continuous	Single Loop	18933				
03	00100552	120m East of railway crossing	non-continuous	Single Loop	22601				
03	00100553	20m West of Dowding Street – Hamilton	non-continuous	Single Loop	13338				
03	00100559	355m past Cherry Lane (Tamahere Motels)	non-continuous	Single Loop	23502	1	1		
03	00100563	120m South of Pickering Rd (North bound)	non-continuous	Single Loop	18072	1			
03	00100575	50m North of Karapiro Stream Bridge	non-continuous	Single Loop	20353	1			
03	00100580	KARAPIRO – south of Hydro turnoff [#20]	continuous	**Telemetry**	14368	1	1		
03	**00100594**	400m South of State Highway 29	non-continuous	Single Loop	8005				1
03	00100613	20m North of Oraka Stream Bridge	non-continuous	Single Loop	10362	1			
03	00100620	LICHFIELD - South of Baldwin Road [#21]	continuous	**Telemetry**	9206	1	1		
03	00100628	TOKOROA - WIM - Site No 51	continuous	**WIM**	8614				
03	00100645	South of Kinleith Rd by RS peg 550/7.09	non-continuous	Single Loop	6511				
03	00100689	100m past Palmer Mill Rd	non-continuous	Single Loop	5136				
03	00100729	HALLETTS BAY - Telemetry Site No 42	continuous	**Telemetry**	5781	1	1		
03	00100758	588m South of ERP 753/04.51	non-continuous	Single Loop	3947				
03	00100763	500m past SH 46 (National Park Rd) Rangipo	non-continuous	Tube	3577			1	1
03	00200002	MAUNGATAWHIRI W of Grahams Bridge [#74]	continuous	**Telemetry**	13604	1	1		
03	00200037	1200m past State Highway 27 (Mangatarata)	non-continuous	Dual Loop	4519	1	1		
03	00200052	650m past Orchard East Rd	non-continuous	Dual Loop	5166	1	1		
03	00200062	130m North of Fisher Rd	non-continuous	Dual Loop	6970	1	1		
03	**00200066**	986m past Awaiti Road	non-continuous	Dual Loop	5939			1	1
03	00200091	WAIHI - East of Samson Road West [#34]	continuous	**Telemetry**	7569	1	1		
03	00200095	40m South of Crean Rd	non-continuous	Single Loop	9079				
03	00200098	200m South of Trigg Rd	non-continuous	Single Loop	5750				
04	00200106	500m East of Athenree Rd (Tauranga side)	non-continuous	Single Loop	7356				
04	**00200127**	Wright Rd	non-continuous	Single Loop	10110			1	1
04	00200143	340m past Snodgrass Rd	continuous	**Telemetry**	16141			1	1
04	**00200146**	480m North of Wairoa Rd	non-continuous	Single Loop	17761			1	1
04	**00200160**	205m before Maungatapu Bridge	non-continuous	Single Loop	22195			1	
04	00200168	Nth of Kairua Rd	non-continuous	Single Loop	19377		1		
04	00200171	500m South of Domain RAB	non-continuous	Single Loop	16062				1
04	00200176	Te Puke - WIM Site 49	continuous	**Telemetry**	18223			1	1
04	00200187	445m before Maketu Rd	non-continuous	Single Loop	13989			1	1
04	**00200204**	OHINEPANEA - West of Rogers Road [#13]	continuous	**Telemetry**	4759			1	1
04	00200225	785m past Speed Restriction (Matata East)	non-continuous	Tube	2710			1	1
04	00200241	163m before SH30 Awakeri Rail Crossing	non-continuous	Tube	3534			1	1
04	00200243	220m past SH30 Awakeri Hall	non-continuous	Tube	1964			1	1
04	00200285	100m before Wainui Rd	non-continuous	Tube	1139				
04	00200286	100m past Wainui Rd	non-continuous	Tube	3488				
04	00200298	525m before Paerata Ridge Rd (Before Opotiki)	non-continuous	Tube	3723				
04	00200308	437m North of Matchetts Road	non-continuous	Tube	1346				
03	00300003	285m South of Dixons Rd	non-continuous	Single Loop	12905				1
03	00300027	200m South of Cambridge Rd roundabout	non-continuous	Single Loop	7079				
03	00300029	350m North of Saint Ledger Rd	non-continuous	Single Loop	11580	1			

Reg	Site Ref	Description	Site Type	Type	AADT	Wk	Wk	vbv	vbv
03	00300034	105m before Tokanui Rd	non-continuous	Single Loop	7822				
03	00300038	335m N of Wharepuhanga Rd (Te Kawa Turnoff)	non-continuous	Single Loop	6600				
03	00300049	100m before Kio Kio Station Road	non-continuous	Single Loop	5157				
03	00300064	100m South of Mangapu #2 Bridge	non-continuous	Single Loop	7124			**1**	**1**
03	00300066	800m past State Highway 37 (Waitomo Rd)	non-continuous	Dual Loop	6710	**1**	**1**		
03	00300075	200m South of Carrol St	non-continuous	Single Loop	5581				
03	00300085	TE KUITI North of 8 Mile Junction [#16]	continuous	**Telemetry**	4221	**1**	**1**		
03	00300103	220m past Hunts Rd (Piopio)	non-continuous	Tube	2232				
03	00400000	400m past State Highway 3	non-continuous	Tube	2051	**1**	**1**		
03	00500000	217m past State Highway 1 (Tirau)	non-continuous	Tube	3500			**1**	**1**
03	00500005	245m west of State Highway 28 (Whites Rd)	non-continuous	Dual Loop	5320	**1**	**1**		
04	00500034	TARUKENGA - 4.7km West of Dalbeth Rd [#15]	continuous	**Telemetry**	5511	**1**	**1**		
04	00500055	795m South of Taupo Road	non-continuous	Single Loop	12588	**1**			
04	00500057	WAIPA - South of SH30 [#41]	continuous	**Telemetry**	7527	**1**	**1**		
04	00500082	520m South of ERP 77/3.70, Waiotapu	non-continuous	Dual Loop	5107	**1**	**1**		
03	00500125	98m before State Highway 1 (Wairakei)	non-continuous	Dual Loop	4495	**1**	**1**		
03	00500138	278m past Crown Rd (Taupo)	non-continuous	Tube	3692				
03	01B00001	Taupiri Town Edge (by RS 0/1.0 peg)	non-continuous	Dual Loop	5300	**1**	**1**		
03	01B00015	500m past Gordonton Rd/Taylor Rd Intersection	non-continuous	Tube	2274	**1**			
03	01B00024	100m past Holland Rd Intersection	non-continuous	Tube	2650	**1**			
03	01B00032	200m before Tauwhare Intersection	non-continuous	Tube	2815	**1**			
03	01B00033	200m after Tauwhare Intersection	non-continuous	Tube	3001	**1**			
03	01B00040	200m past Fencourt Rd	non-continuous	Tube	4147	**1**			
03	01B00043	Outside Cemetery	non-continuous	Dual Loop	6110	**1**	**1**		
03	02100000	225m South of 2nd Roundabout	non-continuous	Dual Loop	6246	**1**	**1**		
03	02100004	55m South of Lochiel Rd	non-continuous	Dual Loop	5727	**1**	**1**		
03	02100007	145m North of State Highway 3	non-continuous	Dual Loop	4942	**1**	**1**		
03	02300009	880m East of Kakaramea Rd	non-continuous	Single Loop	4968				
03	02300011	200m West of Maori Point Rd	non-continuous	Single Loop	5771	**1**	**1**		
03	02300037	90m East of Wrights Rd	non-continuous	Tube	3578				
03	02400001	120m East of Tower Road Roundabout	non-continuous	Single Loop	8879	**1**	**1**		
03	02400013	140m before State Highway 29	non-continuous	Tube	3357				
03	02500000	160m past State Highway 2 (Dalgetys Cnr)	non-continuous	Tube	3556				
03	02500021	335m before Hauraki Rd	non-continuous	Dual Loop	5550	**1**	**1**		
03	02500036	Speed Restriction Sign (Whakatete Bay Sth end)	non-continuous	Tube	3896				
03	02500049	Speed Restriction Sign (Tapu Township Sth end)	non-continuous	Tube	2047				
03	02500072	300m past Goldfields Rd	non-continuous	Tube	1493				
03	02500082	435m North of Road 309, Coromandel	non-continuous	Tube	2169			**1**	**1**
03	02500123	340m past Speed Restriction sign (Wharekaho N)	non-continuous	Tube	1125				
03	02500129	400m North of Joan Gaskell Drive, Whitianga	non-continuous	Tube	1064				
03	02500134	190m Before 309 Road	non-continuous	Tube	2380				
03	02500157	790m past Cooks Beach Rd	non-continuous	Tube	1917			**1**	**1**
03	02500177	Swampy Stream Bridge	non-continuous	Tube	2512				
03	02500185	65m before State Highway 25A	non-continuous	Tube	3097				
03	02500188	200m past State Highway 25A	non-continuous	Tube	1974			**1**	**1**
03	02500240	North of Gladestone Rd	non-continuous	Tube	2150			**1**	**1**
03	02600002	875m West of Lissette Road	non-continuous	Single Loop	5349			**1**	**1**
03	02600009	700m East of Platt Rd	non-continuous	Single Loop	4549				
03	02600022	855m West of Piako Rd (Motumaoho)	non-continuous	Dual Loop	4603	**1**	**1**		
03	02600023	150m East of Piako Rd	non-continuous	Single Loop	8619	**1**			
03	02600034	100m West of SH27	non-continuous	Single Loop	5779				
03	02600038	250m East of No. 7 Road	non-continuous	Single Loop	4598				
03	02600055	515m North of Patuwhao Stream Bridge	non-continuous	Tube	2129				
03	02600067	LSZ Sign past Ryall Rd	non-continuous	Dual Loop	4382	**1**	**1**		
03	02600075	380m past Komata River Bridge	non-continuous	Tube	2872				
03	02600096	200m South of SH25 Junction	non-continuous	Single Loop	6717				
03	02700045	300m North of State Highway 26 (Tatuanui)	non-continuous	Single Loop	4851	**1**			

