EVALUATION OF THE MOTORCYCLE BLACKSPOT PROGRAM

Project Number RSD-670

by

Jim Scully
Stuart Newstead
Bruce Corben

October, 2008

Consultancy Report to VicRoads
Evaluation of the Motorcycle Blackspot Program

This report presents the results of an evaluation of the Motorcycle Blackspot Program which involved the treatment of sites that had a crash history indicating they were especially dangerous for motorcyclists. To December 2007, 95 sites had been treated, with a further eighteen planned. Data from 87 sites were used in the present evaluation. Some sites were excluded because there was insufficient available crash history for analysis after treatments had been completed. The evaluation measured the effectiveness of the program based on the extent to which treatments reduced the number of casualty crashes involving a motorcycle and the number of serious casualty crashes involving a motorcycle. A quasi-experimental analysis design in conjunction with Poisson regression was employed comparing the difference in before treatment and after treatment crash counts at treated sites with those at suitably chosen controls.

Analysis results showed that implementation of the Motorcycle Blackspot Program was associated with a statistically significant (p<0.05) reduction in casualty crashes involving a motorcycle of 24%. A 16% reduction was estimated for serious casualty crashes involving a motorcycle, although this estimate was not statistically significant (p=0.097). The program was also estimated to be associated with a statistically significant (p<0.05) reduction in casualty crashes involving all types of vehicles of 16%. The estimated economic benefits of the program were favourable: over the life of the program an estimated $84.5M would be saved by preventing 40 casualty crashes involving all types of vehicles per annum. This translates into a benefit-cost ratio of 15.1. The average expenditure required to prevent one casualty crash involving a motorcycle over the life of the program was estimated to be less than $19,000, which compares favourably to analogous cost-effectiveness estimates derived for previous blackspot programs that didn’t just focus on motorcycle safety.

Estimates of effectiveness were also derived for each of the three broad types of treatments undertaken as part of the program as well as for individual treated sites. There was some indication that blacklength treatments were associated with greater reductions in casualty crashes involving motorcyclists than long route and intersection treatments. However, further after treatment crash history or the evaluation of additional future treatments would be required to produce a robust comparison.

The report provides detailed discussion of how crash reduction estimates and economic measures can be interpreted to enhance strategies for future investment in road infrastructure and infrastructure aimed at improving motorcycle safety in particular. The report also discusses various methodological issues that should be addressed to further strengthen future evaluations of this type.

Key Words: Motorcycle blackspot, evaluation, motorcycle safety, traffic engineering, statistical analysis, economic analysis

Disclaimer
This report is disseminated in the interest of information exchange. The views expressed here are those of the authors, and not necessarily those of Monash University.

Reproduction of this page is authorised.
Preface

Project Manager / Team Leader:

- Dr Stuart Newstead

Research Team:

- Dr Bruce Corben
- Jim Scully
## Contents

EXECUTIVE SUMMARY .................................................................................................................. IX

1.0 INTRODUCTION .......................................................................................................................... 3
  1.1 AIMS AND SCOPE ..................................................................................................................... 4

2.0 DATA ........................................................................................................................................... 6
  2.1 TREATMENT DATA .................................................................................................................... 6
    2.1.1 Annual Differential Maintenance Cost and Project Life Estimates ..................................... 7
  2.2 CASUALTY CRASH DATA .......................................................................................................... 7
    2.2.1 Definitions of types of crashes .......................................................................................... 8
    2.2.2 Preparation of crash data for analysis .............................................................................. 8
  2.3 CASUALTY CRASH COST DATA ................................................................................................ 15

3.0 METHOD ....................................................................................................................................... 19
  3.1 STUDY DESIGN .......................................................................................................................... 19
  3.2 CHOICE OF CONTROLS ......................................................................................................... 19
    3.2.1 Reallocation of postcodes ............................................................................................... 21
  3.3 BEFORE AND AFTER TREATMENT PERIODS ........................................................................... 22
  3.4 STATISTICAL ANALYSIS METHODS ....................................................................................... 23
  3.5 ACCIDENT MIGRATION AND REGRESSION-TO-THE-MEAN ................................................. 24
    3.5.1 Accident Migration ........................................................................................................... 24
    3.5.2 Regression-to-the-Mean ................................................................................................... 25
  3.6 EVALUATION OUTPUT MEASURES ......................................................................................... 26

4.0 RESULTS ...................................................................................................................................... 29
  4.1 CHANGES IN CASUALTY CRASH FREQUENCY ........................................................................ 29
    4.1.1 Program Level Effects ........................................................................................................ 29
    4.1.2 Effectiveness by type of treatment .................................................................................... 32
    4.1.3 Effectiveness by site ........................................................................................................... 36
  4.2 ECONOMIC WORTH ................................................................................................................. 39
    4.2.1 Treatment costs .................................................................................................................. 39
    4.2.2 Present value of savings associated with treatments ........................................................ 41
    4.2.3 Benefit-cost ratio of treatments ......................................................................................... 44
    4.2.4 Cost-effectiveness of treatments ....................................................................................... 45

5.0 DISCUSSION ............................................................................................................................... 48
  5.1 GENERAL DISCUSSION AND INTERPRETATION .................................................................... 48
  5.2 SUCCESSFULLY TREATED SITES .......................................................................................... 54
  5.3 ECONOMIC EVALUATION ...................................................................................................... 55
    5.3.1 Present value of savings and benefit-cost ratios ................................................................. 55
    5.3.2 Cost-effectiveness .............................................................................................................. 56
  5.4 LIMITATIONS AND POSSIBLE FUTURE RESEARCH ............................................................ 59
    5.4.1 Effect of previous blackspot programs on data .................................................................. 60
    5.4.2 An alternative approach to evaluating different types of treatments when treated sites overlap ....................................................................................................................... 63
6. CONCLUSIONS ..............................................................................................................66

7. REFERENCES .............................................................................................................67

APPENDIX A – TREATMENT DATA PROVIDED BY VICROADS ........................................70

APPENDIX B – ADDITIONAL EFFECTIVENESS BY SITE RESULTS ...............................84

APPENDIX C – ADDITIONAL ECONOMIC ANALYSES ................................................88

APPENDIX D – ASSUMPTIONS AND QUALIFICATIONS ................................................92

Tables

<table>
<thead>
<tr>
<th>Table No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.1</td>
<td>Summary of how the subset of sites treated as part of the Motorcycle Blackspot program that were eligible for analysis were chosen</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Distribution of the types of treated sites for each stage of the process of defining the set of sites to be analysed</td>
</tr>
<tr>
<td>Table 2.3</td>
<td>Summary of casualty crash data used in the analysis for all crash types</td>
</tr>
<tr>
<td>Table 2.4</td>
<td>Summary of casualty crash data used in the analysis for crashes in which a motorcycle was involved</td>
</tr>
<tr>
<td>Table 2.5</td>
<td>Estimates of crash cost values at treated sites, as provided by VicRoads (AUS 2005)</td>
</tr>
<tr>
<td>Table 2.6</td>
<td>Severity of casualty (motorcycle) crashes that occurred at sites treated as part of the Motorcycle Blackspot Program in the before treatment periods</td>
</tr>
<tr>
<td>Table 2.7</td>
<td>Assumed average costs of crashes occurring at treated sites used in the economic evaluation of the program</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Contingency table format used in the analysis method</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Details of sites evaluated separately from remaining sites</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Estimated casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for the whole program, Great Ocean Road sites and Yarra Ranges sites</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Estimated serious casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for the whole program, Great Ocean Road sites and Yarra Ranges sites</td>
</tr>
<tr>
<td>Table 4.3</td>
<td>Estimated casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for blacklengths, long route treatments and intersection treatments</td>
</tr>
<tr>
<td>Table 4.4</td>
<td>Estimated serious casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for blacklengths, long route treatments and intersection treatments</td>
</tr>
<tr>
<td>Table 4.5</td>
<td>Estimated casualty crash reductions for sites at which the estimates of effectiveness were significant to the p&lt;0.05 level only</td>
</tr>
<tr>
<td>Table 4.6</td>
<td>Estimated casualty motorcycle crash reductions for sites at which the estimates of effectiveness were significant to the p&lt;0.2 level only</td>
</tr>
<tr>
<td>Table 4.7</td>
<td>Estimated serious casualty crash reductions for sites at which the estimates of effectiveness were significant to the p&lt;0.2 level only</td>
</tr>
<tr>
<td>Table 4.8</td>
<td>Summary of the costs associated with treatments completed as part of the Motorcycle Blackspot Program</td>
</tr>
<tr>
<td>Table 4.9</td>
<td>Summary of the present value of estimated savings due to treatments completed as part of the Motorcycle Blackspot Program</td>
</tr>
<tr>
<td>Table 4.10</td>
<td>Benefit-cost ratio of treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are not included in project costs</td>
</tr>
<tr>
<td>Table 4.11</td>
<td>Cost-effectiveness of preventing a casualty crash for treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are not included in project costs</td>
</tr>
</tbody>
</table>
TABLE 4.12: COST-EFFECTIVENESS OF PREVENTING A SERIOUS CASUALTY CRASH FOR TREATMENTS COMPLETED AS PART OF THE MOTORCYCLE BLACKSPOT PROGRAM WHERE FUTURE MAINTENANCE COSTS ARE NOT INCLUDED IN PROJECT COSTS ................................................................. 47

TABLE 5.1: POINT ESTIMATES AND 90% CONFIDENCE INTERVALS OF THE EFFECT OF BLACK LENGTH, LONG ROUTE AND INTERSECTION TREATMENTS ON CASUALTY CRASHES INVOLVING A MOTORCYCLE ....... 53

TABLE 5.2: POINT ESTIMATES AND 90% CONFIDENCE INTERVALS OF THE EFFECT OF BLACK LENGTH, LONG ROUTE AND INTERSECTION TREATMENTS ON SERIOUS CASUALTY CRASHES INVOLVING A MOTORCYCLE ........................................................................................................ 54

TABLE 5.3: COMPARISON OF ESTIMATES OF THE COST-EFFECTIVENESS OF PREVENTING SERIOUS CASUALTIES† WITH THOSE OF PREVIOUS PROGRAMS WHERE FUTURE MAINTENANCE COSTS WERE NOT INCLUDED IN PROGRAM COSTS ................................................................................................. 58

TABLE A.1: TREATMENT DATA PROVIDED BY VicRoads (VARIABLES RELATED TO THE LOCATION OF TREATED SITES ONLY) .................................................................................................................... 70

TABLE A.2: TREATMENT DATA PROVIDED BY VicRoads (VARIABLES RELATED TO COST, PROJECT LIFE AND THE DATES ON WHICH TREATMENT WORKS WERE STARTED AND FINISHED) ........................................................................ 75

TABLE A.3: TYPE OF TREATMENT COMPLETED AT SITE ........................................................................................................................................................................................................................................... 79

TABLE B.1: ESTIMATED CASUALTY CRASH REDUCTIONS FOR SITES AT WHICH THE ESTIMATES OF EFFECTIVENESS WERE SIGNIFICANT TO THE P<0.2 LEVEL ONLY .................................................................................. 85

TABLE B.2: ESTIMATED CASUALTY MOTORCYCLE CRASH REDUCTIONS FOR SITES AT WHICH THE ESTIMATES OF EFFECTIVENESS WERE SIGNIFICANT TO THE P<0.2 LEVEL ONLY .................................................................................. 86

TABLE B.3: ESTIMATED SERIOUS CASUALTY CRASH REDUCTIONS FOR SITES AT WHICH THE ESTIMATES OF EFFECTIVENESS WERE SIGNIFICANT TO THE P<0.2 LEVEL ONLY .................................................................................. 87

