NZ TRANSPORT AGENCY
WAKA KOTAHI

Assessment of HPMV Load Limits for Bridges
Lower Bound Loading

Quality Assurance Statement

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Revision Schedule

Rev. No	Date	Description	Prepared by	Reviewed by	Approved by
1	06/12	Amend Lower Bound curve, table and examples	Jeremy Waldin	Walter Wang	Michael Cowan
2	09/12	Remove appendices, alter wording accordingly, and alter title	Jeremy Waldin	Darren Goodall	Darren Goodall

NZ Transport Agency

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Summary

The Transport Industry is now reasonably familiar with the current process for assessing the capacity of bridges for HPMV loads. However, the Industry continues to have difficulty in assessing the actual HPMV loading limit for any particular route, and hence is often unable to make a realistic HPMV Application. This is causing frustration and time delays as applications are often required to be resubmitted. An alternative and complementary approach to the assessment of HPMV load limits for any route is proposed.

In order to assist the Transport Industry, the NZTA has completed a nationwide bridge screening study to identify the capacity of various State Highway routes. In addition to identifying routes that can support "Full" and "Limited" HPMVs, a further "Lower Bound" HPMV load limit has been developed which represents the maximum vehicle weights that can be safely supported by almost all weaker but unposted road structures. The Lower Bound HPMV load limit is simply an extension of the existing Class 1 Gross Weight limits versus wheelbase beyond the existing 44T cap. For most typical HPMV vehicle configurations, there is a considerable increase in gross weight compared to Class 1 limits.

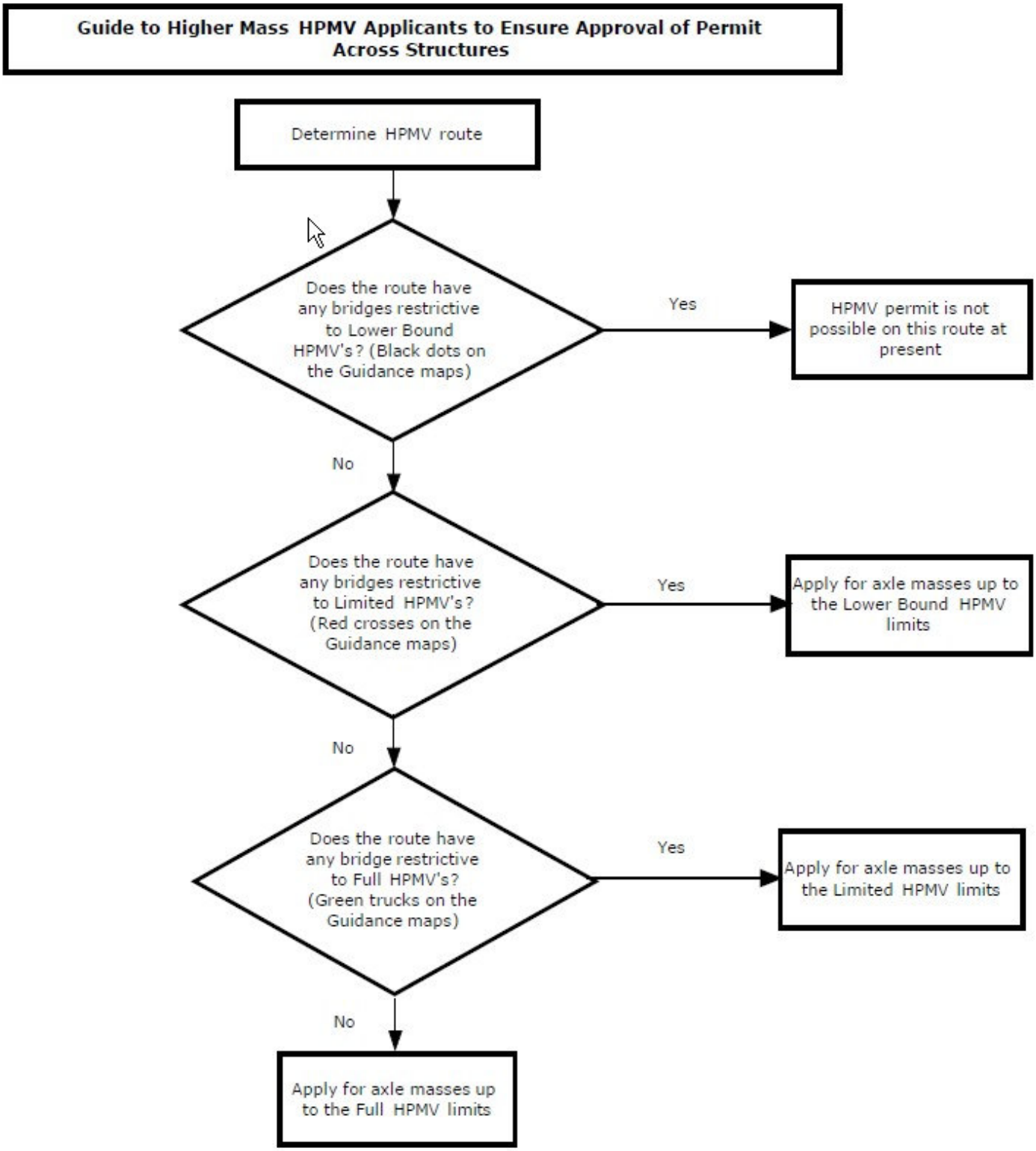
It is intended that HPMV applicants will review the guidance maps on the NZTA website prior to applying for an HPMV permit. Where a route contains a bridge restrictive to Limited HPMVs (currently shown as a "red cross" on the maps), the applicant can apply for vehicle weights complying with the Lower Bound HPMV limits and will be permitted travel over this route. Similarly, where a route contains no "red crosses" but has some bridges restrictive to Full HPMVs (i.e. green trucks), the applicant can apply for vehicle weights complying with the Limited HPMV limits and will be permitted travel over the route. For routes with no bridge restrictions, applicants are free to apply for weights up to the Full HPMV limits. However, there will still be a few bridges (<1% of the State Highway bridge stock) that will not be able to support even Lower Bound HPMVs (these may be shown as a "black dot" on the guidance maps). Routes containing these restrictive bridges will not permit any form of HPMV travel at present.