Reg	Site Ref	Description	Site Type	Type	AADT	Wk	Wk	vbv	vbv
03	02700046	300m South of State Highway 26 (Tatuanui)	non-continuous	Single Loop	5041	1			
03	02700065	200m South of Matamata Airport Entrance	non-continuous	Single Loop	7363	1			
03	02700067	200m South of Wardville Rd	non-continuous	Single Loop	8775	1			
03	02700082	600m North of SH 29 Junction	non-continuous	Single Loop	4009	2			
03	02700083	320m past State Highway 29	non-continuous	Tube	3884			1	1
03	02800000	163m past State Highway 1 (Putaruru)	non-continuous	Tube	2239	1			
03	02800009	245m past State Highway 5 (Whites Rd)	non-continuous	Tube	3140	4			
03	02800024	105m before State Highway 29	non-continuous	Tube	1469			1	1
04	02900017	215m past Oropi Rd	non-continuous	Single Loop	10971	1			
04	02900034	KAIMAI - 100m past Boulder Br (K'titi Str) [#12]	continuous	**Telemetry**	8805			1	1
03	02900049	500m South of SH 24	non-continuous	Single Loop	7402	1			
03	02900051	400m East of Waimou Bridge	non-continuous	Single Loop	4282	1			
03	02900057	450m East of McNab Rd	non-continuous	Single Loop	4429	1			
03	02900063	350m West of Rail Crossing -Hinuera Rugby Club	non-continuous	Single Loop	4544	1			
03	02900069	200m South of Totman Rd	non-continuous	Single Loop	5783	1			
03	03000035	918m past Manaiti St (Bennydale)	non-continuous	Tube	712				
03	03000075	100m North of McLean Rd	non-continuous	Tube	945				
03	03000084	90m before State Highway 32 (Whakamaru)	non-continuous	Tube	2088				
03	03000110	133m past State Highway 1	non-continuous	Tube	2012				
04	03000141	155m before Gun Club Rd	non-continuous	Tube	2998			1	1
04	03000157	385m before SH33	non-continuous	Single Loop	10628			1	1
04	03000160	500m East of Okahu Lane	non-continuous	Dual Loop	4399	1	1		
04	03000188	LAKE ROTOMA - Telemetry Site No 22	continuous	**Telemetry**	3117	1	1		
04	03000205	107m before SH34 (Military Rd)	non-continuous	Tube	2450				
04	03000221	1,120m after Angle Road	non-continuous	Single Loop	7716				
03	03100013	130m before Symes Rd	non-continuous	Tube	2444				
03	03100022	500m West of Ngutunui Rd	non-continuous	Tube	650			1	1
03	03200028	230m before Whakamaru Dam	non-continuous	Tube	1291			1	1
03	03200041	55m before Poihipi Rd	non-continuous	Tube	1312				
03	03200074	West of Taupo - Telemetry Site 43	continuous	**Telemetry**	690	1	1		
04	03300003	230m north of Okawa Bay Road	non-continuous	Single Loop	6067	1	1		
04	03300030	South of Maungarangi Road Paengaroa [#14]	continuous	**Telemetry**	4222	1	1		
04	03400000	220m South of SH2 Intersection	non-continuous	Tube	1366				
04	03400011	195m South of SH30 East	non-continuous	Single Loop	5855	1	1		
04	03400025	230m before SH30 West	non-continuous	Tube	1315				
04	03500006	475m past Wairakia Rd (Tirohanga)	non-continuous	Tube	2069				
04	03500069	1588 past Church Rd (Te Kaha)	non-continuous	Tube	776				
03	03700000	115m past State Highway 3 (Waitomo)	non-continuous	Tube	1454	1	1		
04	03800000	165m past SH5 (Waiotapu)	non-continuous	Tube	2422	1	1		
04	03800035	50m South of Forestry Rd overbridge	non-continuous	Tube	1265				
03	03900003	100m past twin culvert bridge ERP 0/3.46	non-continuous	Tube	3041				
03	03900024	200m past Goile Rd Intersection (North)	non-continuous	Tube	2992				
03	03900034	100m before Meadway Rd Intersection	non-continuous	Dual Loop	5317	1	1		
03	03900052	400m past Mangati Rd Intersection	non-continuous	Tube	2865				
03	03900058	200m before SH 31 Intersection	non-continuous	Tube	2306			1	1
03	**04100049**	5m before 1st Abut Waihi Stream Br (Tokaanu)	non-continuous	Tube	1574	1		1	1
03	04100057	500m past SH47 Junction	non-continuous	Tube	2971				
03	04700046	242m before State Highway 41	non-continuous	Tube	1305	1	1		
03	**25A00011**	NEEVESVILLE - 400m b4 Forest Park Sign [#76]	continuous	**Telemetry**	3408	1	1		

NOTES

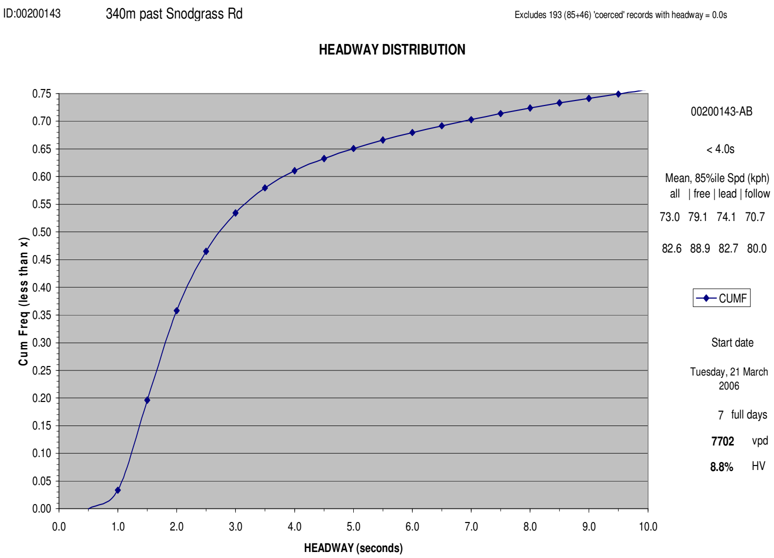
A "1" in the final four columns indicates that nominally one week data for the site was analysed for 2006 for the specified direction, in either interval ('Regular') or individual vehicle ('Plus') MetroCount format.

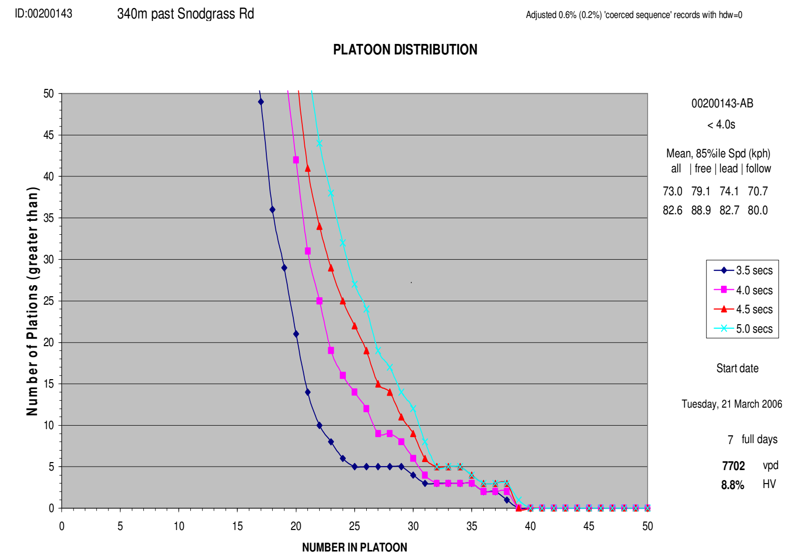
Note that 2006 data were not available for all sites as either not collected (e.g. Tokoroa WIM) or the count was faulty (e.g. 29/17B).