TABLE C.1: BCR OF TREATMENTS COMPLETED AS PART OF THE MOTORCYCLE BLACKSPOT PROGRAM WHERE FUTURE MAINTENANCE COSTS ARE INCLUDED IN PROJECT COSTS ................................................................................ 88

TABLE C.2: COST-EFFECTIVENESS OF PREVENTING A CASUALTY CRASH FOR TREATMENTS COMPLETED AS PART OF THE MOTORCYCLE BLACKSPOT PROGRAM WHERE FUTURE MAINTENANCE COSTS ARE INCLUDED IN PROJECT COSTS ................................................................................ 89

TABLE C.3: COST-EFFECTIVENESS OF PREVENTING A SERIOUS CASUALTY CRASH FOR TREATMENTS COMPLETED AS PART OF THE MOTORCYCLE BLACKSPOT PROGRAM WHERE FUTURE MAINTENANCE COSTS ARE INCLUDED IN PROJECT COSTS ................................................................................ 90

TABLE C.4: COMPARISON OF ESTIMATES OF THE COST-EFFECTIVENESS OF PREVENTING SERIOUS CASUALTIES† WITH THOSE OF PREVIOUS PROGRAMS WHERE FUTURE MAINTENANCE COSTS WERE INCLUDED IN PROGRAM COSTS ................................................................................ 91
EXECUTIVE SUMMARY

In 2003 the Victorian Government announced that funds collected from the Motorcycle Safety Levy would be used for the implementation of a Motorcycle Blackspot Program. These funds would be used to improve the safety of sites that have a crash history that suggests they are especially dangerous for motorcyclists. It was recognised that many sites that are dangerous for motorcyclists may not be treated under traditional blackspot programs because they do not meet the traditionally used criteria to make them eligible for treatment. Furthermore, if a site is particularly dangerous for motorcyclists but not other road users, it is possible that the predicted benefits of a treatment will be small when compared to the benefits due to the treatment of sites where there is a heightened risk for all road users. This means that many sites that represent a particular danger to motorcyclists may not be prioritised for treatment using funds set aside for traditional blackspot programs.

Sites eligible for treatment as part of the Motorcycle Blackspot Program were prioritised based on the predicted benefits of proposed treatments due to reductions in crashes involving motorcyclists. The process of selecting eligible sites and prioritising treatments involved analysis of the crash history of sites and detailed reviews of crashes at eligible sites by experienced motorcyclists. These reviews identified the deficiencies of each site which were then used to identify appropriate treatments.

The final program of treatments consisted of three different components: blackspot or blacklength treatments, which focused on preventing run-off-road crashes; intersection treatments; and long route treatments. Long route treatments aimed to provide consistency along the whole length of high risk motorcycle routes. By making the conditions including delineation and warnings along a high-risk route more consistent, it was planned that long route treatments would address points where motorcyclists were put at increased risk by encountering unexpected hazards or unexpected features in the road environment.

As of December 2007, 95 treatments had been completed using funding set aside for the Motorcycle Blackspot Program. It is expected that a further eighteen treatments will have been completed by July 2008. The aim of the present report was to determine the crash reduction effect and the economic benefits of the first 91 projects completed under the Motorcycle Blackspot Program. Only the first 91 projects were evaluated because there were insufficient post-treatment crash data available for analysis from projects not completed by April 2007. The capital expenditure required to complete the first 91 treatments of the Motorcycle Blackspot Program was $5.8M. A further four projects were not included in the analysis because crash data at these sites were contaminated by the effect of treatment works at excluded Motorcycle Blackspot sites located nearby.

The evaluation measured the effectiveness of the program based on the extent to which treatments reduced both the number of casualty crashes and serious casualty crashes involving a motorcycle. These estimates of crash reduction were measured by comparing crash frequencies at treated sites in the six years before treatment works commenced with crash frequencies at treated sites after treatments had been completed. The percent reduction in crashes at treated sites in the after treatment period compared to the before treatment period were adjusted using the percent reduction in crashes over the same before and after periods at groups of untreated control sites. Poisson regression was used to establish whether changes in the number of crashes at treated sites were statistically significantly different to changes in the number of casualty crashes at the non-treated
control sites. This method has previously been used to evaluate other blackspot programs, including the Accident Blackspot Component of the $240M Statewide Blackspot Program (Scully, Newstead, Corben & Candappa, 2006b), the TAC-funded accident blackspot program implemented in Victoria from 1992-1996 (Newstead & Corben, 2001) and the Federally-funded 1996-2002 blackspot program (BTE, 2001).

Analysis found that overall implementation of the Motorcycle Blackspot Program was associated with a statistically significant 24% (p<0.05) reduction in casualty crashes involving a motorcycle. A reduction of such a magnitude is equivalent to 24 casualty motorcycle crashes being prevented each year, translating to a saving over the life of the program of 296 casualty crashes involving motorcycles. In terms of cost-effectiveness, it was estimated that the program required $18,914 capital expenditure to prevent one casualty crash involving a motorcycle. This estimate of cost-effectiveness in reducing casualty crashes involving a motorcycle compares well to analogous estimates for previous blackspot programs that didn’t just specifically focus on motorcycle safety. This indicates that overall, the program was well targeted with treated sites showing a high proportion of motorcycle crashes and treatments implemented being most effective in reducing motorcycle involved crashes.

There was also evidence that program implementation was associated with reduced serious casualty motorcycle crashes, however the estimated reduction of 16% was not statistically significant (p=0.097). With more time given for the collection of post-treatment crash data, it is possible that future analysis of the estimated effect of the program on serious casualty motorcycle crashes would be significant.

As well as measuring the overall effectiveness of the Motorcycle Blackspot Program, the evaluation also estimated the effectiveness of different types of treatments. There was some indication that the blacklength treatments were associated with the greatest crash reductions of the three types of treatments, although further after treatment crash history or evaluation of additional future treatments would be necessary to provide a robust comparison.

Comparisons of the effectiveness of individual treated sites were also attempted. However, results demonstrated that with the data available, analyses at this level of detail are of limited worth because low crash counts led to insufficient statistical power to make robust comparisons.

Estimates of the effect of the program on the number of crashes involving all types of vehicles were also derived so that economic benefits of the program could be more-accurately determined. An economic evaluation of the program where only benefits due to reductions in motorcycle crashes were considered potentially ignored a large proportion of the total benefits of the treatments, as some treatments are likely to reduce the risk of crash involvement at sites for all road users, not just motorcyclists. Measures of economic worth included the present value of savings expected over the life of the program, benefit-cost ratio and cost-effectiveness, where cost-effectiveness was measured in terms of the average expenditure required to reduce casualty crashes involving motorcycles and serious casualty crashes involving motorcycles, as well as crashes involving all types of vehicles.

The Motorcycle Blackspot Program implementation was associated with a statistically significant (p=0.019) reduction in casualty crashes involving all types of vehicles of 16%. A reduction of a similar magnitude (17%) was estimated for serious casualty crashes involving all types of vehicles. However this reduction was not statistically significant.
(p=0.088). A 16% reduction in casualty crashes involving all types of vehicles is equivalent to a reduction of 40 crashes per annum or 465 crashes over the life of the program. The present value of savings that can be expected over the life of the program due to a 16% reduction in casualty crashes was estimated to be $84.5M if a discount rate of 4% were assumed. Therefore, the best-estimate of the benefit-cost ratio of the program was 15.1.

Although the percent reduction in casualty crashes involving all types of vehicles was less than that estimated for casualty crashes involving motorcycles, the difference between the two estimates was not statistically significant. Despite this, the report does provide evidence that overall, the Motorcycle Blackspot Program significantly improved the safety of treated sites for motorcyclists while also improving the safety of these sites for all road users.

Based on the estimated safety benefits for all road users, the recurrent savings that the program provides by reducing the burden of injury and death caused by all types of motor vehicle crashes at the treated sites are expected to exceed the cost of completing and maintaining these treatments. Even if the savings due to the program are restricted to savings due to the prevention of casualty crashes involving motorcycles, the economic benefits of the program are still expected to exceed the cost of completing and maintaining treatments.

Detailed discussion of the implications of these results as well as several methodological issues that arose during the evaluation is presented in the report. A number of assumptions have been made in obtaining the results for this study and interpreting the results is subject to a number of qualifications. These are presented in Appendix D.
EVALUATION OF THE MOTORCYCLE BLACKSPOT PROGRAM
1.0 INTRODUCTION

In 2003 the Victorian Government announced that funds collected from the Motorcycle Safety Levy would be used for the implementation of a Motorcycle Blackspot Program. This program involved the treatment of locations on the road network that were identified as having a high incidence of crashes involving motorcyclists. One of the differences between this and other blackspot programs is that treatments were designed with motorcycle safety specifically in mind. As of December 2007, 95 treatments had been completed and it is expected that a further eighteen will be completed by 30 June 2008. The program consisted of three components: treatments aimed at addressing run-off-road type crashes; intersection treatments; and long route treatments. The first two components were employed either at a discrete location (i.e. a blackspot) or along a length of road (i.e. a black length). Long route treatments were intended to provide consistency along the whole length of high-risk motorcycle routes.

A study conducted by MUARC in 2006 examined the effect that previous blackspot programs, such as the $240M Statewide Blackspot Program, had on motorcycle crash counts (Scully, Newstead, Corben & Candappa, 2006a). It was found that overall, these blackspot programs were just as effective in preventing crashes involving motorcyclists as they were in preventing crashes involving all types of vehicles. Therefore, treating sites considered as having a poor history of crashes involving all road users improved the safety of these sites for motorcyclists as well as for the general population of road users. However, many sites that are dangerous for motorcyclists may not be treated under traditional blackspot programs because they do not meet the criteria to make them eligible for treatment in blackspot programs. Furthermore, if a site is particularly dangerous for motorcyclists but not other road users, it is possible that the predicted benefits of a treatment will be small when compared to the benefits due to the treatment of sites where there is a heightened risk for all road users.

The Motorcycle Blackspot Program was unique from other blackspot programs in that sites were selected based on their crash history with respect to motorcycle crashes only. The predicted benefits of proposed treatments with respect to motorcycle crashes only were also used to prioritise which sites were treated. For run-off-road and intersection treatments, sites that posed a high-risk for motorcyclists were identified through detailed crash analysis and detailed reviews of crashes and sites by experienced motorcyclists. These reviews were used to identify the deficiencies of the sites and how these deficiencies contributed to the crashes.

The types of work completed as part of the long route treatments were chosen using the same approach as the Safer Road Infrastructure Program which used a mass action approach to reduce crashes and injuries along a high-risk road by implementing engineering treatments along the length of the route. In the Motorcycle Blackspot Program, these treatments aimed to make the conditions, delineation and warnings along the route more consistent to make riding along the route more predictable for motorcyclists and reducing points where they encounter unexpected hazards or features in the road environment.

The safety of motorcyclists is likely to continue to be a factor when planning for future infrastructure improvement initiatives. Therefore, it is important to evaluate the effectiveness of the projects completed so far using a rigorous methodology so that the benefits of future treatments can be maximised. In March 2006, MUARC completed a study to establish the feasibility and timing of conducting an evaluation of the Motorcycle
Blackspot Program (D’Elia & Newstead, 2006). This feasibility study recommended that in order to employ a crash-based methodology similar to the methodology recently used in various evaluations of the $240M Statewide Blackspot Program (Scully, Newstead & Corben, 2006; Scully, Newstead et al., 2006a; 2006b), an additional 12-18 months of data were required. Therefore, it was expected that as of December 2007, sufficient data exist to complete a meaningful evaluation.