It should be noted that applicants will still require Local Authority approval for travel over their networks. However, the vast majority of unposted Local Authority bridges are also expected to be capable of carrying Lower Bound HPMV loads."

The flow chart below provides a guide to the proposed alternative HPMV application process. Applicants are able to apply for axle, axle set and gross masses greater than the limits described; but by applying for the limits specified, they will be guaranteed travel over the particular route. This should reduce the extent of feasibility permits and discussions back-and-forth between applicants, Permit Issuing Officers (PIOs) and Bridge Consultants to determine the capacity of a route to support a particular vehicle combination.

Note that the Full, Limited and Lower Bound HPMV load limits have axle weight flexibility already included, and hence there is no need to apply for axle weight flexibility.

It is intended that the current HPMV application process will also continue, in order to provide maximum flexibility for Industry.


Guide to Higher Mass HPMV Applicants to Ensure Approval of Permit Across Structures
Determine HPMV route
Does the route have any bridges restrictive to Lower Bound HPMV's? (Black dots on the Guidance maps)
Yes
HPMV permit is not possible on this route at present
No
Does the route have any bridges restrictive to Limited HPMV's? (Red crosses on the Guidance maps)
Yes
Apply for axle masses up to the Lower Bound HPMV limits
No
Does the route have any bridge restrictive to Full HPMV's? (Green trucks on the Guidance maps)
Yes
Apply for axle masses up to the Limited HPMV limits
No
Apply for axle masses up to the Full HPMV limits

1 Introduction

In order to provide information to the Transport Industry, the NZTA commissioned a nationwide bridge screening study to identify the capacity of various State Highway routes. Following this study, guidance maps were produced by the NZTA to show the State Highway Network's capability of supporting Full and Limited HPMVs. Further information on the National HPMV Screening Methodology and development of the "Limited" HPMV curve can be found in the *"National HPMV Screening Methodology"* (NZTA Report Number 455CS).