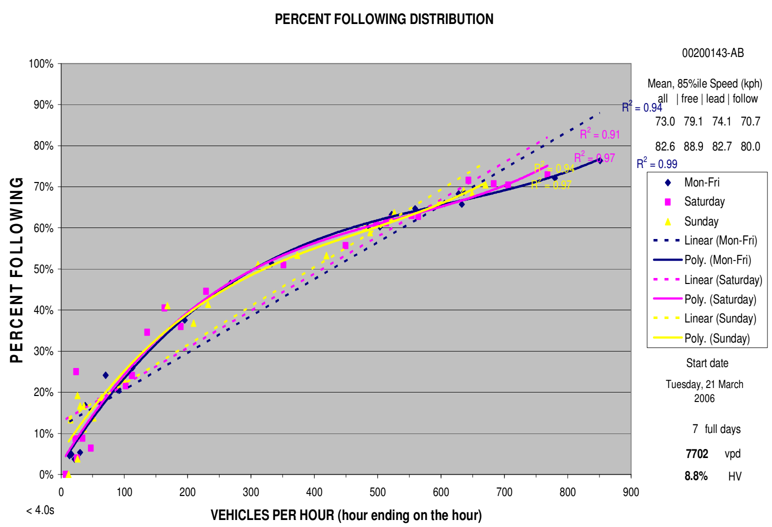
All 'Plus' files were analysed, and thereafter both directions for the telemetry and dual loop sites; at least one site for each State Highway by direction was also analysed.

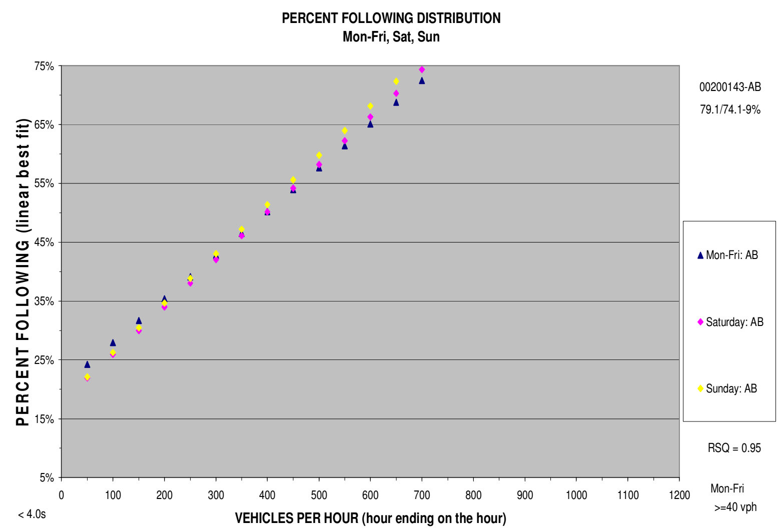
Generally all sites with AADT < 8000 were surveyed with a single MetroCount device and those with AADT > 12000 were surveyed with two devices.

Appendix B Example analysis output graphs for "vbv" sites

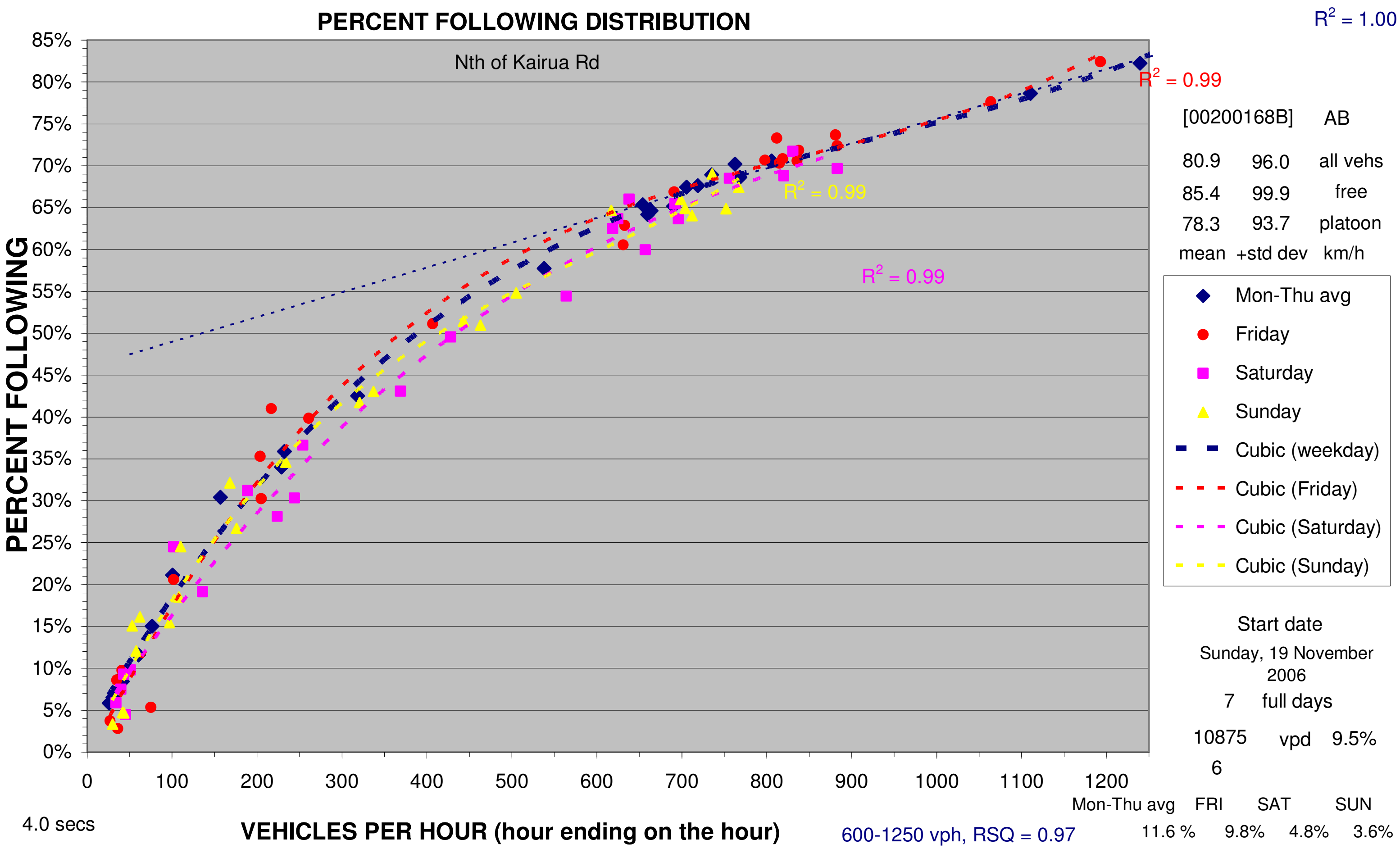








Appendix C Example analysis output graph for interval sites



Appendix D Summary aggregate weekday graphs

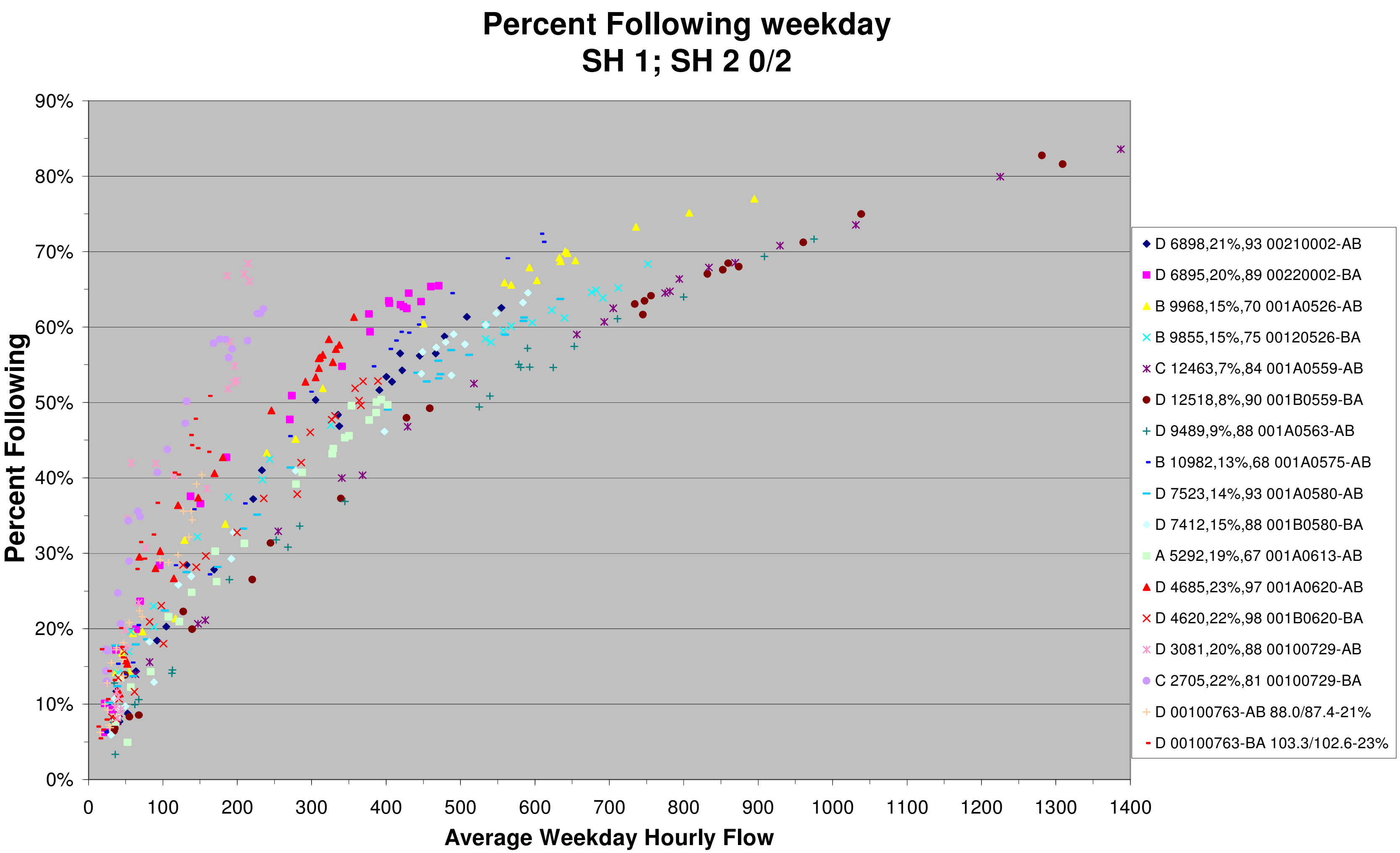
LEGEND

All sites: key for the first letter, speed for all vehicles
A: <68 km/h; B: 68-78, C: 78-88; D: >=88 km/h