1.1 AIMS AND SCOPE

The aim of this report was to determine the crash reduction effect and the economic benefit of the first 91 projects completed under the Motorcycle Blackspot Program. Treatments at a further ten treated sites were not evaluated as treatment works had not been completed by April 2007. It was decided that the after treatment periods at these ten sites would be prohibitively short to enable reliable evaluation of these ten projects.

The study aimed to measure the effectiveness of the program in terms of the extent to which it reduced the number of casualty crashes involving a motorcycle and the number of serious casualty crashes involving a motorcycle. A serious casualty crash was defined as a crash that resulted in a road user being seriously injured or killed. A casualty crash was defined as a crash in which a road user was injured, but no road user was seriously injured or killed. Therefore, for crashes involving motorcycles, the definition of crash severity used in the present report was based on the injury level of the most seriously-injured road user involved in the crash, which may or may not have been the motorcyclist.

Estimates of effectiveness in preventing fatal crashes involving a motorcycle have not been made. This is because it was anticipated that there would be insufficient data to provide reliable estimates of effectiveness for reductions in fatal crashes involving motorcycles. Estimates of the effectiveness in the prevention of property damage only crashes have not been reported because such crashes are not consistently recorded by police in Victoria and hence are not included in the Road Crash Information System (RCIS), which was the source of crash data used to complete the evaluation.

The evaluation also reported the extent to which the annual number of crashes involving motorcycles was reduced after treatments had been completed for each of the 91 sites. This enabled the identification of individual sites where treatments were particularly effective and discussion of why treatments at some sites were more effective than treatments at other sites.

Estimates of the effectiveness of the program in preventing casualty crashes and serious casualty crashes involving all types of road users were also made so that the economic benefits of the Motorcycle Blackspot Program in preventing all types of crashes could be derived. An economic evaluation of the program where only benefits due to reductions in motorcycle crashes were considered would potentially ignore a large proportion of the total benefits of the treatments as some treatments are likely to reduce the risk of crash involvement at sites for all road users, not just motorcyclists. However, the report does quantify the economic benefits specifically related to the reduction in motorcycle crashes by reporting the proportion of the economic benefits for all types of crashes that is due to reductions in crashes involving motorcycles.

As well as estimating the reduction in costs due to reducing the number of crashes at treated sites, the study also aimed to estimate the benefit-cost ratio (BCR) of the program as a whole and for the three broad categories of treatment. Cost-effectiveness measures, in
terms of the expenditure required to prevent one casualty crash and one serious casualty crash, have also been presented. These cost-effectiveness measures were given for all types of crashes as well as crashes involving motorcycles only.

Null hypotheses tested in the present evaluation include:

H1: That the Motorcycle Blackspot Program had no effect on the frequency of casualty crashes involving motorcycles at treated sites;

H2: That the Motorcycle Blackspot Program had no effect on the frequency of serious casualty crashes involving motorcycles at treated sites;

H3: That the effect of treatments on the frequency of casualty crashes involving motorcycles at treated sites did not differ for different types of treatments completed at sites;

H4: That the effect of treatments on the frequency of serious casualty crashes involving motorcycles at treated sites did not differ for different types of treatments completed at sites.

Each of the null hypotheses tested in this evaluation was tested against a two-sided alternative hypothesis. Most previous evaluations of similar road safety programs (such as blackspot programs) have resulted in evidence that the programs led to significant reductions in crashes at treated sites. Based on these evaluations it may seem plausible to test each null hypothesis against a one-sided alternative hypothesis that assumes the program will result in a reduction in casualty crashes at treated sites. However, there have been some previous blackspot evaluations that have shown instances where treatments have actually increased crash rates due to unintended consequences of the treatment. Therefore, for the present evaluation, it was deemed more appropriate to use a more-conservative two-sided alternative hypothesis. This approach makes no a-priori assumptions about whether the treatment will decrease or increase crash frequency at the treated site.

The reader can change from a two-sided alternative hypothesis to a one-side alternative hypothesis by simply halving the statistical significance values presented for the two-sided test. Changing from a two-sided alternative hypothesis to a one-sided hypothesis only affects the calculated statistical significance values and does not alter the point estimates of the program effects on casualty crash frequency.
2.0 DATA

2.1 TREATMENT DATA

VicRoads provided MUARC with data on each of the 101 Motorcycle Blackspot sites for which treatment works had commenced as of September 2007. The data provided by VicRoads included the following information of each treated site:

- VicRoads region in which the site was located;
- Municipality of the treated site;
- Name of the road on which the site was located;
- Names of the roads or towns that define the boundaries of treated lengths of road;
- Melways or VicRoads Country Directory map reference of the treated site;
- Start and finish dates of treatment works;
- Capital cost of treatment works;
- Estimated annual differential maintenance and operating costs (see Section 2.1.1);
- Estimated treatment life; and
- The type of treatment works completed at the site.

The treatment data provided by VicRoads are shown in Appendix A. In Table A.3 of Appendix A, it can be seen that treatment works completed as part of the program were grouped into three broad categories:

- blacklength treatments, which were aimed at addressing run-off-road type crashes;
- intersection treatments; and
- long route treatments, which were intended to provide consistency along the whole length of high-risk motorcycle routes.

The types of works completed at long route treatments included improved delineation of centre and edge lines, consistent application of road side signage and installation of curve alignment markers. The types of treatment works completed at sites treated as blacklengths generally included countermeasures to improve the safety at sites considered to be high risk for the occurrence of serious run-off-road crashes. Of the 101 projects completed as part of the Motorcycle Blackspot Program, 74 were blacklength treatments, 26 were long route treatments and there was only one intersection treatment.

The treatment data provided by VicRoads indicated that of the 101 sites treated under Motorcycle Blackspot Program, treatment works had been completed by April 2007 at all but ten sites. Crash data at these ten sites were not included in the evaluation of the Motorcycle Blackspot Program because the after treatment periods from which crash data would be collected were prohibitively short. However VicRoads did provide details of the
ten treated sites so that crashes at these sites could be identified and the sites excluded from being eligible to be used as control sites for any of the other 91 treated sites. Eight of these ten sites were long route treatments, with the other two being blacklength treatments.

The ten sites that were excluded from the analysis sample are indicated with an asterisk next to the project number in Table A.1 of Appendix A. The aggregated cost of completing the treatments at the ten sites that were excluded from the analysis was estimated to be $1,107,692, which is based on a predicted capital cost at two of the sites (project numbers AI784 and AJ694) so removing these ten sites from the sample to be analysed reduced the capital costs of the program from $6,894,901 to $5,787,209. Therefore, the average cost of completing the treatments at the 91 sites was $63,595 per site.

2.1.1 Annual Differential Maintenance Cost and Project Life Estimates

Two methodologies for evaluating the economic worth of treatments were employed. For the first methodology, the future costs of maintaining treatments were not included in the cost of the treatments, i.e. only the capital costs of the program were considered costs associated with the program. In the second methodology, costs associated with treatments were the sum of the future costs of maintaining treatments and the capital costs of the program.

The maintenance of treatments in the future is unlikely to be funded using funds allocated to the Motorcycle Blackspot Program. Treated sites are more likely to be maintained using funding from each VicRoads region’s maintenance budget. However, including future maintenance costs in program costs enables the benefits that a program provides to be compared with the true costs associated with the treatments, both on a community wide basis.

There were inconsistencies in the estimates of maintenance costs across VicRoads regions. It is likely that there is variation between regions in how likely maintenance costs are predicted. Therefore, it was decided that the economic results presented in Section 4.2 of this evaluation would not include maintenance costs in the costs associated with Motorcycle Blackspot Program treatments. However, Appendix C contains economic measures of effectiveness where future maintenance costs have been included in the present value of the costs associated with completing and maintaining Motorcycle Blackspot treatments. For some motorcycle blackspot projects, estimates of annual maintenance costs and project life were not available. In these cases, treatment data for similar projects completed either as part of the Motorcycle Blackspot Program or the Accident Blackspot Component of the $240M Statewide Blackspot Program were used as approximations. Annual maintenance costs and project life estimates that were estimated in this way are italicised in Table A.1 of Appendix A.

As previously explained, there were ten sites for which treatments had not been completed by April 2007. The cost of treating these ten sites was not included in the economic evaluation of the program because the effect of these treatments could not be determined. Section 4.2 provides further discussion of how the cost of the program was derived for the purposes of evaluating the economic worth of the program.

2.2 Casualty Crash Data

This section describes the casualty crash data that were used to evaluate the Motorcycle Blackspot Program. To facilitate an understanding of how the data were used to evaluate
the program it is worth introducing the following definitions of different types of crashes. These definitions were the same as those used in the evaluation of the effects of the $85M TAC-funded blackspot program (implemented from 1992 to 1996) and the Accident Blackspot Component of the $240M Statewide Blackspot Program (2000-2004) on motorcycle safety (Scully, Newstead et al., 2006a).

2.2.1 Definitions of types of crashes

**Casualty crash:** A crash that was reported to police and involved a road user being injured.

**Fatal crash:** A casualty crash in which a road user received injuries that result in their death within 30 days of the crash.

**Serious casualty crash:** A casualty crash in which the most seriously injured road user was either killed within 30 days as a result of the crash or transported to hospital or admitted to hospital as a result of the crash.

**Serious but not fatal crash:** A casualty crash in which the most seriously injured road user was not killed within 30 days as a result of the crash but was transported to hospital or admitted to hospital as a result of the crash.

**Other injury crash:** A casualty crash in which the most seriously injured road user was not killed or did not require hospitalisation or transportation to hospital.

**Casualty motorcycle crash:** A casualty crash in which one of the vehicles involved was a motorcycle. The Road Crash Information System (RCIS) used in this evaluation contained fields that described the types of vehicles involved in a crash. This system allowed for a maximum of five vehicles from one crash to be coded. For this report, if a crash involved a vehicle that was coded as a motorcycle, motor scooter or moped, then the crash was defined to be a casualty motorcycle crash.

**Serious casualty motorcycle crash:** A casualty motorcycle crash in which a road user (not necessarily a motorcyclist) received a fatal or serious injury. The reader should note that for a casualty motorcycle crash to be defined as a serious casualty motorcycle crash, it is not necessary that a person riding on a motorcycle is seriously injured or killed, only that a road user involved in the crash is seriously injured or killed. Therefore if a particular crash involved an impact between a motorcycle and a car and the motorcyclist was not injured but the driver of the car was seriously injured, then the crash would be defined as a serious casualty motorcycle crash.

**Serious but not fatal motorcycle crash:** A casualty motorcycle crash in which the most seriously injured road user (not necessarily a motorcyclist) received a serious injury but did not die within 30 days of the crash.

**Other injury motorcycle crash:** A casualty motorcycle crash in which a road user received an injury that was not serious or fatal and no other road user received a serious or fatal injury in the crash.

2.2.2 Preparation of crash data for analysis

Prior to commencement of the present evaluation, it was decided that the length of the pre-treatment period at each treated site should be six years. As discussed in Section 3.5.2, allowing a reasonably long before treatment period reduces the effects of regression to the
mean. Since the 12 May 2003 was the earliest date on which treatment works were commenced at any of the 91 sites analysed, it was decided that data for crashes occurring from May 1997 would be used to evaluate the Motorcycle Blackspot Program.