Around 5-10% of the State Highway bridge stock is unable to safely support even Limited HPMVs. To provide further information to HPMV applicants, a third "Lower Bound" HPMV load limit has been developed to represent the maximum vehicle weights that can be safely supported by almost all unposted road structures within New Zealand. This report outlines the methodology used to develop the Lower Bound HPMV Limits, and the load effects caused by this loading.

2 Three HPMV Load Limits

In addition to the HPMV load limits specified in Tables 1-6 in Part B of Schedule 2 of the VDM Rule Amendment (2010); Limited HPMV mass limits were developed, as described in *"National HPMV Screening Methodology"* (NZTA Report Number 455CS). Furthermore, at the request of the NZTA, a third "Lower Bound" HPMV load limit has now been developed to represent the maximum vehicle weights that can be safely supported by almost all unposted road structures within New Zealand. These two lower HPMV load limits were developed to provide information to the Transport Industry around the capacity of critical road structures, with each structure being analysed to confirm which load limit it can safely support. Details of the three HPMV load limits are illustrated in Figure 2.1 below.

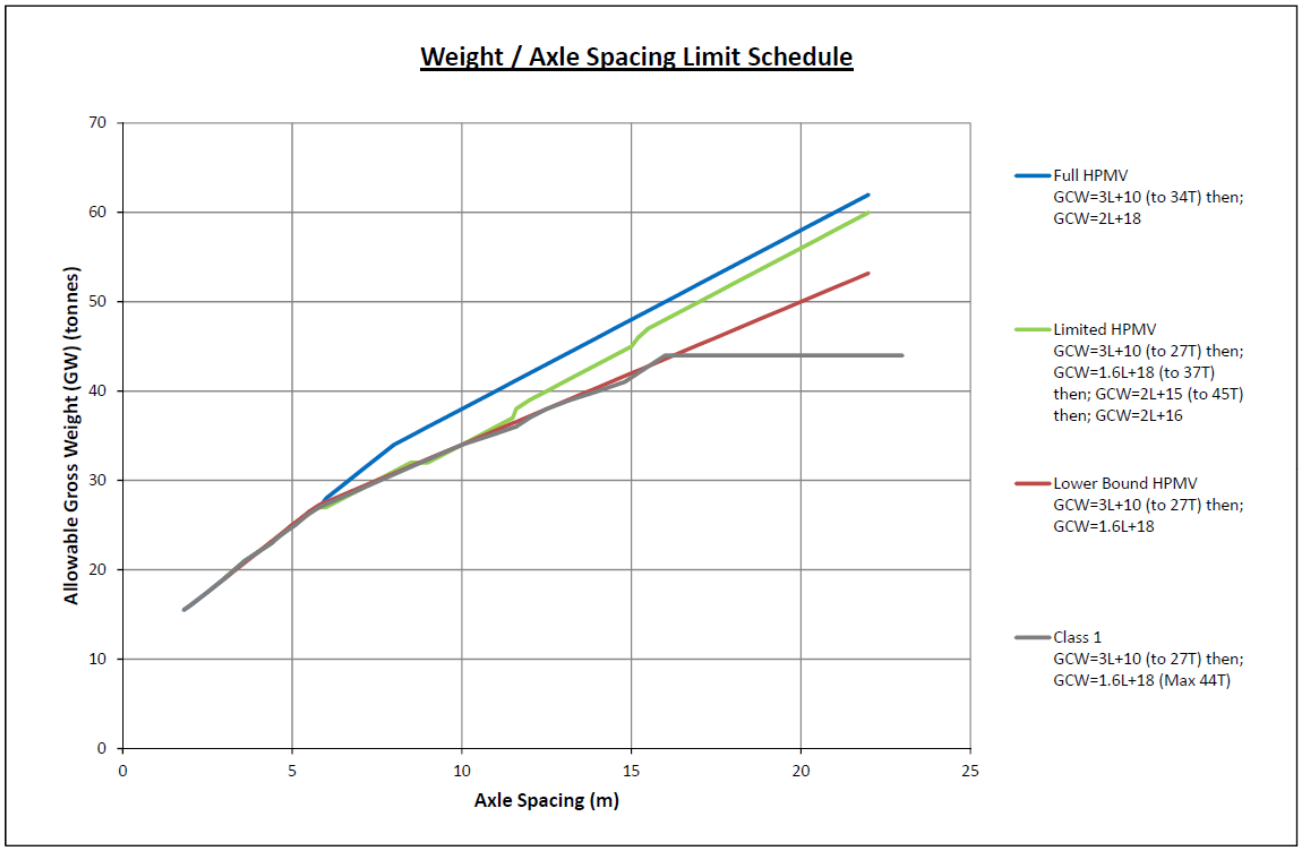


Figure 2.1: Allowable Gross Weight vs Axle Spacing for Full, Limited, and Lower Bound HPMVs

2.1 Full HPMV Loading

Full HPMVs are defined as vehicles complying with the limits specified in Tables 1-6 in Part B of Schedule 2 of the VDM Rule Amendment (2010). The assessment of Full HPMV load effects is outlined in the *"National HPMV Screening Methodology"* (NZTA Report Number 455CS). In summary, Full HPMVs can have load effects (i.e. bending moments and shears) considerably higher than Class 1 vehicle effects, with the load effects increasing above HN load effects for longer spans.

The 2011 Draft Amendment to Section 6 of the NZTA Bridge Manual defines the HPMV posting load as 0.90HN for bridge spans up to and including 25m, and 0.95HN for bridge spans greater than 25m (as shown in Table 2.1). This aligns well with the results of the NZTA *"National HPMV Screening Methodology"*, with the Bridge Manual values being slightly lower than those from the national screening due to the assessed conservatism of the screening vehicle stream and Posting Load factors.

