# The Development of a Wet Weather Speed Limit Trial on a NSW Freeway

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## ABSTRACT

An analysis of crashes on the 6 km section of the Sydney to Newcastle or F3 Freeway north of the Hawkesbury River Bridge to Mount White between 2000 and 2004 has shown that there were a total of 134 crashes. Long term climatic data from the nearby Bureau of Meteorology Automatic Weather Station showed that on average 32% of days each year experience rain in this area. In contrast 57% of all crashes in this area occur in the rain, this is substantially higher than what would be expected. Almost 60% of all crashes occurring in this area when it is raining have had speeding identified as a contributing factor to the crash compared to only 27% of crashes that occurred in fine weather.

A key outcome of the New South Wales Road User's Summit held in March 2005, was for the NSW Roads & Traffic Authority (RTA) to develop a Wet Weather Speed Limit trial on the northbound lanes of the Sydney to Newcastle Freeway between the Hawkesbury River and Mount White.

The demonstration project utilises Variable Speed Limit (VSL) signs, weather stations, pavement moisture detectors and static signs to reduce the speed limit to 90 km/h limit when raining. The 90 km/h wet and 100 km/h dry speed limits are enforced by a new fixed speed camera.

Major challenges in introducing a wet weather speed limit included the high cost of electronic VSL signs, calibration of equipment, incidence of electrical storms in the area and remote monitoring of the geographically isolated scheme by the RTA's Transport Management Centre in Sydney.

## ACKNOWLEDGEMENT

I would like to acknowledge Fernando Tula the RTA's Technical Systems Project Manager who died suddenly after a brief illness in August 2006. The majority of the technical information in this paper has been sourced from Fernando's final project report, completed only a few weeks before his death. Without his dedication, extensive knowledge and enthusiasm for the project this system would never have been developed to a stage where it could be trialed.

## INTRODUCTION

The F3 or Sydney-Newcastle Freeway is the major road transport corridor for vehicles travelling north of Sydney. It links Sydney and the major provincial city of Newcastle and is also a major commuter corridor from residents of the rapidly growing Central Coast Region. In 2005 the Average Annual Daily Travel (AADT) in 2004 for the northbound section of the F3 Freeway in the vicinity of the proposed scheme was 36,916. The annual average growth of AADT in the project area ranges from 1.2% to 2.6%.

An analysis of crashes on the 6 km northbound section of the F3 Freeway north of the Hawkesbury River Bridge to Mount White between 2000 and 2004 has shown that there were a total of 134 crashes. Two of these were fatal crashes, 42 resulted in injuries and 90 were non-injury or tow away crashes.

Long term climatic data from the nearby Bureau of Meteorology Automatic Weather Station at Gosford shows that on average 32% of days each year experience rain in this area. In contrast 57% of all crashes in this area occur in the rain, this is substantially higher than what would be expected.

Almost 60% of all crashes occurring in this area when it is raining have had speeding identified as a contributing factor to the crash compared to only 27% of crashes that occurred in fine weather.

The F3 from Sydney to New England Highway has been rated as having High Collective Risk by the Australian Risk Assessment Program (AAA 2005) during the period 1999-2003. A relatively high number of casualty crashes along the entire Highway have been reported and all links have a high collective risk.

The RTA has developed a number of public education and Intelligent Transport Systems (ITS) interventions in the past to reduce the number and severity of wet weather crashes within NSW. A driver aid system was installed on the F6 Freeway south of Sydney from 1995. The system comprises of a 12 km network of fibre-optic variable message signs connected to 10 fog detection units and 24 speed detection devices to target individual drivers. Each sign is connected to road loops and a visibility detector. Drivers are advised by large VMS of a recommended speed based on the visibility distance and the speed of the preceding vehicle (Brisbane 1996). A post implementation analysis of crashes has not been published for the section of the freeway covered by the fog warning system.

In 1999 the RTA trialled the use of enhanced curve advisory signs at two locations. The standard advisory signs were enhanced with flashing amber lights that were activated by a weather station located on the sign. In 2001 a prismatic sign was installed on the Princes Highway on the Kiama bends (Brisbane & Vasiliou 2001). The sign changed the advisory speed for a curve from 65 km/h to 55 km/h when pavement detectors indicated the presence of moisture on the road downstream from the curve. A 20% reduction in the number of vehicles exceeding the advisory speed of 65 km/h was measured at this location (Brisbane 2003). The proportion of crashes involving wet road conditions also fell from 89% before the sign was installed to 25% after the sign was activated. However, Brisbane notes that other treatments including re-surfacing occurred in the area which may have also contributed to the positive results.