VicRoads provided MUARC with accident numbers of the 169,438 police-reported casualty crashes identified as having occurred during the period 1 May 1997 to 31 October 2007. The latter date was the most-recent date for which VicRoads could supply crash data at the time of the study. VicRoads also provided the accident numbers of crashes occurring at sites treated as part of the Motorcycle Blackspot Program during this period. Matching the two sets of crash data using the accident number variable revealed that there were four Motorcycle Blackspot sites with zero crash counts in the period from 1 May 1997 to 31 October 2007, while 2,898 (1.7%) of the 169,438 crashes occurred at the remaining 97 sites. Sites treated as part of the Motorcycle Blackspot Program were selected because they had a history of motorcycle crashes. It is possible that these four sites were identified as being suitable candidates for treatment based on the occurrence of motorcycle crashes at these sites prior to May 1997.

The projects for which no crash data were recorded were project numbers 44UAA5, BMUAA1, AJ627 and AJ694, with the latter two being two of the ten sites previously excluded from the sample to be analysed because treatments had not been completed by April 2007. The fact that sites 44UAA5 and BMUAA1 had no casualty crashes occurring in their before treatment periods or their after treatment periods reduced the number of projects that contributed data for the present evaluation from 91 projects to 89 projects.

Excluding the crashes at the ten sites for which treatment works had not been completed by April 2007 was just the first step in defining a sample of crashes that could be used to evaluate the Motorcycle Blackspot Program. Table 2.1 summarises the process of excluding sites that were for some reason not suitable for analysis. The table also gives the aggregated capital cost of treatments at sites that had not been excluded for each stage of the elimination process. It can be seen that after the exclusion of data from the ten sites for which treatment works had not been completed by April 2007 and the 2 sites with no recorded crashes, there were 2,493 crashes occurring at the remaining 89 sites.

Table 2.1: Summary of how the subset of sites treated as part of the Motorcycle Blackspot Program that were eligible for analysis were chosen

<table>
<thead>
<tr>
<th>Step 1: Obtain original data from VicRoads</th>
<th>Number of Sites</th>
<th>Aggregated Capital Costs</th>
<th>Number of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Remove sites in which treatment works had not been completed by April 2007</td>
<td>91</td>
<td>$5,787,209</td>
<td>2,493</td>
</tr>
<tr>
<td>Step 3: Remove sites without crash data</td>
<td>89</td>
<td>$5,726,380</td>
<td>2,493</td>
</tr>
<tr>
<td>Step 4: Merge coincident sites</td>
<td>75</td>
<td>$5,726,380</td>
<td>2,493</td>
</tr>
<tr>
<td>Step 5: Remove sites that overlap with ineligible sites</td>
<td>71</td>
<td>$5,530,566</td>
<td>2,431</td>
</tr>
</tbody>
</table>

On closer examination of the matched crash data, it was found that 356 crashes occurred at sites that were treated by more than one motorcycle blackspot project. The following
section explains how such a situation could occur and how data at these sites were treated in the analysis.

2.2.2.1 Crashes occurring at sites treated by more than one project

On inspection of the 356 crashes that occurred at sites treated under two different motorcycle blackspot projects, it was found that each of the crashes fell into one of the following categories:

a) the crash occurred at a site which was a T-intersection between a road treated by one project and a road treated by another project;

b) the crash occurred at a point on the road network where the end points of two different projects met, with the two projects only overlapping at this point; or

c) the crash occurred along a length of road which was treated under two different motorcycle blackspot projects.

To ensure the assumptions of the statistical modelling process were met, it was necessary that where a crash occurred at sites treated under more than one motorcycle blackspot project, the crash be grouped in the before or after treatment period of only one of the projects. It was decided that where the crash occurred at a site that was a T-intersection treated by two different projects (i.e. case a) above), crashes at this site should be randomly allocated to the before or after treatment period of only one of the sites. Similarly if a crash occurred at a point on the road that was an end point for two different motorcycle blackspot projects which only overlapped at that point on the road network (case b) above), then the crashes at the site should also be randomly allocated to the before or after period of one of the two projects.

It was found that there were only twenty-two crashes occurring at five different sites that were either a T-intersections treated as part of two separate motorcycle blackspot projects or the meeting of two end points. For four of the five sites, there was only one crash occurring at these sites in the period from 1 May 1997 to 31 October 2007. However, for one site, where the end points of project numbers 413UNI1 and 413UNI2 meet at St Andrews on Heidelberg-Kinglake Road, there were eighteen crashes during this period. Each of these eighteen crashes was randomly allocated to either one of the projects. The period of time in which treatments were undertaken for project 413UNI1 was the same period in which works were undertaken for project 413UNI2, meaning that both projects would have the same before and after treatment periods. Therefore, the treatment effects at one site should not affect the casualty crash counts in the before treatment period of the other site.

When a crash occurred along a length of road that was treated by two different motorcycle blackspot projects so that the two projects actually overlapped for some distance along the road (i.e. case c) above), it was decided that the two projects should be redefined as one site. In such instances, the before treatment period was defined using the earliest of the dates on which the treatments began and the after treatment period was defined using the most recent of the two completion dates. This conservative approach to defining before and after treatment periods was adopted in order to limit the possibility of crash counts in a before or after period being biased by the effect of the other treatment being applied at the site.
It was found that there were twenty-four sites that overlapped another project in the manner described: there were six pairs of projects that were found to overlap for some distance of the road network; and four groups of three projects in which at least one of the projects overlapped with two other projects. The number of crashes that occurred at these twenty-four sites during the period 1 May 1997 to 31 October 2007 was 699. For some of these projects, the section of road treated by one project completely encompassed the section of road treated as part of another project. For cases where two projects overlapped, the overlapping projects were redefined as one site. Similarly, where a project overlapped two other projects, the three projects were redefined as one site for the purposes of the analysis. This meant that the twenty-four projects were condensed into a group of ten sites, six of which comprised of two projects each, four of which comprised of three projects.

Table 2.1 shows that when overlapping sites were redefined in this manner, the number of distinct sites at which treatments occurred reduced from 89 sites to 75 sites. As can be seen from Table 2.1, the aggregated cost of treating these 75 sites was the same as the cost of completing the 89 projects for which crash data were available. Similarly, annual maintenance costs for each of the overlapping sites were aggregated to give annual maintenance cost of each newly defined distinct site. For sites that comprised of two or more overlapping sites, the project life was assumed to be equal to the longest project life of the component sites.

On examination of the crash data provided by VicRoads, it was also found that some crashes occurred at sites treated under two or more Motorcycle Blackspot projects, with one of the projects being one of the ten previously excluded because treatment works had not been completed by April 2007. For example, it was found that four crashes occurred at a site that was the intersection of the end points of two different projects and one these projects was one of the ten projects previously excluded from the sample to be analysed. It was decided that such crashes would not contribute to the crash counts for the eligible project as the number of crashes at the coincident end points may have been affected by the treatment works at the site previously excluded from the analysis sample.

It was also found that four motorcycle blackspot projects that were eligible to be included in the sample to be analysed each overlapped with one of the ten sites previously excluded from the sample of sites to be analysed. These four sites were also excluded from the sample of sites to be analysed as crash counts in the after treatment periods at these sites would likely be affected by the treatment works being undertaken at the excluded sites during these periods, thus masking the true effect of treatments. Excluding projects that overlapped with one of the ten previously-excluded projects reduced the number of distinct treated sites used in the analysis sample from 75 sites to 71 sites. As can be seen from Table 2.1, excluding crashes that occurred at sites that overlapped with one of the ten previously-excluded sites reduced the number of crashes at treated sites from 2,493 crashes to 2,431 crashes.

To summarise, of the 169,438 crashes that occurred in the period 1 May 1997 to 31 October 2008, 2,898 occurred at a site treated as part of the Motorcycle Blackspot Program. After completing the process of excluding ineligible or contaminated sites, the number of crashes occurring at the remaining sites had been reduced from 2,898 to 2,431 (i.e. a reduction of 467 crashes). Therefore the number of crashes eligible to be included in the analysis sample, either as a crash occurring at a control site or a treated site, was also reduced by 467 crashes, from 169,438 crashes to 168,971 crashes. Section 2.2.2.2 describes how these crashes were distributed among treatment and control groups and pre- and post-treatment groups.
As detailed in Section 2.1, of the 101 sites treated as part of the Motorcycle Blackspot Program, 26 were long route treatments, 74 blacklength treatments and one was an intersection treatment. Table 2.2 describes how each stage of the process of eliminating ineligible sites or merging coincident sites affected the distribution of the different types of treatments. It can be seen from Table 2.2 that eight of the ten sites excluded in step 2 were long route treatments, with the other two being blacklength treatments, while the two sites that did not have any crash data were both blacklength treatments.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>All treatments</th>
<th>Long route treatments</th>
<th>Blacklength treatments</th>
<th>Intersection treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Obtain original data from VicRoads</td>
<td>101</td>
<td>26</td>
<td>74</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Remove sites in which treatment works had not been completed by April 2007</td>
<td>91</td>
<td>18</td>
<td>72</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Remove sites without crash data</td>
<td>89</td>
<td>18</td>
<td>70</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Merge coincident sites</td>
<td>75</td>
<td>18</td>
<td>56</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Remove sites that overlap with ineligible sites</td>
<td>71</td>
<td>18</td>
<td>52</td>
<td>1</td>
</tr>
</tbody>
</table>

When the 24 coincident sites were merged into ten distinct sites in Step 4, it was found that eight of the ten were a mixture of blacklengths and long route projects. In order to model the affect of treatments on casualty crash frequency at treated sites by treatment category, it was necessary crashes at each of the 71 distinct treated sites only contributed to the crash counts of one of the three treatment groups (i.e. blacklength treatments, intersection treatments or long route treatments). The fact that eight of the ten distinct sites were a mixture of blacklength and long route treatments created a problem in that it was not clear whether to define the treatment category of the newly-defined distinct site as a blacklength or a long route treatment or a mixture of the two.

On closer examination, it was found that for five of these eight distinct sites, projects were merged because one or two smaller blacklength sites were contained entirely within a long route treatment. For the remaining three distinct sites, one or two smaller blacklength sites were partly contained within a larger long route treatment. For each of the eight distinct sites, the blacklength sites were on the same length of road as the long route site that overlapped them. It was decided that each of these eight distinct sites would be defined as long route treatments because they defined a length of road longer than the typical blacklength site and that all or most of each of the eight sites were treated under the long route treatment component of the program.

This approach was adopted in preference to two alternative ways of resolving the problem of some long route treatments overlapping blacklength treatments. One of the alternative approaches would be to analyse the eighteen long route treatments with crash data from
sections of the long route site that overlapped blacklength sites removed. This would mean that crash data from sections of road treated as both blacklengths and long route treatments would not contribute to the estimates of crash reduction at the sites being analysed. Another alternative would be to exclude all eight long route treatments that were contaminated by blacklength sites from analyses that estimated the effectiveness of the different types of treatments. This would mean that estimates of effectiveness for long route treatments would only be based on crash reductions observed at the ten non-contaminated long route sites. Section 5.4.2 provides further discussion of the merits of each approach. It also provides discussion of whether different conclusions about the effectiveness of long route treatments would have been likely if one of these alternative approaches was adopted.

Returning to Table 2.2, at step five, the four sites omitted because they overlapped with sites that were previously excluded in Step 2 were all blacklength sites.