However, there are a number of road structures that cannot safely support Full HPMVs (approximately 15% nationally). By screening the State Highway Network to Limited and Lower Bound HPMVs, considerable economic gains can be made in the short term, for minimal costs.

Span Range	**0-17m**	**17-25m**	**25m+**
HPMV Loading	0.90HN	0.90HN	0.95HN
Limited HPMV Loading	0.85HN	0.90HN	0.95HN
Lower Bound HPMV Loading	0.85HN	0.85HN	0.90HN
Class 1 Loading	0.85HN	0.85HN	0.85HN

Table 2.1: Posting Loads for various HPMV Limits

2.2 Limited HPMV Loading

The Limited HPMV mass limits have been developed to provide vehicle combinations that achieve a substantial gross mass increase, with minimal increase in moment and shear effects on bridge elements. To do this, the weight/axle spacing limits for Limited HPMVs were set the same as the existing Class 1 limits for axle spacings less than 11m. The Limited HPMV weight/axle spacing curve then jumps up to follow a similar slope to the Full HPMV curve, with the gross weights being 3T below the Full HPMV limits for spans between 11m and 15m and 2T below the Full HPMV limits for spans greater than 15m. This can be seen diagrammatically in Figure 2.1.

As a result, the load effects of Limited HPMVs on bridges with spans less than about 17m are not significantly greater than for Class 1 vehicles. The load effects of Limited HPMVs on bridges with spans less than 25m are only marginally (less than 6%) greater than for Class 1 vehicles. Therefore the large majority of bridges, and almost all short span bridges, should be able to safely support Limited HPMVs (provided they can currently safely support Class 1 loading). A comparison between Limited HPMV loading and HN loading

has also been shown in Table 2.1. This has been developed in a similar way to the Full HPMV loading. Note that the load effects for all HPMV load limits have been calculated assuming equivalent simply supported spans, in accordance with the Bridge Structural Inventory Data Entry Guide (i.e. assuming any continuous beams have full moment continuity between spans, are of normal proportions, and show no signs of distress).

The individual axle limits and axle set limits for Limited HPMVs have been restricted to Class 1 limits (i.e. as given in Tables 1-5 in Part A of Schedule 2 of the VDM Rule 2002). This means that the loading of transverse elements and decks is no greater for Limited HPMVs than for existing Class 1 vehicles.