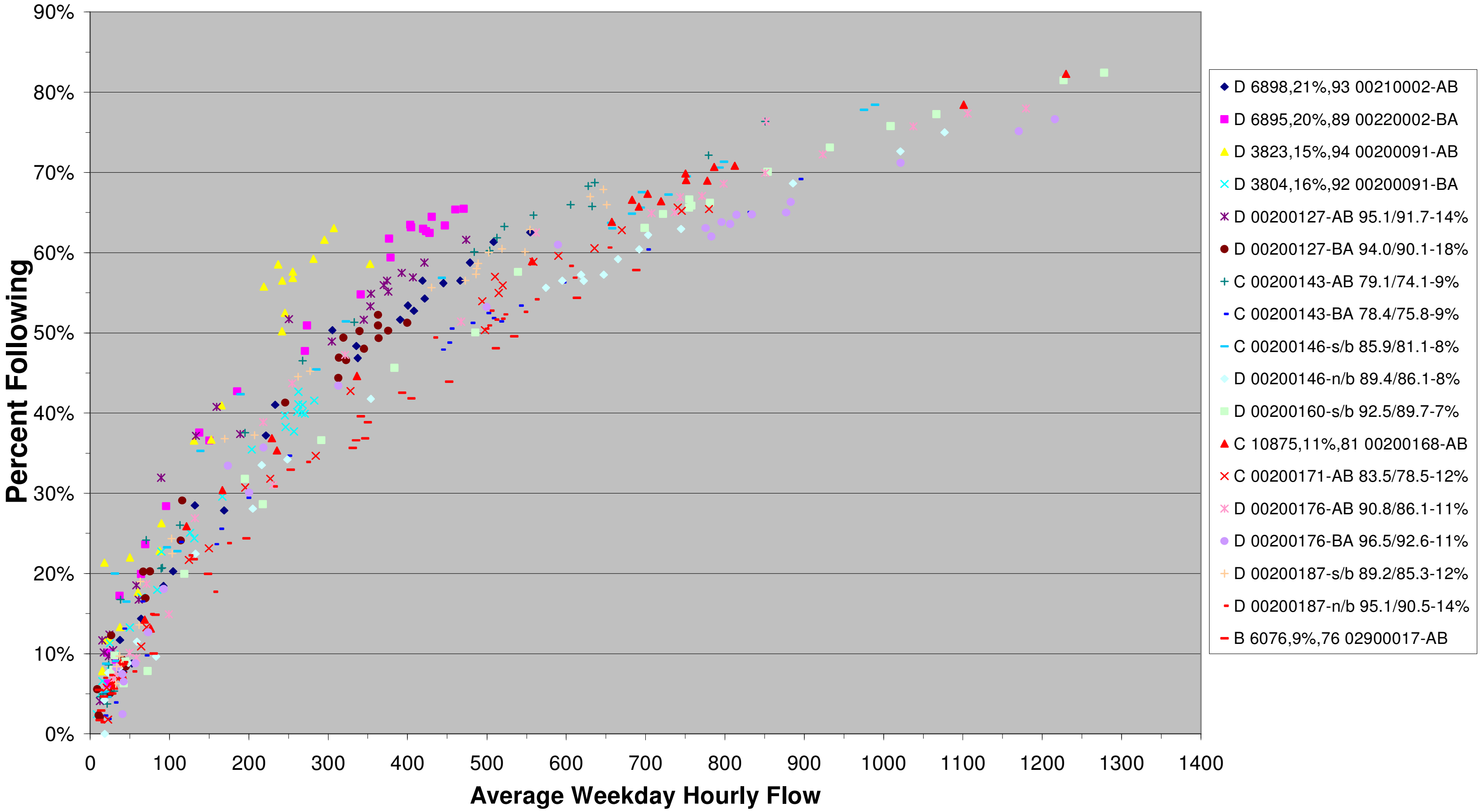
Interval sites
WADT, weekday (Mon-Fri) %HV, mean speed all vehs surveyed, site ID

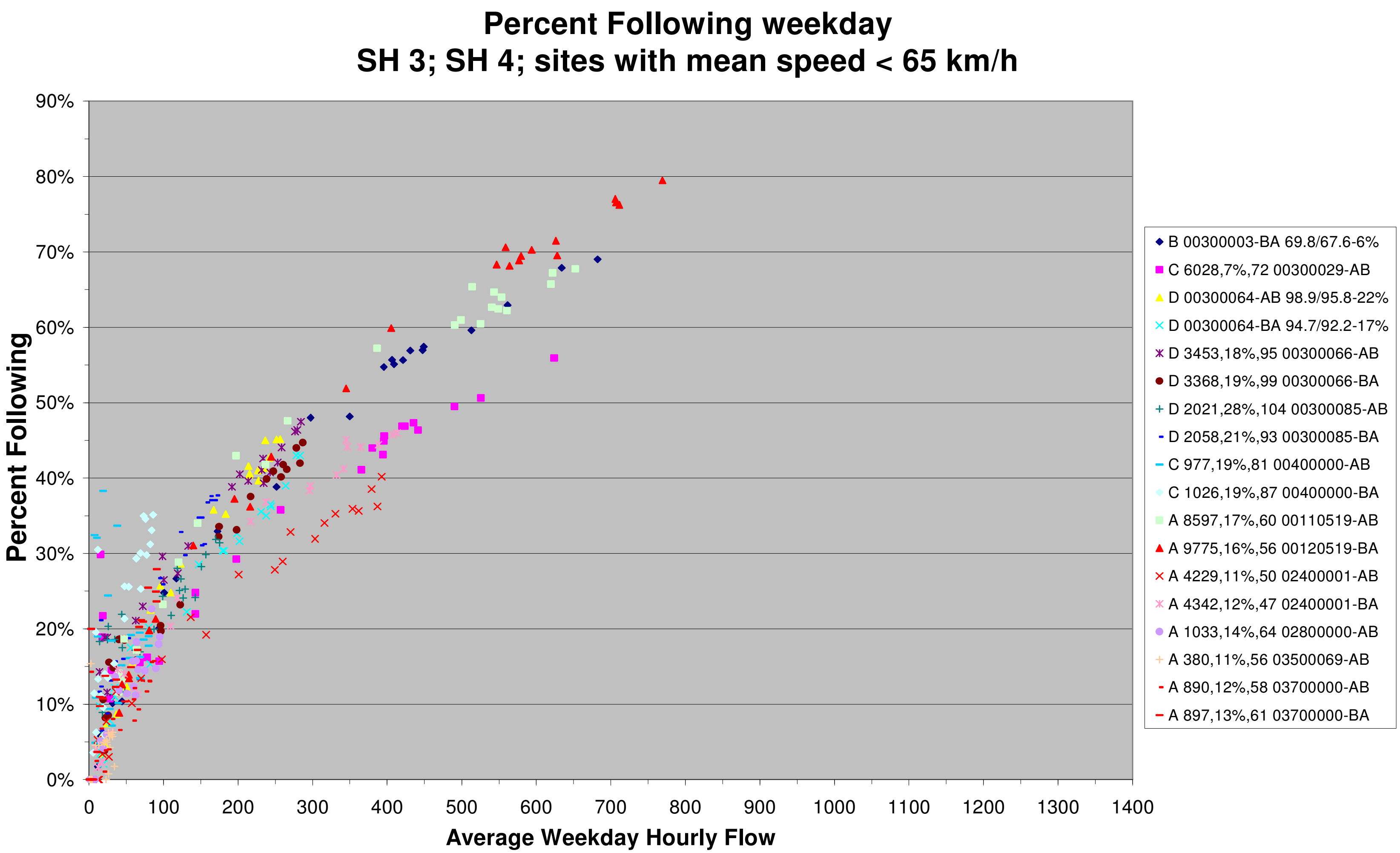
Individual vehicles sites
Site ID, mean free speed, mean lead vehicle speed, %HV whole week