To summarise, the 71 distinct sites used in the analysis used data from crashes at 85 of 101 treated sites originally provided by VicRoads. Of the 71 distinct sites, eighteen were classified as long route treatments, 52 were classified as blacklength treatments and one was classified as an intersection treatment. Data from 30 of the original sites were used to analyse the eighteen distinct sites classified as sites treated using long route treatments, while data from 54 of the original sites were used to analyse the effectiveness of the 52 blacklengths, i.e. two pairs of blacklengths were merged to create two distinct sites (projects 415DU2 and 413UN12 were merged to form a new distinct site, as were 4760239A and 4760232A). There was only one intersection site and this site did not need to be merged with any other sites in order to be included in the analysis.

2.2.2.2 Disaggregation of casualty crashes by treatment/control and before/after groups

The Method section of this report describes how the casualty crash data supplied by VicRoads were disaggregated according to whether crashes occurred at treated sites or control sites (Section 3.2) and, for crashes that did occur at treated sites or control sites, whether they occurred in the pre-treatment period or the post-treatment period (see Section 3.3). Table 2.3 describes the results of categorising casualty crash data in this manner.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Treated site</th>
<th>Control</th>
<th>Not a treated or control site</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to before treatment period</td>
<td>360</td>
<td>2,680</td>
<td>0</td>
<td>3,040</td>
</tr>
<tr>
<td>During treatment period</td>
<td>232</td>
<td>1,781</td>
<td>0</td>
<td>2,013</td>
</tr>
<tr>
<td>Not in treatment or control areas</td>
<td>0</td>
<td>0</td>
<td>145,867</td>
<td>145,867</td>
</tr>
<tr>
<td>Subtotal of omitted Crashes</td>
<td>592</td>
<td>4,461</td>
<td>145,867</td>
<td>150,920</td>
</tr>
<tr>
<td>After treatment period</td>
<td>301</td>
<td>3,497</td>
<td>0</td>
<td>3,798</td>
</tr>
<tr>
<td>Before treatment period</td>
<td>1,538</td>
<td>12,715</td>
<td>0</td>
<td>14,253</td>
</tr>
<tr>
<td>Subtotal of Treatment/Control Crashes</td>
<td>1,839</td>
<td>16,212</td>
<td>0</td>
<td>18,051</td>
</tr>
<tr>
<td>Total</td>
<td>2,431</td>
<td>20,673</td>
<td>145,867</td>
<td>168,971</td>
</tr>
</tbody>
</table>
VicRoads supplied data on a total of 169,438 police-reported crashes. As described in the previous section, 467 crashes at treated sites were excluded from the analysis sample because they either occurred at sites that had not been completed by April 2007 or because they occurred at sites that overlapped these excluded sites. This left 168,971 crashes that could contribute to crash counts at either treated sites or control sites. Table 2.3 confirmed that a total of 2,431 of the 168,971 crashes occurred at treated sites while 20,673 occurred at control sites. A description of how control sites were defined for each treated site has been provided in Section 3.2. The remaining 145,867 crashes occurred at sites that were not associated with either a treated site or a control site.

Of the 2,431 crashes at treated sites, 1,538 occurred in the pre-treatment period and 301 occurred in the post-treatment period. For control sites, 12,715 crashes occurred in pre-treatment periods while 3,497 occurred in after treatment periods. A description of how pre-treatment and post-treatment periods were defined for sites in each treatment-control pair is given in Section 3.3.

Table 2.3 also shows that 592 casualty crashes at treated sites and 4,461 crashes at non-treated control sites were excluded from the sample to be analysed either because they occurred during the period in which treatment works were being completed or because they occurred more than six years prior to these treatment works commencing.

Of the 168,971 crashes eligible for evaluation, only 18,815 (11%) involved a motorcycle. Table 2.4 shows how these 18,815 crashes involving a motorcycle were disaggregated across treatment/control and pre/post-treatment groups. It can be seen that 14,231 of the motorcycle crashes occurred at locations that were not associated with either a treated site or a control site.

### Table 2.4 Summary of casualty crash data used in the analysis for crashes in which a motorcycle was involved

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Treated site</th>
<th>Control</th>
<th>Not a treated or control site</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to before treatment period</td>
<td>113</td>
<td>338</td>
<td>0</td>
<td>451</td>
</tr>
<tr>
<td>During treatment period</td>
<td>88</td>
<td>422</td>
<td>0</td>
<td>510</td>
</tr>
<tr>
<td>Not in treatment or control areas</td>
<td>0</td>
<td>0</td>
<td>14,231</td>
<td>14,231</td>
</tr>
<tr>
<td>Subtotal of omitted Crashes</td>
<td>201</td>
<td>760</td>
<td>14,231</td>
<td>15,192</td>
</tr>
<tr>
<td>After treatment period</td>
<td>130</td>
<td>689</td>
<td>0</td>
<td>819</td>
</tr>
<tr>
<td>Before treatment period</td>
<td>614</td>
<td>2,190</td>
<td>0</td>
<td>2,804</td>
</tr>
<tr>
<td>Subtotal of Treatment/Control Crashes</td>
<td>744</td>
<td>2,879</td>
<td>0</td>
<td>3,623</td>
</tr>
<tr>
<td>Total</td>
<td>945</td>
<td>3,584</td>
<td>14,286</td>
<td>18,815</td>
</tr>
</tbody>
</table>

Of the 945 motorcycle crashes identified as occurring at treated sites, 201 were excluded from the analysis because they either occurred during the period in which treatment works were being completed or because they occurred more than six years before treatment works commenced. This meant that the analysis of the effect of the treatments on casualty crashes involving a motorcycle would be based on how the remaining 744 crashes at treated sites were distributed into either the before treatment period or the after treatment period when compared to the distribution for control sites. Of the motorcycle crashes at
treated sites, 614 occurred in the before treatment periods, while 130 occurred in the after treatment periods.

2.3 CASUALTY CRASH COST DATA

To estimate the economic benefits of the program, the crash reductions attributable to Motorcycle Blackspot Program have been translated into measures of economic worth. To complete these analyses, it was necessary to estimate the average cost of crashes of different severities.

VicRoads provided MUARC with estimates of the cost of crashes occurring at sites treated as part of Stage 2 of the Safer Road Infrastructure Program. These estimates are shown in Table 2.5. It can be seen that different cost estimates were provided for intersection treatments and run-off road treatments. Furthermore, within each of these categories, different estimates were provided for crashes occurring in different speed zones.

Table 2.5 Estimates of crash cost values at treated sites, as provided by VicRoads (AU$ 2005)

<table>
<thead>
<tr>
<th>Intersection sites</th>
<th>Speed Zone (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 60</td>
</tr>
<tr>
<td>Crash Severity</td>
<td>70-90</td>
</tr>
<tr>
<td>Serious casualty</td>
<td>$467,000</td>
</tr>
<tr>
<td>Other injury</td>
<td>$19,100</td>
</tr>
<tr>
<td></td>
<td>100-110</td>
</tr>
<tr>
<td>Serious casualty</td>
<td>$557,000</td>
</tr>
<tr>
<td>Other injury</td>
<td>$20,800</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run-off road sites</th>
<th>Speed Zone (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80-90</td>
</tr>
<tr>
<td>Crash Severity</td>
<td>100-110</td>
</tr>
<tr>
<td>Fatal crash</td>
<td>$1,814,000</td>
</tr>
<tr>
<td>Serious but not fatal crash</td>
<td>$463,700</td>
</tr>
<tr>
<td>Other injury crash</td>
<td>$20,800</td>
</tr>
<tr>
<td></td>
<td>$1,924,000</td>
</tr>
<tr>
<td></td>
<td>$459,000</td>
</tr>
<tr>
<td></td>
<td>$20,300</td>
</tr>
</tbody>
</table>

For most of the treatments completed as part of the Motorcycle Blackspot Program, the speed limit varied along the route. Furthermore, most blacklengths and long route treatments passed through several intersections, meaning that some crashes along the route occurred at intersections while others occurred along lengths of road between intersections. Therefore, a decision had to be made about which cost estimates from Table 2.5 would be used to estimate the average cost of crashes prevented at each site.

Examining crash data at the treated sites revealed that 43% of crashes occurred in 100km/h speed zones, with the remainder occurring in slower speed zones. The median value of the speed zone in which crashes at treated sites occurred was 80 km/h. Furthermore, only 26% of crashes occurred at intersections. Therefore, the most common type of crash at treated sites were crashes in speed zones of 80 km/h or greater that occurred along lengths of road between intersections. Based on these distributions, it was decided that the crash cost estimates from Table 2.5 that specifically related to run-off road crashes occurring on roads with speed limits of 80-90 km/h should be used to estimate the average cost of crashes occurring at treated sites. These cost estimates were also used to estimate the average cost of crashes prevented at the one site treated as an intersection treatment (project number
AI745). This decision was made so that the cost estimates used in the economic evaluation were consistent across all the sites evaluated.

Based on these decisions, from Table 2.5, the average cost of a fatal crash at a treated site was assumed to be $1,814,000, while the average cost of a “serious but not fatal” crash was assumed to be $463,700 and the average cost of an “other injury” crash was assumed to be $20,800. Furthermore, it was assumed that these average cost estimates were also relevant for crashes involving a motorcycle. It may be true that within each severity category, the cost of run-off road crashes involving motorcycles may differ to those involving all types of vehicles. However, given average cost estimates specific to motorcycle crashes were not available, it was decided that the same cost by severity estimates would be used to estimate the cost of (serious) casualty motorcycle crashes and (serious) casualty crashes that did not involve a motorcycle.

These estimates of crash cost by crash severity were used to estimate the average cost of the following types of crashes at treated sites:

- casualty crashes;
- serious casualty crashes;
- casualty motorcycle crashes; and
- serious casualty motorcycle crashes.

The average cost of each of these four types of crashes was estimated by calculating the weighted average of the estimates of crash cost by crash severity. Table 2.6 shows the number of crashes by crash severity of casualty crashes occurring at treated sites during the before treatment periods for casualty motorcycle crashes and casualty crashes involving all types of vehicles.

**Table 2.6: Severity of casualty (motorcycle) crashes that occurred at sites treated as part of the Motorcycle Blackspot Program in the before treatment periods**

<table>
<thead>
<tr>
<th>Crash severity</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casualty crashes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal crash ((av_f))</td>
<td>48</td>
<td>3.1%</td>
</tr>
<tr>
<td>Serious but not fatal crash ((av_s))</td>
<td>551</td>
<td>35.8%</td>
</tr>
<tr>
<td>Other injury crash ((av_o))</td>
<td>939</td>
<td>61.1%</td>
</tr>
<tr>
<td>All casualty crashes ((av_f + av_s + av_o))</td>
<td>1,538</td>
<td>100%</td>
</tr>
<tr>
<td>Casualty motorcycle crashes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal crash ((mc_f))</td>
<td>26</td>
<td>4.2%</td>
</tr>
<tr>
<td>Serious but not fatal crash ((mc_s))</td>
<td>290</td>
<td>47.2%</td>
</tr>
<tr>
<td>Other injury crash ((mc_o))</td>
<td>298</td>
<td>48.5%</td>
</tr>
<tr>
<td>All casualty motorcycle crashes ((mc_f + mc_s + mc_o))</td>
<td>614</td>
<td>100%</td>
</tr>
</tbody>
</table>
Using these distributions in a weighted sum of the previously-estimated crash costs by severity, the average cost of a casualty crash occurring at a treated site can be estimated in the following manner:

\[
\text{Ave. cost of casualty crashes} = \frac{1,814,000 \times av_f + 463,700 \times av_s + 20,800 \times av_o}{av_f + av_s + av_o} = \frac{1,814,000 \times 48 + 463,700 \times 551 + 20,800 \times 939}{1,538} = \frac{87,072,000 + 255,498,700 + 19,531,200}{1,538} = \frac{362,101,900}{1,538} = \$235,437.
\]

Therefore, the average cost of casualty crashes occurring at treated sites was estimated to be $235,437. Similarly, the averaged cost of a casualty motorcycle crash occurring at a treated site can be estimated as follows:

\[
\text{Ave. cost of casualty MC crash} = \frac{1,814,000 \times mc_f + 463,700 \times mc_s + 20,800 \times mc_o}{mc_f + mc_s + mc_o} = \frac{1,814,000 \times 26 + 463,700 \times 290 + 20,800 \times 298}{614} = \frac{47,164,000 + 134,473,000 + 6,198,400}{614} = \frac{187,835,400}{614} = \$305,921.
\]

Therefore, the average cost of a casualty motorcycle crash was estimated to be $305,921.