Since 1998 the RTA has run a number of public education campaigns promoting the need for drivers to travel 10 km/h under the speed limit when it was raining. In December 1999, the State Emergency Service (SES) and Roads and Traffic Authority launched a public education initiative to change driver behaviour and reduce the impact of wet weather (Stone 1999).

Known as the Rain Activated Weather for Roads, the aim was to introduce a new model for reporting wet road conditions in three trial areas. Over 300 reports were issued to individual radio stations during the trial period.

Following the New South Wales Road User's Summit in March 2005, the then NSW Minister for Roads, Hon Michael Costa instructed the RTA to expedite the implementation of a Wet Weather Speed Limit scheme on the northbound lanes of the F3 Freeway between the Hawkesbury River and Mount White.

The Auslink White Paper (DOTARS 2004) outlined the Federal Government's desire to undertake a trial project to develop a variable speed limit system integrated with weather detection technology in association with State Governments. This will be the first trial of weather related variable speed limits in NSW and possibly Australia. Already the project team has faced a number of challenges with the integration of the Intelligent Transport Systems (ITS) and meteorological sensing technologies. The detailed documentation of the trial's technical systems and processes will be of great assistance to other jurisdictions embarking on similar projects.

## AIM

The aim of this project is to trial a variable speed limit system that is integrated with weather detection equipment and linked to the RTA's Transport Management Centre.

## METHOD

The F3 wet weather speed limit ITS demonstration project zone commences approximately 1.6 km north of the Hawkesbury River Bridge and continues for approximately 5.5 km. The trial is located on the northbound carriageway of the F3 Freeway which was recently upgraded from two to three lanes. The trial utilises Variable Speed Limit (VSL) signs, weather stations, pavement moisture detectors and static signs. Speed limits will be enforced by a new fixed speed camera. It is expected that the fixed speed camera as a key component of the system will deliver road safety benefits by enforcing both wet and dry speed limits.

An economic evaluation was conducted using a generalised cost benefit analysis framework. The evaluation identified travel time and net safety benefits from the project implementation. The analysis of safety benefits was measured for both dry and wet weather.

The F3 wet weather speed limit project is a complex system that integrates the following:

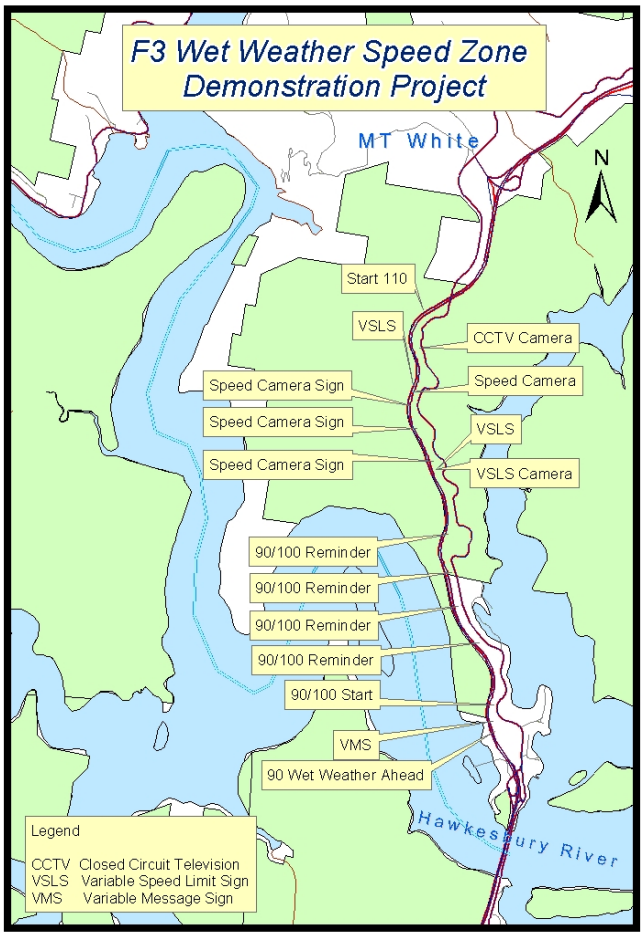
- Intelligent Transport Systems (ITS)
- Enforcement Technologies
- Incident Management Systems
- Road Safety
- Environmental Technology.

The project followed a systems engineering approach to ensure the best possible return on investment for system stakeholders adopting a risk management approach. Examples of this include:

- Provision for flexibility of the system to support other types of detection (such as fog, surface water).
- Change in the initial system design (concept) to cater for incident management applications (in addition to enforcement).