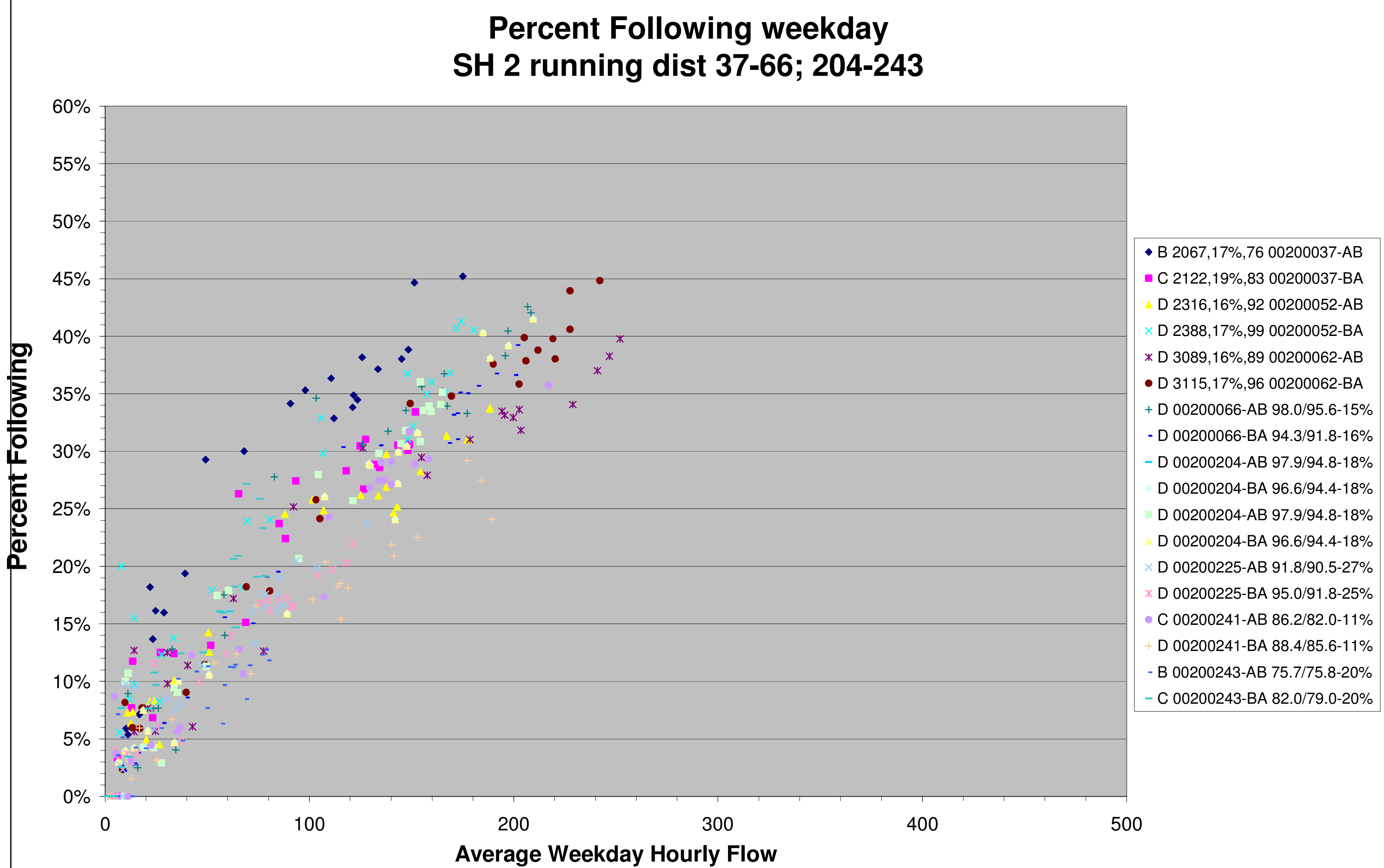
Note that the site ID pertains to the survey filename and so the fourth character is sometimes a “1” or “A” for a survey for the increasing direction only, or a “2” or “B” for decreasing direction only.

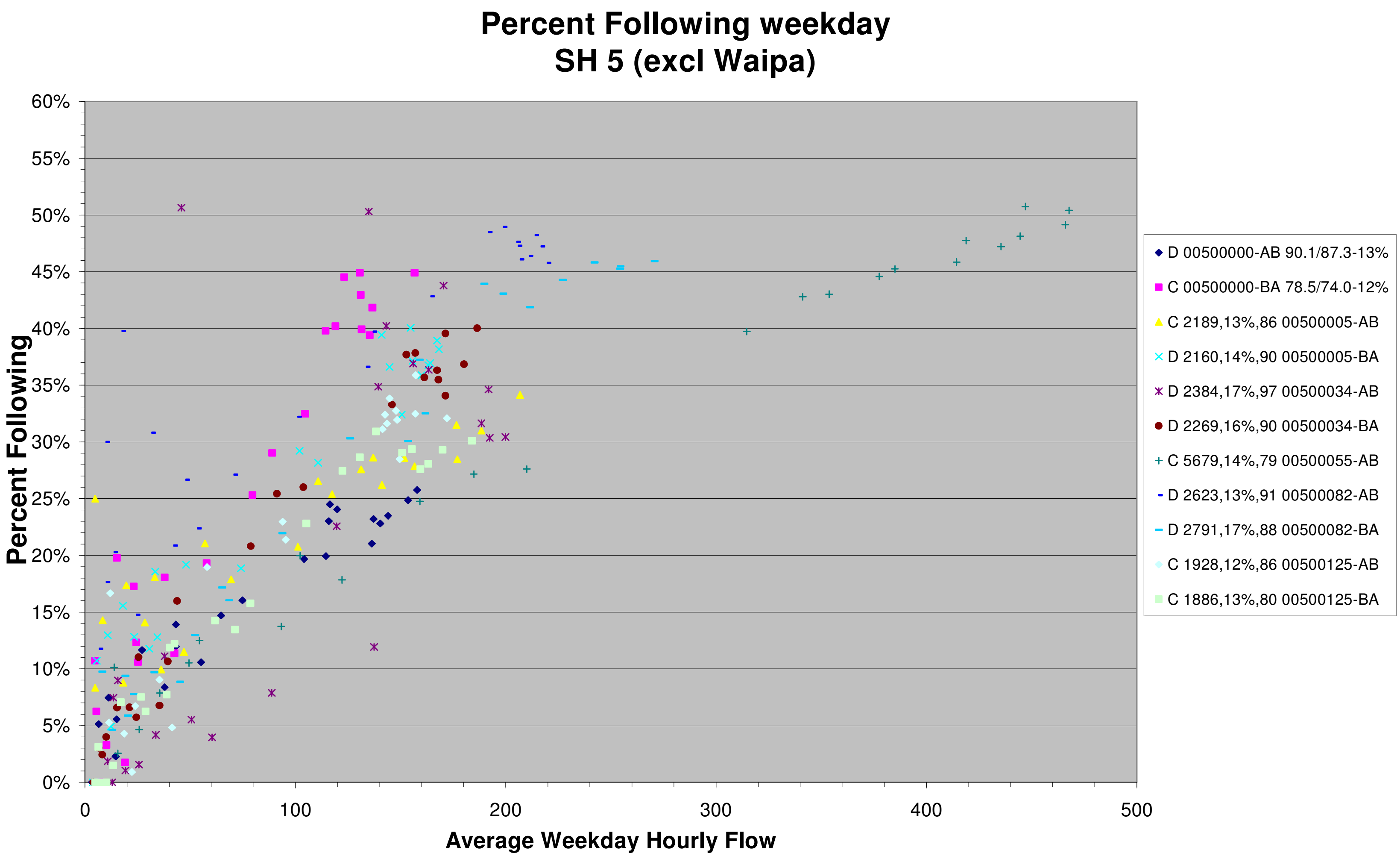

Percent Following weekday
SH 1; SH 2 0/2
Percent Following
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
Average Weekday Hourly Flow
D 6898,21%,93 00210002-AB
D 6895,20%,89 00220002-BA
B 9968,15%,70 001A0526-AB
B 9855,15%,75 00120526-BA
C 12463,7%,84 001A0559-AB
D 12518,8%,90 001B0559-BA
D 9489,9%,88 001A0563-AB
B 10982,13%,68 001A0575-AB
D 7523,14%,93 001A0580-AB
D 7412,15%,88 001B0580-BA
A 5292,19%,67 001A0613-AB
D 4685,23%,97 001A0620-AB
D 4620,22%,98 001B0620-BA
D 3081,20%,88 00100729-AB
C 2705,22%,81 00100729-BA
D 00100763-AB 88.0/87.4-21%
D 00100763-BA 103.3/102.6-23%