The same approach was used to estimate that the average cost of a serious casualty crash at treated sites was $571,904, while the average cost of a serious casualty motorcycle crash was estimated to be $574,800.

Table 2.7 summarises the final crash costs used in the evaluation. These estimated crash costs were applied in the economic evaluation of the program in Section 4.2 of the report. When interpreting the results of Section 4.2, the reader should assume that all the estimates of crash costs derived in this section are in year 2004 Australian dollar values.
Table 2.7: Assumed average costs of crashes occurring at treated sites used in the economic evaluation of the program

<table>
<thead>
<tr>
<th>Crash type</th>
<th>Estimated Average Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casualty crashes</td>
<td>$235,437</td>
</tr>
<tr>
<td>Serious casualty crashes</td>
<td>$571,904</td>
</tr>
<tr>
<td>Casualty motorcycle crashes</td>
<td>$305,920</td>
</tr>
<tr>
<td>Serious casualty motorcycle crashes</td>
<td>$574,800</td>
</tr>
</tbody>
</table>
3.0 METHOD

3.1 STUDY DESIGN

The method used to assess the effectiveness of the Motorcycle Blackspot Program in reducing (serious) casualty crashes and (serious) casualty crashes involving motorcycles at treated sites was similar to that employed in the evaluation of the Accident Blackspot Component of the $240M Statewide Blackspot Program (Scully, Newstead et al., 2006b). Scully, Newstead et al. (2006b) used a quasi-experimental study design, employing Poisson regression to establish whether changes in the number of casualty crashes at treated sites were significantly different to changes in the number of casualty crashes at non-treated sites. This quasi-experimental approach to evaluating road safety programs was originally proposed by Bruhning and Ernst (1985) and modifications of the original method have been used by MUARC (e.g. Newstead & Corben, 2002) and other road safety researchers (BTE, 2001) to estimate the effectiveness of road safety programs across all treated sites.

The first step in employing this study design was to determine the numbers of casualty crashes that occurred at each treated site before treatment works had begun and the number that had occurred after treatment works were completed. Each treated site was then matched to a set of non-treated control sites. The numbers of casualty crashes in the pre-treatment and post-treatment periods at each control site were used to adjust the percentage reduction in the number of casualty crashes at treated sites in the post-treatment period when compared with the pre-treatment period. The resulting adjusted percentage reduction was a measure of the reduction in crashes due to treatment.

Provided control sites were chosen carefully, comparing casualty crash reductions at treated sites against those at non-treated control sites enabled the effects of treatments on casualty crash counts to be isolated from other factors that may affect casualty crash counts in the post-treatment period. Such factors not related to treatments that could have an effect on casualty crash counts at treated sites include economic trends, changes in traffic flow in the local area of a treatment, the effect of other road safety programs occurring in the local area and general trends in the State’s road toll.

Furthermore, provided that the before treatment period of each control site was coincident with the before treatment period at the treated site to which it was matched and that the same was true for the after treatment periods, this design allowed the length of time used to define a before treatment period at a particular site to be different to the length of time used to define the after treatment period.

3.2 CHOICE OF CONTROLS

As in previous evaluations of programs involving infrastructure investment, in order to improve the statistical power of the analyses, the before and after casualty crash counts of each treated site were compared with aggregated casualty crash counts at a group of control sites. As described in the feasibility study carried out by D'Elia & Newstead (2006), the selection of control sites should balance matching specific site characteristics in order to control for confounding influences on casualty crash trends with ensuring that a sufficient number of casualty crashes remain in the dataset so that the statistical power of the site is not compromised. For the present study, it was proposed that controls would consist of all casualty crashes occurring in the same postcode region as the treated site.
This meant that for each treated site, control sites consisted of all casualty crashes occurring in close proximity to the treated location. Postcode regions were used to define control sites because casualty crashes occurring in the same postcode area are likely to be equally affected by other factors not related to the Motorcycle Blackspot Program (such as other road safety programs being completed in the area and local trends in exposure). Where a treated site was located along a length of road that travelled through more than one postcode area, crashes at non-treated sites in each postcode region were used to define control site crash counts.

On closer examination of the casualty crash data, it was found that many postcode areas contained more than one treated site. For example, the region corresponding to postcode 3221 contained all or part of five different motorcycle blackspot projects. One way of dealing with this situation was to match treated sites in the same postcode region with the same set of control sites. When evaluating the effectiveness of the program as a whole, the aggregated before and after casualty crash counts of treated sites in the same postcode region were compared with the casualty crash counts at the same group of control sites. For example, if there were two distinct sites in the one postcode region, the crash counts of each of these two sites would be compared against the crash counts at the non-treated control sites in the particular postcode region. This many-to-one method of matching treated sites to control sites was employed in most cases in which it was found that a postcode region contained more than one treated site. However, exceptions were made for treated sites that passed through more than one postcode area where only a small proportion of the crashes that occurred at the treated site occurred in a postcode area that contained a second treated site. In such cases the postcode area that contained more than one treated site was matched to only one of the treated sites. This would have minimal affect on the estimate of effectiveness for either of the treated sites that were partially or completely contained in the postcode. Excluding crashes from the postcode as control sites for one of the treated sites will not reduce the quality of the match between treated sites and control sites as only a small proportion of the crashes at the treated site were contained within the excluded postcode. However, reducing the number of crashes at control sites will reduce the statistical power when evaluating the effect of crashes at the particular treated site. However, this will not affect overall estimates of effectiveness or estimates of effectiveness for sites grouped by treatment type or location.

In addition to matching treated sites to crashes in the same postcode when defining control sites, the evaluation of Accident Blackspot Component of the $240M Statewide Blackspot Program by Scully, Newstead et al. (2006b) also matched treated sites with controls based on the type of road on which crashes occurred and whether the treated site was a discrete intersection or a length of road. One of the reasons two additional variables were used to match treated sites with control sites was that when preparing the data used to evaluate the 865 sites treated as part of the Accident Blackspot Component of the $240M Statewide Blackspot Program, it was found that there were many postcode regions that contained multiple blackspot sites. As the present evaluation involves evaluating far fewer treated sites, it was not necessary to use additional variables to define control sites. Furthermore, sites treated as part of the Motorcycle Blackspot Program were far more homogeneous than sites treated as part of the Accident Blackspot Component of the $240M Statewide Blackspot Program. For example, only one of the projects completed as part of the Motorcycle Blackspot Program involved the treatment of a discrete intersection. Similarly, nearly 70% of sites treated as part of the Motorcycle Blackspot Program were classified as “main roads” using the State Road Classification. The road classification was more evenly distributed among the five categories for sites treated as part of the Accident Blackspot Component of the $240M Statewide Blackspot Program.
After the method of matching treated sites to controls had been applied, it was found that the 71 distinct treated sites used in the analysis were matched to 49 distinct groups of control sites.

### 3.2.1 Reallocation of postcodes

An assumption required when using postcodes to match treated sites with groups of control sites is that the boundaries of the postcodes used in the matching process are consistent in the before period and the after period. If only a small proportion of postcode regions have had their boundaries redefined after the commencement of treatment works, the effect on the accuracy of the estimate of effectiveness for the program as a whole is likely to be minor. However, reallocation of postcodes or the redefining of their boundaries can have a dramatic effect on estimates of the effectiveness of treatments at individual sites. If the boundary of a postcode region was changed in the after treatment or during treatment periods, this may affect the accuracy of the effectiveness estimates for that particular site. The extent of the resulting error will be dependent on the extent to which the postcode’s boundaries changed.

There is evidence that postcode boundaries do change. In fact, in the present evaluation it was found that the reallocation of postcodes in the Baw Baw Shire was affecting the accuracy of effectiveness estimates for two of the sites in this area (i.e. 1BBF1 and 1BDU1). Both these sites were located close to Neerim Junction and were matched to untreated sites in the 3821 postcode region. However it was found that within this postcode region, the number of crashes at untreated sites increased from nine in the before period to twenty in the after period despite the before period being nearly twice as long as the after period (six years compared with 3.4 years). Of the 49 groups of control sites, this was the only one for which the post-treatment crash counts exceeded the pre-treatment crash counts.

In order to be sure that the surprisingly high number of crashes in the after treatment period was not a result of changes in the allocation of postcodes, a list of the names of the roads on which control crashes in the 3821 postcode region occurred was compiled and then mapped using GIS data of the Victorian Road Network. It was found that for most of these roads; no crashes that occurred prior to 2006 were designated as occurring in the 3821 postcode region. Prior to 2006, most crashes on these roads were listed as occurring in either the 3818 (Drouin area), 3820 (Warragul), 3831 or 3832 (the latter two being both postcode regions for the Neerim area). It seems that at some point prior to 2006, the postcodes for sections of these roads were changed from one of the above postcodes to 3821, which meant that there were more crashes with 3821 postcodes in the after treatment period than the before treatment period. Furthermore, crashes occurring in the area around Neerim Junction changed from 3821 to 3832 in the period from 2006 onwards.

It was considered important that the region used to source control data for 1BBF1 and 1BDU1 was consistent in the before treatment period and the after treatment period. As things stood, the region used to source control data for the after treatment period covered a different and larger area than the region used to source control data for the before treatment period. The two regions were made more consistent by defining control sites as all crashes at untreated sites within the postcodes 3831 and 3832 as well as the postcode 3821. Sites within the 3818 and 3820 postcode regions were not used to match control data with treatment data as these postcodes appeared to correspond to sections of road much further away from the treated sites than sections of road in the 3831 and 3832 postcode regions. With this adjustment, the average number of crashes per year at control sites was 14.5 for
the before treatment period and 15.8 for the after treatment period, whereas prior to this adjustment the analogous rates were 1.5 crashes per year (before treatment) and 5.9 (after treatment).

Before treatment and after treatment crash counts were also examined at other control sites. There was no evidence that the accuracy of effectiveness estimates at these sites were adversely affected by changing postcode boundaries. Hence, the procedure used in this evaluation to match treated sites with control data enabled reliable evaluation of the effectiveness of the entire program.

### 3.3 BEFORE AND AFTER TREATMENT PERIODS

Before and after treatment periods for each treatment-control pair were determined using the treatment data provided by VicRoads (see Appendix A). Pre-treatment periods were defined as the period beginning six years before the date of the commencement of treatment works up until a day before the commencement of works, while the post-treatment period was defined as the period beginning a day after the treatment works had been completed to the 31st of October 2007.

As described in Section 3.2, for some treatment-control pairs, several different treated sites were matched to the same set of control sites. This meant that some treated sites in the treatment-control pair would have different dates for the commencement (or completion) of treatment works to other treated sites in the same treatment-control pair. Where this occurred, the before treatment period for all sites was determined using the earliest commencement of works date from among the group of treated sites. Similarly, when several treated sites shared the same set of control sites, the after treatment period for treatment and control sites was determined using the date of the most-recently completed treatment works.