However, there are still a number of road structures that cannot safely support Limited HPMVs (approximately 7% nationally).

2.3 Lower Bound HPMV Loading

As a number of road structures are not able to safely support even Limited HPMV loading, a further "Lower Bound" HPMV load curve was proposed. This curve has been designed to limit the vehicle load effects (i.e. bending moments and shears) based on the capacity of the weakest road structures on the State Highway Network (typically reinforced concrete T-beam bridges built prior to the 1940's and designed to Traction Engine loading).

A review of the Bridge Structural Inventory (BSI) data within OPermit indicates that the weakest State Highway structures have theoretical GROSS Posting Weight Limits of around 80-85% Class 1. This aligns with the minimum expected capacity of around 80-83% Class 1 for 10-20m span Traction Engine designed bridges, based on a comparison between design and assessment loadings and load factors. It is noted that there are a number of bridges with even lower capacities than this; however most of these structures have been found to have overly conservative data, or conservatism in the modelling of some elements (i.e. VBeam elements). Despite having GROSS capacities lower than Class 1 within OPermit, these weaker structures have not had posting weight restrictions installed due to a number of reasons (i.e. data being conservative, reduced load factors being justified, lane load reduction factors being used, posting analysis not being undertaken, etc). It is also noted that the majority of vehicles loaded to their maximum Class 1 limits cause load effects of 80-90% of the 0.85HN Loading assumed to represent a stream of Class 1 vehicles (based on research undertaken during the *"Study of the impact of High Productivity Vehicles on NZTA's Bridge Stock"*, May 2010). Only a few vehicle combinations are able to cause load effects equivalent to 100% 0.85HN loading. Therefore on a risk basis, the lack of posting on these weaker State Highway structures may be justified.

To create a Lower Bound HPMV load curve that produces load effects that can be safely supported by these weaker road structures, the gross weight limits must be around 15-20% lower than the Class 1 limits over critical vehicle lengths (typically 6-12m axle spacings for 9-18m span lengths). However, this is considered overly conservative given that some shorter legal vehicles can achieve the full Class 1 limits. Therefore, a Lower Bound HPMV curve was developed that replicated the Class 1 load curve over axles spacings less than 16m, but continued beyond the existing 44T gross mass limit (see Figure 2.1 for details). At these gross mass limits, the vehicle mass over shorter 6-12m vehicle lengths will typically be around 10-15% below the Class 1 limits, ensuring bridges with capacities below 0.85HN are not overloaded. If uneven mass distribution (or axle weight flexibility) causes load effects to near 0.85HN load effects, this can be justified as an uncommon case, similar to certain shorter vehicle combinations that can cause similar load effects.

This Lower Bound loading provides a modest to significant gain in gross mass compared to Class 1 loading (5-20% increase over typical HPMV lengths), but ensures the load effects remain equal to or below Class 1 load effects for bridge spans less than about 25m. In reality, the load effects caused by Lower Bound HPMVs will be almost identical to those caused by the Class 1 vehicle runs undertaken in the 2010 National Screening, as a Lower Bound HPMV slightly heavier than 44T will cause the same load effects as two shorter, closely spaced Class 1 vehicles, as modelled in National Screening (see Sections 3 and 4 of the NZTA *"National HPMV Screening Methodology"* for more details).

Based on the load approximation in Table 2.1, it is expected that all unposted bridges with span lengths less than 25m, and longer span bridges with GROSS Posting Capacities greater than 106% Class 1 will be able to safely support Lower Bound HPMV loading. Therefore, almost all State Highway road structures (>99%) should be able to safely support this loading. This will provide a minimum HPMV limit that applicants can apply for, with confidence that they will be approved on almost all State Highway (and Local Authority) routes.

As for Limited HPMVs, the individual axle limits and axle set limits for Lower Bound HPMVs have been restricted to Class 1 limits (i.e. as given in Tables 1-5 in Part A of Schedule 2 of the VDM Rule 2002). This means that the loading of transverse elements and decks is no greater for Lower Bound HPMVs than for existing Class 1 vehicles.