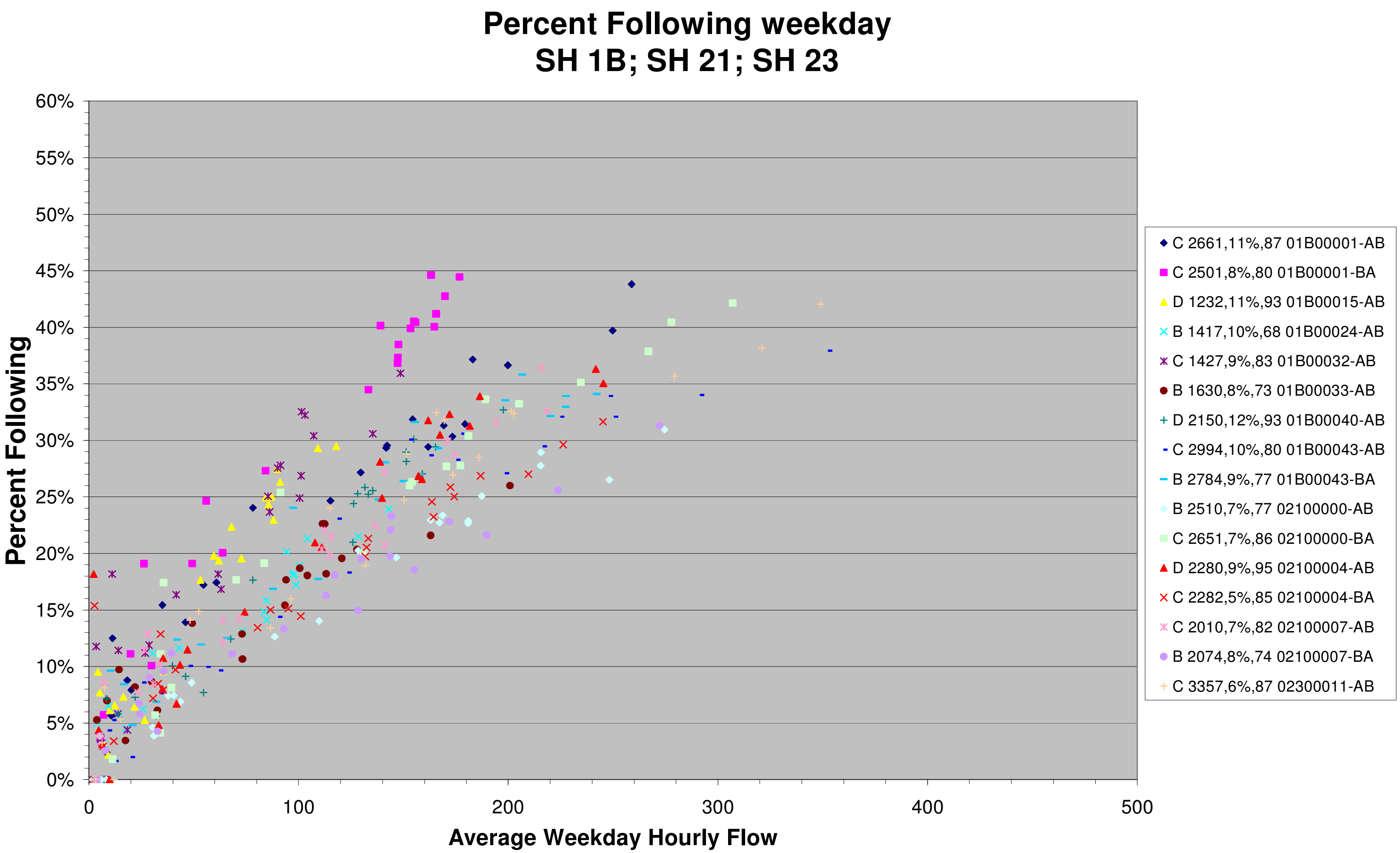
Percent Following weekday
SH 2: 0/2 & running dist 91-187; SH 29 :17

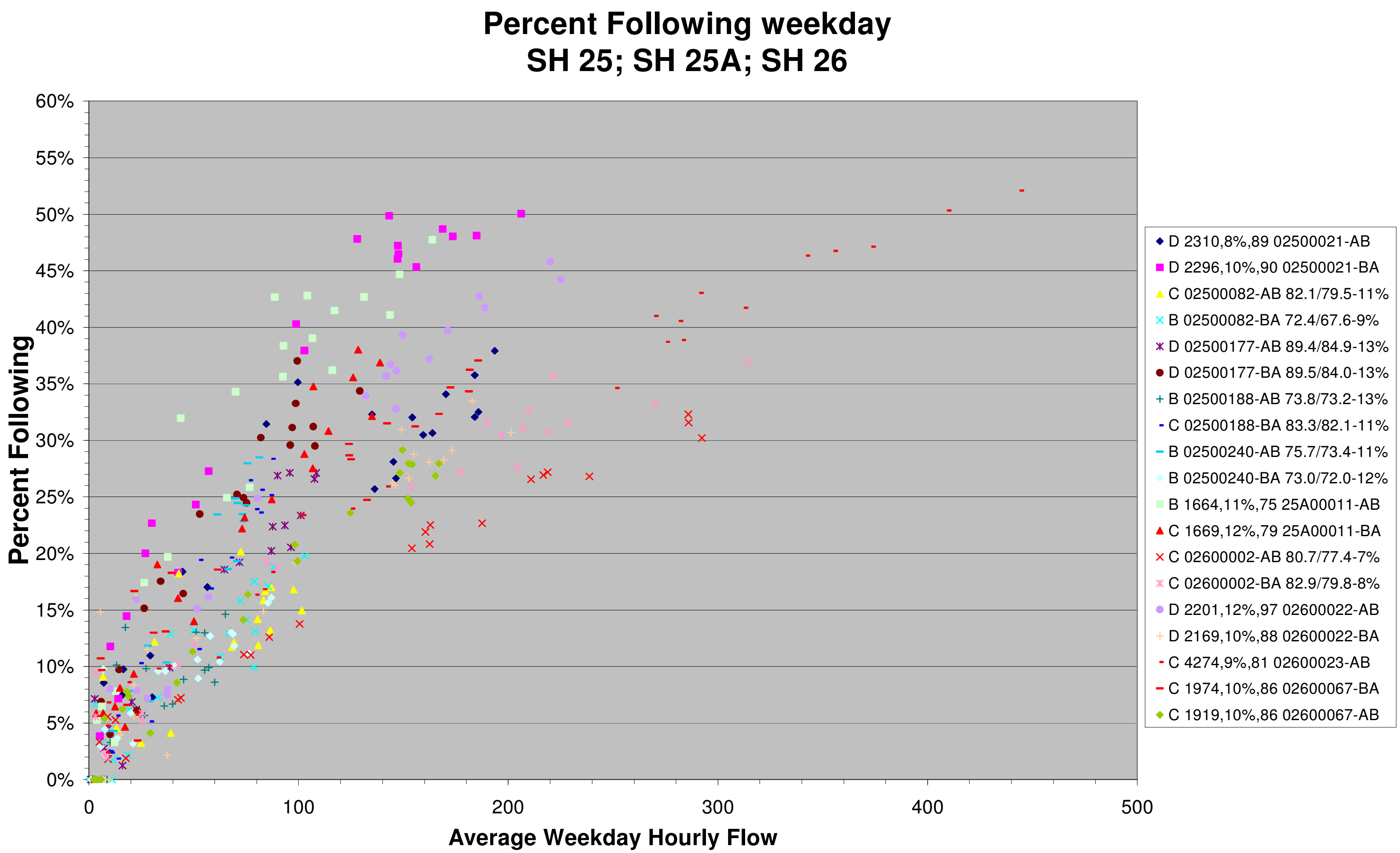



Percent Following weekday
SH 3; SH 4; sites with mean speed < 65 km/h
Percent Following
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
Average Weekday Hourly Flow
B 00300003-BA 69.8/67.6-6%
C 6028,7%,72 00300029-AB
D 00300064-AB 98.9/95.8-22%
D 00300064-BA 94.7/92.2-17%
D 3453,18%,95 00300066-AB
D 3368,19%,99 00300066-BA
D 2021,28%,104 00300085-AB
D 2058,21%,93 00300085-BA
C 977,19%,81 00400000-AB
C 1026,19%,87 00400000-BA
A 8597,17%,60 00110519-AB
A 9775,16%,56 00120519-BA
A 4229,11%,50 02400001-AB
A 4342,12%,47 02400001-BA
A 1033,14%,64 02800000-AB
A 380,11%,56 03500069-AB
A 890,12%,58 03700000-AB
A 897,13%,61 03700000-BA