As the earliest date on which treatment works commenced for a motorcycle blackspot project was 12 May 2003 and crash data from May 1997 were available, all treatment and control pairs had pre-treatment periods of six years. As explained in Section 2.1, data from ten projects were excluded from the analysis sample as treatment works at these sites had not been completed by April 2007. When these data were excluded from the sample to be analysed, it was found that the latest date on which treatment works were completed was 28 February 2007. As VicRoads provided crash data to 31 October 2007, the minimum length of a post-treatment period was eight months, with the average being 2.4 years across the 49 treatment-control pairs. The longest post-treatment period was in excess of four years. Therefore, for all matched pairs of treatment and control sites, the post-treatment period was a shorter duration than the pre-treatment period. As explained by Scully, Newstead et al. (2006b), even if a treatment didn’t have an effect on casualty crash frequency at a treated site, the number of crashes in the post-treatment period would likely to be fewer than that in the pre-treatment period simply because the post-treatment period was of a shorter duration.

Matching each treated site to a set of non-treated control sites enabled comparison of crash counts in the pre-treatment and post-treatment periods of treated sites even if the two periods were of different durations. As explained by Scully, Newstead et al. (2006b), it is acceptable to have pre-treatment and post-treatment periods of differing durations as long as for each treatment-control pair, the pre-treatment period for the treated sites cover the same time-span as the pre-treatment period at the control sites and that the same applies for the post-treatment periods. This ensures that seasonal differences in crash occurrence are
taken into account. As control sites were not treated, differences between casualty crash counts for the pre-treatment period and the post-treatment period at the control sites will be due to factors not related to the treatment works. Provided treated sites and control sites have been match appropriately, factors not related to treatment works should have an equal effect on casualty crash counts at both treated and control sites. Such factors may include the effects of other road safety programs operating in the local area, exposure related changes, economic influences such as fluctuating petrol prices as well as differences in the duration of the pre-treatment and the post-treatment periods. Therefore, the reduction in the number of crashes in the post-treatment period compared to the pre-treatment for the control sites can be used to normalise the reduction at the treated sites. This will give a measure of the effect of the treatment on crash counts at the treated site. Appendix C of the report by Scully, Newstead et al. (2006b) provided an example of data involving a matched treatment-control pair that illustrates how crash data at control sites were used to enable analysis using unequal pre-treatment and post-treatment periods.

3.4 STATISTICAL ANALYSIS METHODS

Poisson Regression has been used by MUARC in many evaluations of the road safety benefits of various infrastructure improvement programs based on quasi-experimental designs (e.g. Newstead & Corben, 2001; 2002; Newstead, Corben & Diamantopoulou, 1997; Scully, Newstead & Corben, 2006; Scully, Newstead & Corben, 2008; Scully, Newstead et al., 2006a; 2006b).

Count data assembled for analysis in a quasi-experimental before/after treatment/control design define a two by two contingency table for each treatment site-control site pair. The aim of the statistical analysis is to estimate the percentage change in casualty crash frequency from before treatment to after treatment at the treated sites relative to that at the control sites. Apart from the lack of treatment and control group site randomisation, this is the same analysis framework used in analysis of clinical trials where a randomised treatment-control structure is used.

Medical literature shows the most appropriate means of analysing count data from trials to estimate net treatment effects relative to a control is via a log-linear analysis with a Poisson error structure (Breslow & Day, 1987). The estimate resulting from the analysis in the case of the casualty crash data being analysed here is not a relative risk of an outcome, such as cancer in a clinical trial, but the relative casualty crash change in the treatment group compared to the control group. The distribution assumptions about casualty crash frequency made in the use of this method are consistent with those proposed by Nicholson (1986a, 1986b).

Bruhning and Ernst (1985) demonstrated the application of log-linear Poisson models to the analysis of quasi-experimental road safety evaluation designs. Demonstrated as part of the application were techniques for estimating aggregate treatment effectiveness across subsets of treated sites in an analysis, as well as tests for homogeneity of treatment effectiveness across selections of treated sites. Newstead and Corben (2001) also successfully demonstrated use of these methods in evaluating the TAC-funded accident blackspot program implemented in Victoria during 1992 to 1996.

The Poisson log-linear analysis method can be described as follows. Data defined by the quasi-experimental study design with before and after treatment data in each of L treatment and control pairs can be summarised in a series of L 2x2 contingency tables, as represented in Table 3.1.
A log-linear model with Poisson error structure, appropriate for the variability in the casualty crash data, is then fitted to the data, with the model form given by Equation 1. The log-linear model form of Equation 1 can easily be fitted using common statistical software packages such as SAS.

\[
\ln(n_{ijk}) = \beta_0 + \beta_i + \beta_{ij} + \beta_{ik} + \beta_{ijk} \quad (\text{Eqn. 1})
\]

In Equation 1, \(i\) is the site number, \(j\) is the treatment or control group index, \(k\) is the before or after treatment index, the \(\beta\) values are the model parameters and \(n_{ijk}\) is the cell casualty crash count. The percentage casualty crash reduction at site \(i\) attributable to the treatment, adjusted for the corresponding change in casualty crash frequency at the control site is given by Equation 2

\[
\Delta_i = 100 \times (1 - \exp(\beta_{i22})) \% \quad (\text{Eqn. 2})
\]

where \(\beta_{i22}\) represents the parameter for the after treatment period at treated site \(i\).

Statistical significance of \(\Delta_i\) is equal to the statistical significance of \(\beta_{i22}\), obtained directly from the fitted log-linear model. Confidence limits for \(\Delta_i\) are computed in the normal way using the estimated standard error of \(\beta_{22}\) obtained from the fitted log-linear model and using the transformation given by Equation 2. Subtle modifications of the above model can be made to estimate the average treatment effect across a number of treated sites as well as to accommodate multiple treatments compared against a single control. These modifications were detailed in Bruhning and Ernst (1985). These modifications were used to estimate the overall program effect of the Motorcycle Blackspot Program.

### 3.5 ACCIDENT MIGRATION AND REGRESSION-TO-THE-MEAN

The road safety literature has identified two important issues that should be considered when using a quasi-experimental study design to evaluate road safety programs. These issues are *accident migration* and *regression-to-the-mean*. Both of these issues are discussed below in the context of the methodology used to complete the evaluation of the Motorcycle blackspot program.

#### 3.5.1 Accident Migration

One possible outcome of treating sites on the road network is accident migration, which involves the casualty crash risk being moved, either entirely or partly, from the treated site to another site nearby or. If not considered in an analysis, accident migration effects can lead to an incorrect estimate of the net benefit of a treatment program to the community. The most likely cause of accident migration in this study would be through a treatment altering traffic volume at the treated site due to reduced or transferred exposure. To assess
this likelihood, traffic volume data for the treated sites and for neighbouring sites where traffic may have diverted would be needed. In addition, it would not only have been necessary to examine changes in traffic flows to the sites neighbouring the treated sites but also casualty crash records would need to have been analysed at the neighbouring sites. This is because the neighbouring sites may be inherently safer with net risk at the neighbouring site not necessarily increasing with the extra traffic volume diverted to it.

Traffic volume data at treated sites and neighbouring sites that might have been affected by accident migration was not available for the present evaluation. In addition it was beyond the scope of the project to analyse changes in casualty crash risk at all sites neighbouring treated sites, which would be required to properly assess the migration of casualty crash risk. Consequently, no results presented from this study are compensated for the effects of accident migration.

Accident migration effects are considered unlikely to be large provided treatments do not lead to substantial shifts in traffic volumes. VicRoads advised that treatments completed as part of the Motorcycle Blackspot Program are unlikely to affect traffic volumes.

### 3.5.2 Regression-to-the-Mean

Regression-to-the-mean is another potentially confounding influence on estimated treatment effectiveness. It is caused by selecting sites for treatment from a set with the same underlying crash rate that have a high casualty crash frequency measured over a narrow window in time, due to the expression of an extreme in random variation. Selecting sites for treatment on such a basis means that the likelihood of the casualty crash frequency at the selected site reducing in the immediate next period, merely due to chance, is high. If the treatment effect at the site is evaluated using the same inadequate casualty crash data from which the site was selected for treatment, the results of the evaluation will be spurious.

Numerous analysis methods have been proposed to overcome the problem of regression-to-the-mean, such as Abbess, Jarrett and Wright (1981). Many of these methods, however, make potentially restrictive assumptions about the likely distribution of accident frequencies both at individual sites and, more importantly, between sites. The estimates of regression-to-the-mean effects, and hence treatment effects, are potentially largely a product of the assumptions made about these distributions. The authors feel that it is potentially dangerous and misleading to use such methods that rely so heavily on the assumptions made. A further problem with these methods is that they require comparison of crash rates across treated sites as well as across all untreated sites in a region on a common basis such as crashes per weekly traffic volume. Generally, such data are not available on the scale needed to achieve this, a problem acknowledged by the BTE in its evaluation of the Federal Blackspot Program (BTE, 2001).

Other methods described in the literature recommend more pragmatic strategies for minimising the potential for regression-to-the-mean problems. These include the use of adequate pre-treatment casualty crash histories to give an accurate estimate of the true pre-treatment casualty crash frequency at the chosen site, and not analysing exactly the same data period that was used to select the treatment site. As explained in the feasibility study of the present evaluation that was conducted by D’Elia & Newstead (2006), Nicholson (1986a) suggested that the accuracy of calculations of the running mean accident rate increased steadily as the length of pre-treatment period was increased from one to five years. However, after five years, the rate at which the accuracy improved decreased
clearly. For the present study, each treated site that was evaluated had six years of pre-treatment casualty crash data. Furthermore, an analysis technique was used that properly recognised the level and distribution of random variation in the data and that computed confidence limits and significance probability levels that properly reflected this variation.

3.6 EVALUATION OUTPUT MEASURES

In order to test the null hypotheses discussed in the Introduction, this evaluation examined changes in casualty motorcycle crash frequencies at treated sites in the after treatment period compared with the before treatment period. As well as estimating the effect of the program on the frequency of casualty motorcycle crashes at treated sites, this evaluation also estimated the effect of the program when crash frequencies were limited to the following types of crashes:

- Serious casualty motorcycle crashes;
- Casualty crashes; and
- Serious casualty crashes.

The definitions for these types of crashes can be found in Section 2.2.1 of the report.

At VicRoads’ request, each of these four measures of effectiveness were completed for the program as a whole as well as for the program where sites located in the Yarra Ranges or on the Great Ocean Road had been excluded. The reason that VicRoads requested that the effects of excluding these sites be examined was that there was concern that speed reduction and enforcement programs operating on the Great Ocean Road and in the Yarra Ranges could have affected the crash counts for these sites in addition to the treatments. Details on the timing and duration of the enforcement and speed reduction programs conducted along the Great Ocean Road were unavailable for this evaluation. Information on the timing of speed enforcement activities in the Yarra Ranges was available (these activities were conducted between January and April 2004). However, data describing which routes were targeted were not available. Without such data, it was decided that the evaluation should provide estimates of effectiveness where treated sites in the Yarra Ranges or on the Great Ocean Road had been excluded.

Using the information provided in Appendix A, of the 101 sites treated as part of the Motorcycle Blackspot Program, eight treated sites were located along the Great Ocean Road, while fifteen projects were identified as being located in the Yarra Ranges. One site (AI1988) located in the Yarra Ranges was excluded from the analysis as treatment works had not been completed by April 2007. Table 3.2 lists the project numbers of the remaining sites located in the Yarra Ranges and along the Great Ocean Road.