The project can be divided into two major sections, namely a static sign section followed by an Intelligent Transport Systems section. Ideally the total length of the demonstration project would have been serviced by electronic signs, however it was estimated that the cost of this option would have exceeded $10 million. A map of the scheme is included below:

*Figure 1 – Map showing location of demonstration project*



*Static Sign Section*

Static signs for the demonstration project were developed by the RTA's Road Safety and Traffic and Transport Branches in consultation the Authority's Legal Branch. The major issue discussed by the design team was the text to be used on the sign. It was decided that rain would be used as the trigger for the speed limit reduction. The lower speed limit applies as soon as a driver detects droplets of water on their windscreen.

A diagram of the diagram of the finalised sign design is shown below.

*Figure 2 –Static Wet Weather Speed Limit Sign*


*Intelligent Transport System Section*

The system includes weather stations with rain gauges (tipping bucket) and electronic sensor that detect rain in the area (on-set), triggering an alarm that is forwarded to the RTA's Transport Management Centre (TMC) Central Management Computer System to activate automatically a 90 km/h wet weather speed limit response plans utilising Variable Speed Limit (VSL) signs and the gateway Variable Message Sign.

A Variable Message Sign (VMS), managed by Transport Management Centre displays warning messages on wet weather speed limits when it is raining. The VMS provides a gateway for vehicles entering the demonstration project length of the freeway. Road safety messages are displayed at all other times. A Closed Circuit Television (CCTV) provides information on road conditions to Transport Management Centre. The ITS components of the project are fully integrated to enforcement technology equipment to activate the 90 km/h wet weather speed limit enforcement scheme.

Two pairs of Variable Speed Limit signs are installed on two gantries in the vicinity of the enforcement camera system, to inform drivers of the speed limit in both wet and dry conditions. The system is functions automatically, but can also be overridden by an operator from the Transport Management Centre, as required.

The demonstration project includes weather stations that detect rain and automatically lower or raise the speed limits displayed on the VSL signs. The weather stations are comprised of tipping bucket rain

gauges and a sensitive rain sensor. In addition to this road moisture sensors installed into the pavement provide back-up information.

The Weather Stations have internal timers called 'onset delay' and 'offset delay' (these are adjustable parameters). The onset delay will determine how long the weather station shall wait before generating a speed zone change. The onset delay was initially set to zero, as we wanted the weather station to react as quickly as possible. The offset delay is currently set at 15 minutes. This timeframe would prevent rapid changes (hysteresis effect) and would also allow the any surface water to dissipate after it has stopped raining.

Where the rain is intermittent; the offset delay timer is reset to zero each time rain is detected. Thus, there is a 15 minute wait window before the speed limit is lifted after the rain has ceased. If any weather station detects rain, the speed will be dropped to 90 km/h. All the weather stations must indicate 'not raining' before the speed limit can be returned to 100 km/h.

In the event of a communications failure between the site and Transport Management Centre, the local system (on site) will take over and run autonomously. The weather stations detect the start and finish of rain events as normal. When rain is detected, the local system activates a facility switch on the VSL sign group controller and sets message 1 (90 km/h). When rain ceases, the local system drives the facility switch to message 2 (100 km/h). When communication to Transport Management Centre is restored, the local control ceases and Central Management Computer System takes control again.

When communication between the site and Transport Management Centre is working, the Transport Management Centre operators are able to over-ride the system in order to change the set speed limits as required (eg. during a crash event). The operator has highest priority in the system and can thus determine what speed limit shall be set. This will allow intervention when there is an incident or planned road works.

The demonstration project includes a Short Message Service (SMS) facility. In the event of communications failure between the project and the Transport Management Centre, the weather station controller sends SMS alarms (text messages) via the mobile phone network to the Transport Management Centre and other recipients. Text messages (cancelling SMS alarms) are sent when communications are restored.

There are two camera units used in the enforcement system, one camera monitors the upstream VSL signs and the second camera is used to capture images of vehicles exceeding the speed limit. The first camera located at the first VSL gantry captures an image of the first VSL sign as evidence that both sets of VSL signs were displaying the same speed limit. The second camera (fixed speed camera) captures the image of the offending vehicle. Enforcement only occurs when all four VSL signs (2 VSL signs per gantry) display the same speed at the same time. Enforcement of the electronic VSL signs can only occur when both VSL sites display simultaneously the same speed.

*Figure3 –Photograph of weather station, speed camera and VSL sign gantry*

The cost of the project was $2.3 million. The project commenced construction in June 2005 and opened on 10 April 2006. It is proposed that the trial will monitor the effectiveness of the scheme for a period of three years.

## RESULTS

### *Economic Analysis*

An economic evaluation for the project was conducted using a generalised cost benefit analysis framework. The evaluation identified travel time and net safety benefits from the project implementation. The total travel time savings were measured in both light and heavy vehicles. A total saving of $12.4 million is achievable at 7% discount rate. The discount rate is the value used in accounting procedures to determine the present value of future benefits arising from the project. Seven percent is the most common discount rate used in the calculation of benefit to cost ratios (BCR) of road safety projects by Australian Government Agencies.