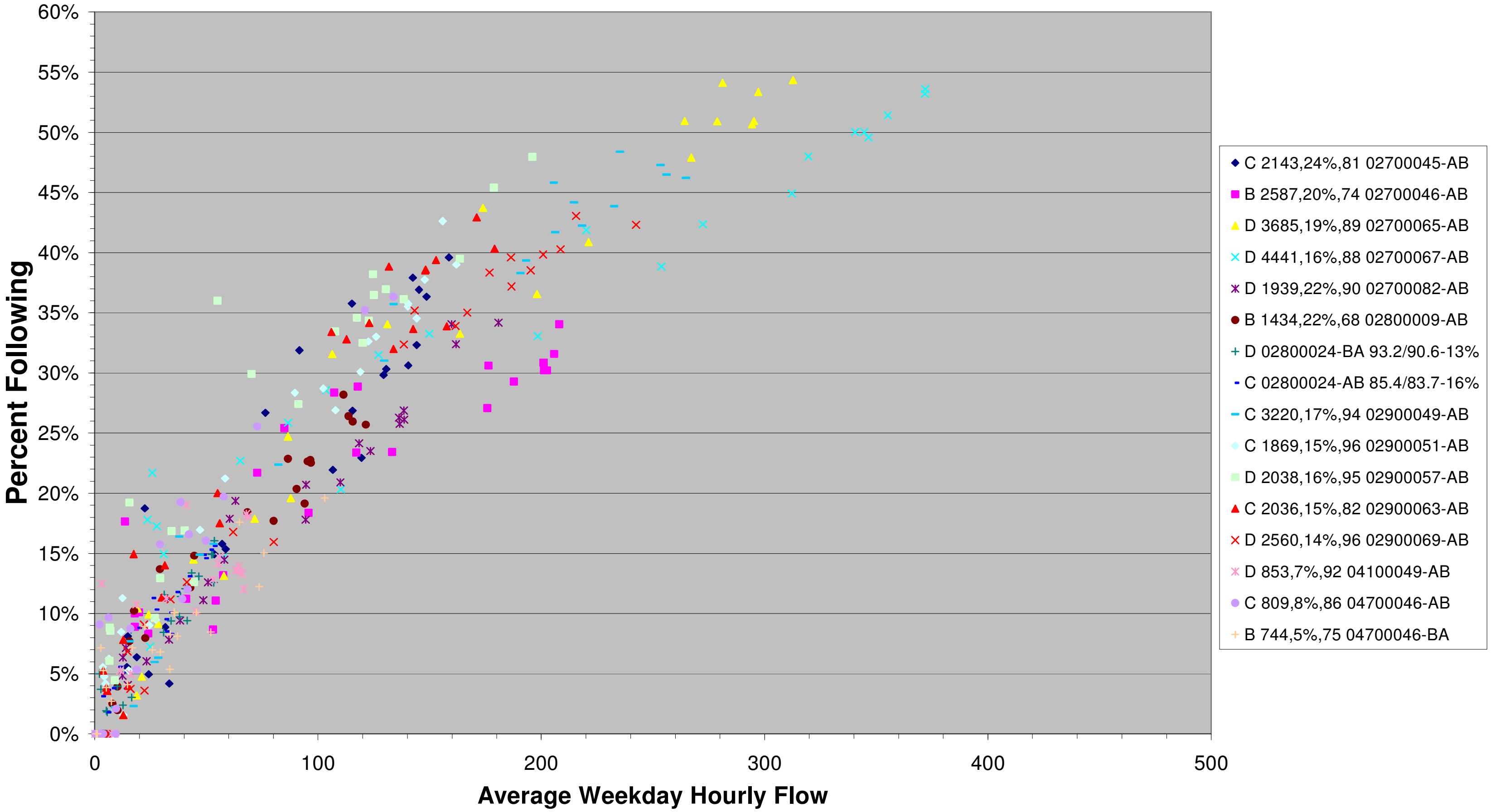

Percent Following weekday
SH 2 running dist 37-66; 204-243
Percent Following
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
0
100
200
300
400
500
Average Weekday Hourly Flow
B 2067,17%,76 00200037-AB
C 2122,19%,83 00200037-BA
D 2316,16%,92 00200052-AB
D 2388,17%,99 00200052-BA
D 3089,16%,89 00200062-AB
D 3115,17%,96 00200062-BA
D 00200066-AB 98.0/95.6-15%
D 00200066-BA 94.3/91.8-16%
D 00200204-AB 97.9/94.8-18%
D 00200204-BA 96.6/94.4-18%
D 00200204-AB 97.9/94.8-18%
D 00200204-BA 96.6/94.4-18%
D 00200225-AB 91.8/90.5-27%
D 00200225-BA 95.0/91.8-25%
C 00200241-AB 86.2/82.0-11%
D 00200241-BA 88.4/85.6-11%
B 00200243-AB 75.7/75.8-20%
C 00200243-BA 82.0/79.0-20%


Percent Following weekday
SH 5 (excl Waipa)
Percent Following
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
100
200
300
400
500
Average Weekday Hourly Flow
D 00500000-AB 90.1/87.3-13%
C 00500000-BA 78.5/74.0-12%
C 2189,13%,86 00500005-AB
D 2160,14%,90 00500005-BA
D 2384,17%,97 00500034-AB
D 2269,16%,90 00500034-BA
C 5679,14%,79 00500055-AB
D 2623,13%,91 00500082-AB
D 2791,17%,88 00500082-BA
C 1928,12%,86 00500125-AB
C 1886,13%,80 00500125-BA

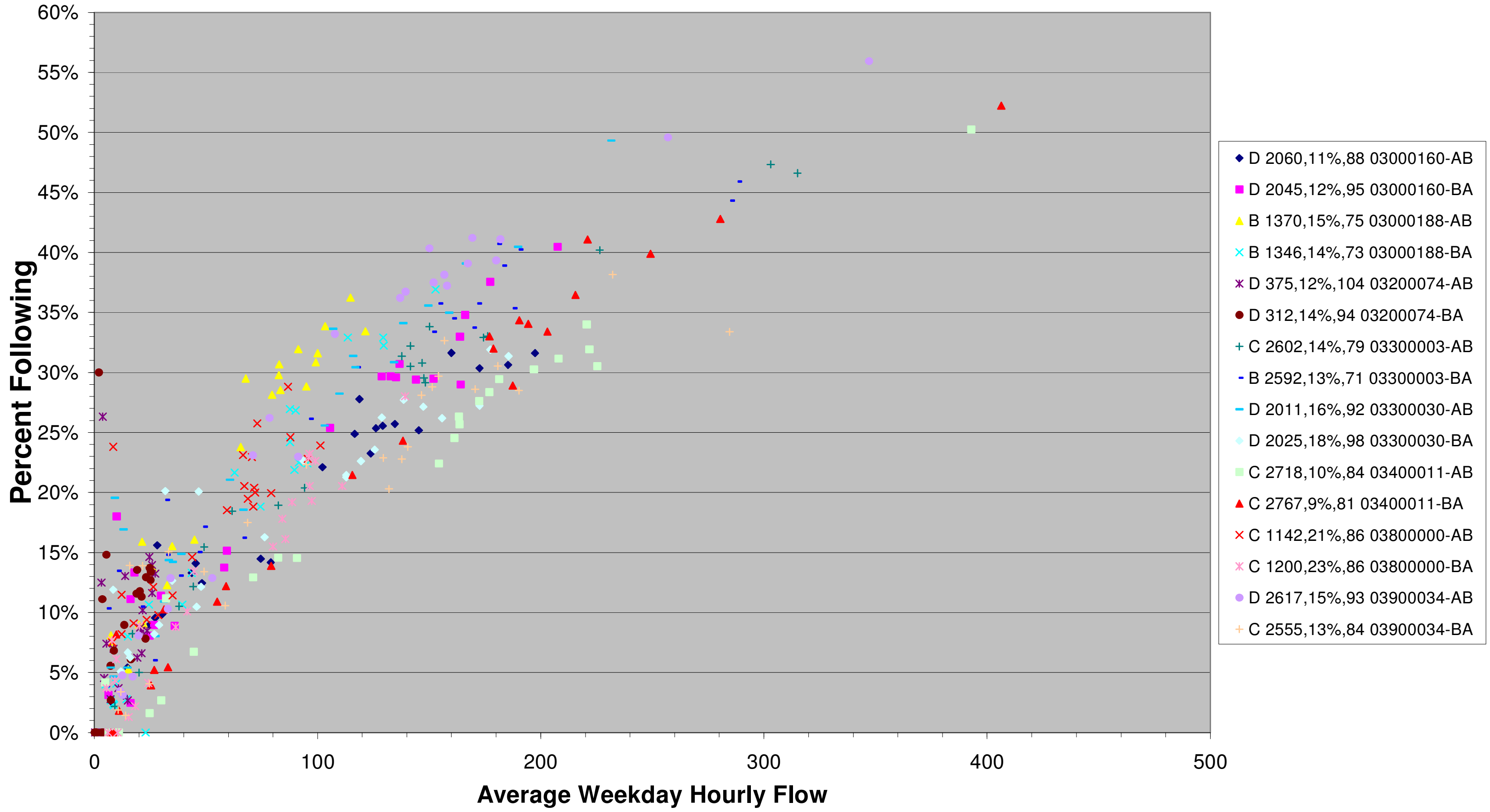

Percent Following weekday
SH 1B; SH 21; SH 23
Percent Following
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
100
200
300
400
500
Average Weekday Hourly Flow
C 2661,11%,87 01B00001-AB
C 2501,8%,80 01B00001-BA
D 1232,11%,93 01B00015-AB
B 1417,10%,68 01B00024-AB
C 1427,9%,83 01B00032-AB
B 1630,8%,73 01B00033-AB
D 2150,12%,93 01B00040-AB
C 2994,10%,80 01B00043-AB
B 2784,9%,77 01B00043-BA
B 2510,7%,77 02100000-AB
C 2651,7%,86 02100000-BA
D 2280,9%,95 02100004-AB
C 2282,5%,85 02100004-BA
C 2010,7%,82 02100007-AB
B 2074,8%,74 02100007-BA
C 3357,6%,87 02300011-AB