The analysis of safety benefits was measured for both dry and wet weather. The analysis of wet weather indicated that a positive safety benefit was achievable with the installation of VSL signs that required drivers to slow down during wet weather and the enforcement of the variable speed limit with a fixed digital speed camera. The conservative scenario on wet weather assumes 20% reduction in fatal, 2% reduction in injury and property damage only crashes. This supported by research into the effectiveness of NSW fixed speed cameras (ARRB 2005) which found that there was a 90% reduction in fatal crashes and a 23% reduction in casualty crashes on lengths of road with a fixed speed camera installed. In addition to this it was found that there was a 70% reduction in the number of vehicles exceeding the speed limit in the vicinity of the fixed speed cameras.

Overall, the proposed project generates positive travel time and safety benefits. The table below summarises the economic results. At 7%, the benefit cost ratios (BCR) range from 2.1 to 3.4 and the net present values (NPV) from $2.3 million to $5.1 million under 3 scenarios, which reflect varying assumptions on crash reductions due to the presence of the signs and speed camera.

*Table 1 - F3 Wet Weather Speed Limit Demonstration Project Summary of Economic Analysis*

| DISCOUNT RATES | NPV of benefits in million $ | | | BENEFIT COST RATIO (BCR) | | |
|---|---|---|---|---|---|---|
| | Conservative | Medium | Optimistic | Conservative | Medium | Optimistic |
| 4% | $3.4 | $5.0 | $6.7 | 2.5 | 3.3 | 4.1 |
| 7% | $2.3 | $3.7 | $5.1 | 2.1 | 2.7 | 3.4 |
| 10% | $1.6 | $2.7 | $3.9 | 1.8 | 2.3 | 2.9 |

*Knowledge and Attitudes*

It is planned to undertake a number of quantitative and qualitative investigations to gauge the knowledge and attitudes of road users to the wet weather speed limit system. At the time of writing, an omnibus survey and media monitoring had taken place.

An omnibus survey (RTA 2005) of 200 Sydney residents in the last week of June 2005 found that 79% of drivers supported altered speed limits during wet weather conditions.

An analysis of thirteen articles appearing in newspapers found only one negative article (a letter to the editor) on the introduction of the wet weather speed limit, other articles had an informational or positive content.

Communication with the RTA Call Centre has confirmed that a small number of calls were taken by Call Centre Staff on the new wet weather speed limit system. Only one call was directed to the Project Manager by the Call Centre and this related to the definition of rain used to enforce the speed limit along the static sign section of the project.

*Compliance with Wet Weather Speed Limit*

Wet weather speed surveys during have not been undertaken by the RTA at this stage.

Approximately 50 vehicles have been detected by the speed camera exceeding the wet weather speed limit (average speed of vehicles detected 107 km/h) over the first full month of enforcement operations. This indicates that drivers are continuing to comply with the lower wet weather speed limit given that almost 40,000 vehicle movements occur on this section of the freeway each day.

*Crash Statistics*

Provisional[1] crash statistics received from the NSW Police indicate that only two crashes have occurred in the demonstration area in the first four months of operation. This is about 70% less crashes than expected based on 2000 – 2004 crash data.

Both crashes were minor, with neither crash resulting in an injury to vehicle occupants. Only one of the two crashes occurred under wet road conditions and the driver was not travelling in excess of the 90 km/h wet weather speed limit at the time of the incident.

## DISCUSSION

The implementation of a wet weather speed limit demonstration project on the F3 Freeway in New South Wales will enable the RTA to evaluate the benefits of environmentally based variable speed limits. The combination of both static sign as well electronic variable speed limit signage systems provides a unique evaluation opportunity. The effectiveness of the new speed limit will be measured using speed surveys, crash statistics and interviews with drivers and riders that have travelled through the scheme.

Major challenges in introducing a wet weather speed limit on the freeway have included the high cost of electronic VSL signs, calibration of equipment, incidence of electrical storms in the area and remote monitoring of the geographically isolated scheme by the RTA's Transport Management Centre in Sydney.

Preliminary infringement data and crash statistics indicate that the scheme will have a positive road safety benefit when fully evaluated. The introduction of a wet weather speed limit in NSW may have added another tool in the road safety manager's chest of countermeasures. In the past the best one could do in many circumstances was to advise vehicle controllers of dangerous road conditions caused by wet weather. The F3 demonstration project will enable the RTA to evaluate if mandating a maximum travelling speed under adverse environmental conditions will yield an improvement in road safety outcomes.

[1] *2006 crash data is provisional and may change upon the results of further Police or Coronial Investigations. Approximately 70% of all crashes had been coded into the RTA's crash database at the time of writing.

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