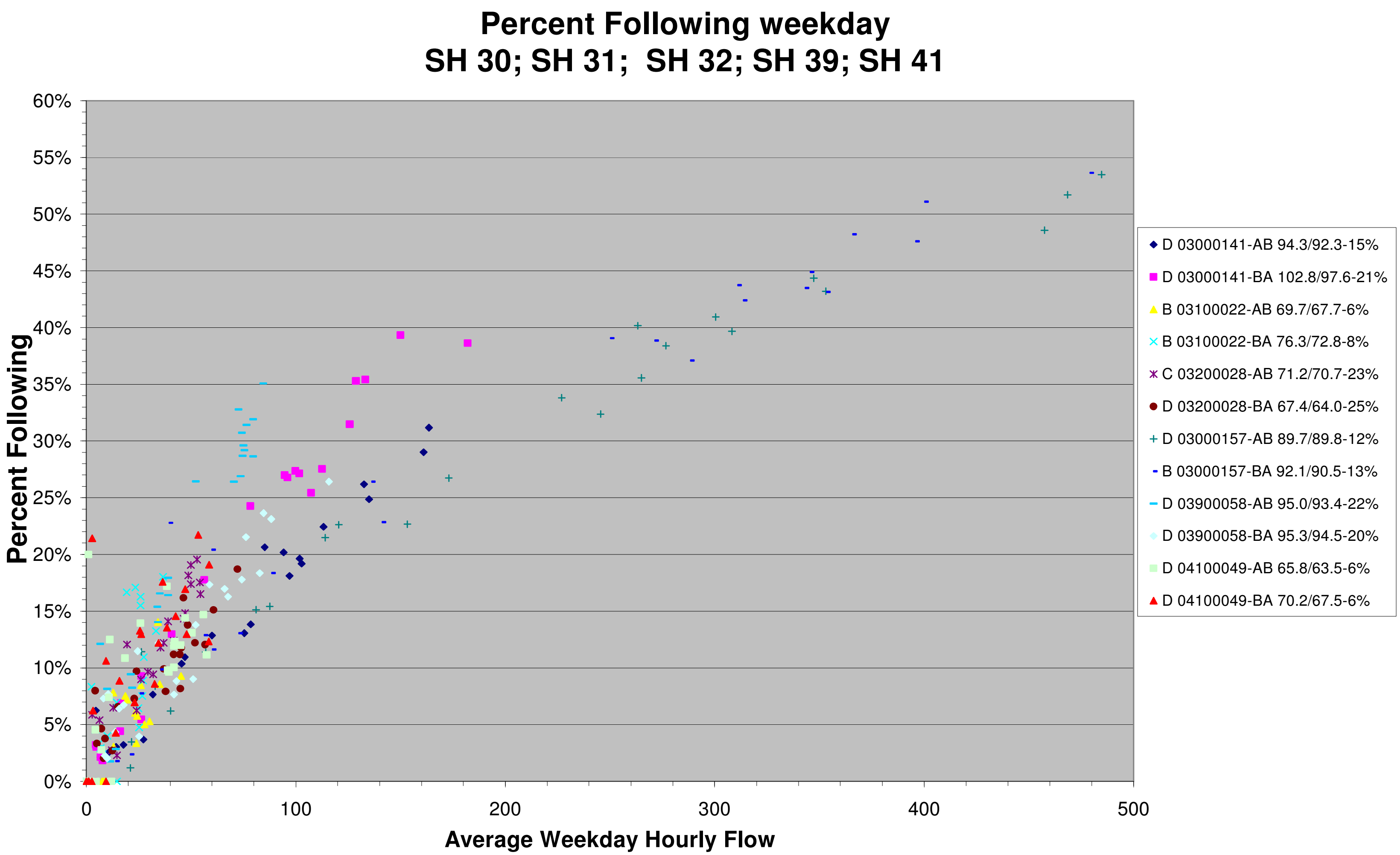

Percent Following weekday
SH 25; SH 25A; SH 26
Percent Following
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
100
200
300
400
500
Average Weekday Hourly Flow
D 2310,8%,89 02500021-AB
D 2296,10%,90 02500021-BA
C 02500082-AB 82.1/79.5-11%
B 02500082-BA 72.4/67.6-9%
D 02500177-AB 89.4/84.9-13%
D 02500177-BA 89.5/84.0-13%
B 02500188-AB 73.8/73.2-13%
C 02500188-BA 83.3/82.1-11%
B 02500240-AB 75.7/73.4-11%
B 02500240-BA 73.0/72.0-12%
B 1664,11%,75 25A00011-AB
C 1669,12%,79 25A00011-BA
C 02600002-AB 80.7/77.4-7%
C 02600002-BA 82.9/79.8-8%
D 2201,12%,97 02600022-AB
D 2169,10%,88 02600022-BA
C 4274,9%,81 02600023-AB
C 1974,10%,86 02600067-BA
C 1919,10%,86 02600067-AB

Percent Following weekday
SH 27; SH 28; SH 29 (x 17); SH 41; SH 47

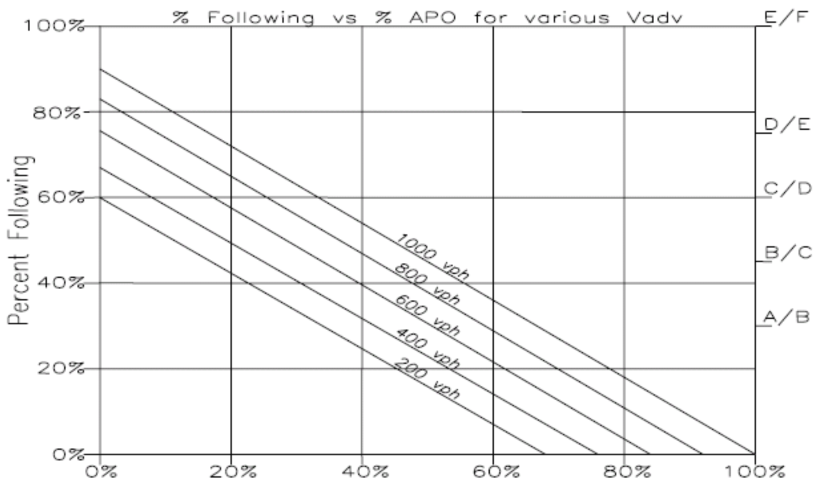


Percent Following weekday
SH 30; SH 32; SH 33; SH 34; SH 38; SH 39

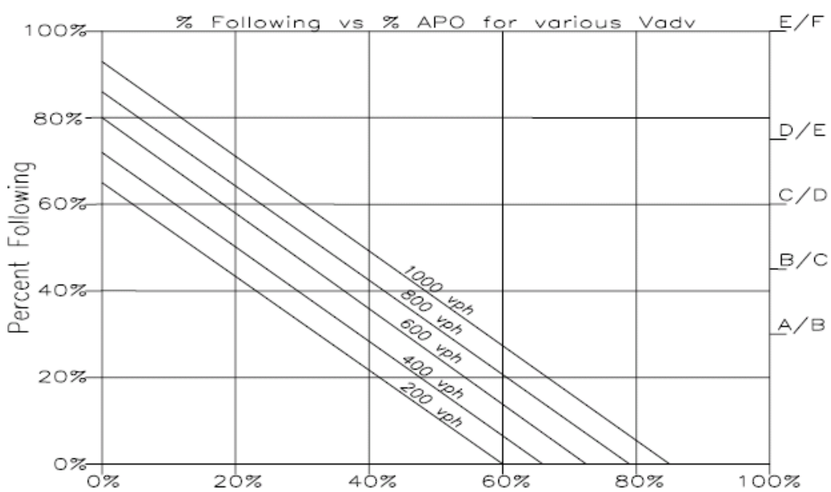



Percent Following weekday
SH 30; SH 31; SH 32; SH 39; SH 41
Percent Following
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
100
200
300
400
500
Average Weekday Hourly Flow
D 03000141-AB 94.3/92.3-15%
D 03000141-BA 102.8/97.6-21%
B 03100022-AB 69.7/67.7-6%
B 03100022-BA 76.3/72.8-8%
C 03200028-AB 71.2/70.7-23%
D 03200028-BA 67.4/64.0-25%
D 03000157-AB 89.7/89.8-12%
B 03000157-BA 92.1/90.5-13%
D 03900058-AB 95.0/93.4-22%
D 03900058-BA 95.3/94.5-20%
D 04100049-AB 65.8/63.5-6%
D 04100049-BA 70.2/67.5-6%

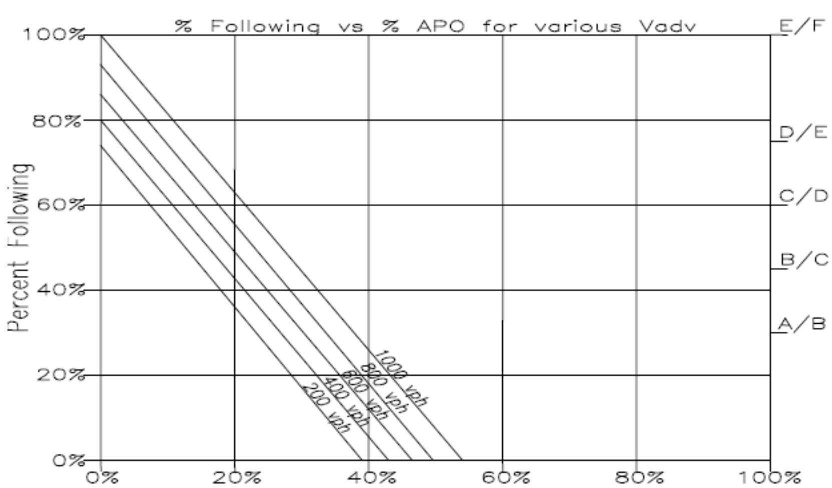
Appendix E British Columbia Passing Lane Warrants level of service



Level Terrain



Rolling Terrain



Mountainous Terrain

APO is the Assured Passing Opportunity; Vadv is the One – Way Advancing Volume (following not opposing)