Table 3.2 also lists the construction costs of the Great Ocean Road and Yarra Ranges projects. The aggregated construction cost for the Great Ocean Road sites was $526,967, while the aggregated cost for the Yarra Ranges projects was $574,886, which included the cost of completing two projects that were not actually located in the Yarra Ranges but overlapped sites that were defined by VicRoads as Yarra Ranges projects.

Separate analyses were also completed for sites grouped according to the type of treatment works completed at the site (intersection, blacklength or long route treatment). In addition to this, each of the 71 distinct sites (see Table 2.1 of Section 2.2.2) was ranked according
to the effectiveness of the treatments at the sites. However, due to low crash counts at some of the treated sites, effectiveness at the site-specific level was only measured in terms of reductions in casualty crashes, serious casualty crashes and casualty motorcycle crashes. There were insufficient data to evaluate individual sites in terms of their effectiveness in preventing serious casualty motorcycle crashes.

Table 3.2: Details of sites evaluated separately from remaining sites

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Location</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Great Ocean Road Projects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4760232A</td>
<td>Chainage: 52,500-55,500m, Mt Defiance</td>
<td>$7,823</td>
</tr>
<tr>
<td>4760239A</td>
<td>Mt Defiance Lookout, Mt Defiance</td>
<td>$12,663</td>
</tr>
<tr>
<td>4760242A</td>
<td>Smythes Creek Bridge, Smythes Creek</td>
<td>$72,357</td>
</tr>
<tr>
<td>4760243A</td>
<td>Chainage: 29,439-31,939m, Moggs Creek</td>
<td>$2,191</td>
</tr>
<tr>
<td>4760244A</td>
<td>Andersons Creek to Herschell Rd</td>
<td>$53,551</td>
</tr>
<tr>
<td>4760245A</td>
<td>Chainage: 70,719-71,715m, West of Grey River</td>
<td>$184,274</td>
</tr>
<tr>
<td>AH895</td>
<td>Chainage: 103,006-107,500m, Maits Rest</td>
<td>$119,116</td>
</tr>
<tr>
<td>AH900</td>
<td>Chainage: 128,089-137,500m, Johanna Heights</td>
<td>$74,992</td>
</tr>
<tr>
<td><strong>Capital cost of all Great Ocean Road projects</strong></td>
<td></td>
<td>$526,967</td>
</tr>
<tr>
<td><strong>Yarra Ranges Projects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42NS</td>
<td>Mt Dandenong Tourist Rd, Sassafras</td>
<td>$44,554</td>
</tr>
<tr>
<td>42YFJ2</td>
<td>Mountain Hwy, Ferny Creek</td>
<td>$55,003</td>
</tr>
<tr>
<td>42YFJ3</td>
<td>Belgrave-Gembrook Rd, Menzies Creek</td>
<td>$35,628</td>
</tr>
<tr>
<td>42YFJ4</td>
<td>Yarra Junction-Noojee Rd, Powelltown</td>
<td>$27,843</td>
</tr>
<tr>
<td>42YFH5</td>
<td>Mt Dandenong Tourist Rd, Tremont</td>
<td>$27,982</td>
</tr>
<tr>
<td>42YFH6</td>
<td>Yarra Junction-Noojee Rd, Gilderoy</td>
<td>$23,638</td>
</tr>
<tr>
<td>42YFH7</td>
<td>Mt Dandenong Tourist Rd, Kalorama</td>
<td>$18,225</td>
</tr>
<tr>
<td>42YFH8</td>
<td>Mt Dandenong Tourist Rd, Ferny Creek</td>
<td>$3,657</td>
</tr>
<tr>
<td>42YFH9</td>
<td>Emerald-Monbulk Rd, Monbulk</td>
<td>$21,323</td>
</tr>
<tr>
<td>AI963*</td>
<td>Healesville-Kinglake Rd, Healesville, Toolangi, Kinglake</td>
<td>$27,328</td>
</tr>
<tr>
<td>42TH</td>
<td>Healesville-Kinglake Rd, Chum Creek</td>
<td>$118,249</td>
</tr>
<tr>
<td>AI967</td>
<td>Warburton-Woodspoint Rd, East Warburton</td>
<td>$58,247</td>
</tr>
<tr>
<td>AI969†</td>
<td>Marysville-Woodspoint Rd, Saint Fillans</td>
<td>$80,295</td>
</tr>
<tr>
<td>AI979</td>
<td>Olde Warburton Rd, Warburton</td>
<td>$32,914</td>
</tr>
<tr>
<td><strong>Capital cost of all Yarra Ranges projects</strong></td>
<td></td>
<td>$574,886</td>
</tr>
</tbody>
</table>

* AI963 was merged with 42TH and M4UAA3 in Step 4 of Table 2.1. The cost of completing M4UAA3 (which is not located in the Yarra Ranges) was added to the cost of completing AI963
† AI969 was merged with 44UAA5M in Step 4 of Table 2.1. The cost of completing 44UAA5M (which was not located in the Yarra Ranges) was added to the cost of completing AI969

Where it was shown that significant changes in crash frequency at treated sites could be attributed to the program, estimates of the number of crashes prevented over the life of the program were also presented. These estimates, along with data supplied by VicRoads on the cost of implementing treatments, were used to give estimates of the cost-effectiveness of the program in preventing casualty motorcycle crashes and casualty crashes involving all types of vehicles. Where it was found that the program was effective at preventing crashes with more serious outcomes, the cost-effectiveness of preventing these types of crashes was also presented. These measures of cost-effectiveness were also given for each of the three different treatment groups where it was found that the sites in the treatment group had a significant effect on the frequencies of the relevant crash type at treated sites.
Another measure of economic effectiveness used to evaluate the program in the current report was the savings associated with reductions in crashes at treated sites. These savings were estimated for reductions associated with crashes involving all types of vehicles and savings associated with crashes that involved a motorcycle. These savings were estimated using estimates of the average costs of casualty crashes involving all types of vehicles and casualty crashes that involved a motorcycle, which were derived in Section 2.3.

The estimated savings due to reductions in the frequency of crashes at treated sites were used to estimate the benefit-cost ratio of the entire program where the benefits of the program were calculated based on changes in the frequency of all types of crashes as well as changes in the frequency of casualty motorcycle crashes. Where it was found that there was a significant reduction in casualty (motorcycle) crashes for projects belonging to a particular treatment group (i.e. blacklength, intersection or long route treatments), benefit-cost ratio estimates specific to the particular treatment category were also given.

The evaluation also addressed sensitivity of economic measures to the discount rates assumed when estimating the present value of future costs and savings. This was done by presenting economic measures for discount rates of 4%, 6% and 8%.
4.0 RESULTS

This section presents the main results of evaluating the effectiveness and economic worth of the Motorcycle Blackspot Program. Section 4.1 describes the effectiveness of the program in terms of estimated reductions in the frequency of casualty crashes at treated sites. This is followed by an economic evaluation of the program in Section 4.2.

4.1 CHANGES IN CASUALTY CRASH FREQUENCY

This section presents estimates in the reduction in casualty crash frequency of sites treated as part of the Motorcycle Blackspot Program relative to casualty crash frequencies at chosen control sites. The data used to complete the evaluation included crash data from the 85 (75 unique aggregated) treated sites meeting the criteria for inclusion. Estimates have been calculated at the program level (i.e. aggregated across all 85 (75 unique) sites), for sites grouped by the type of treatment completed at each site and when sites located on the Great Ocean Road and the Yarra Ranges have been excluded from the analysis because of concern that speed enforcement programs operating in the vicinity and other road improvements funded from other programs may bias measures of effectiveness.

Throughout the results section of this report, the p<0.05 significance level has been designated as statistically significant. However, the results presented throughout the report may be interpreted using a less conservative level of significance if it is considered appropriate.

4.1.1 Program Level Effects

4.1.1.1 Casualty crashes

Table 4.1 shows the estimated reduction in the number of casualty crashes and the number of casualty motorcycle crashes occurring at sites treated as part of the Motorcycle Blackspot Program relative to crash frequencies at control sites. Measures presented include the estimated percent reduction in the number of casualty crashes, as well as the estimated annual number of casualty crashes prevented because of the program aggregated across all 85 sites. This estimate of the number of casualty crashes prevented due to the program was determined using the annual numbers of casualty crashes at treated sites before treatments were implemented. Upper and lower 95% confidence intervals have been given for each estimate of the percent reduction in casualty crashes. These 95% confidence intervals give the range in which real casualty crash savings due to the program lie with 95% probability. Statistical significance values of the estimated percentage reduction for each type of crash have also been given. These values give the probability that crash reduction was observed due to chance variation in the data when no real underlying program effect took place.
Table 4.1: Estimated casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for the whole program, Great Ocean Road sites and Yarra Ranges sites

<table>
<thead>
<tr>
<th></th>
<th>Estimated casualty crash reduction (%)</th>
<th>Statistical significance</th>
<th>Lower 95% confidence limit (%)</th>
<th>Upper 95% confidence limit (%)</th>
<th>Annual casualty crash frequency at treated sites before treatment</th>
<th>Annual casualty crash saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole program (85 sites)</td>
<td>MC Involved</td>
<td>23.9</td>
<td>0.0232</td>
<td>3.7</td>
<td>39.9</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>All Vehicles</td>
<td>15.6</td>
<td>0.0188</td>
<td>2.8</td>
<td>26.7</td>
<td>256</td>
</tr>
<tr>
<td>Whole program excluding G.O.R and Y.R. sites (61 sites)</td>
<td>MC Involved</td>
<td>20.0</td>
<td>0.0130</td>
<td>-6.9</td>
<td>40.2</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>All Vehicles</td>
<td>13.6</td>
<td>0.0875</td>
<td>-2.2</td>
<td>26.9</td>
<td>191</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td>MC Involved</td>
<td>54.7</td>
<td>0.0857</td>
<td>-11.8</td>
<td>81.7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>All Vehicles</td>
<td>46.0</td>
<td>0.0689</td>
<td>-4.9</td>
<td>72.2</td>
<td>10</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td>MC Involved</td>
<td>21.4</td>
<td>0.2967</td>
<td>-23.5</td>
<td>50.0</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>All Vehicles</td>
<td>13.3</td>
<td>0.3299</td>
<td>-15.6</td>
<td>35.0</td>
<td>56</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness.

It can be seen that the program as a whole was estimated to have resulted in a 16% reduction in the number of casualty crashes involving all vehicle types relative to the crash frequencies at matched control sites. By comparison, it was also estimated that the program reduced the number of casualty motorcycle crashes by 24%. Both these estimates of crash reduction attributable to the program were significant. However it should be noted that although the estimate of effectiveness in reducing the number of casualty motorcycle crashes was greater than the estimated effectiveness for casualty crashes involving all types of vehicles, the difference between the two estimates was not statistically significant as evidenced by the fact that the 95% confidence intervals of the two estimates overlap.

A 16% reduction in the number of casualty crashes involving all vehicle types occurring across the 85 sites considered in the analysis was estimated to be equivalent to a saving of 40 casualty crashes per annum over the life of the program. The average life of the 85 treatments was 12.4 years. Multiplying the annual crash savings at each of the 85 sites by the assumed project life of each site gave the crash saving expected over the life of the program. It was estimated that 465 casualty crashes would be prevented over the life of the program. Similarly, a 24% reduction in the number of casualty motorcycle crashes was estimated to be equivalent to a saving of 24 casualty motorcycle crashes per annum, which was equivalent to 296 casualty motorcycle crashes being prevented over the life of the program.

When sites that were located either on the Great Ocean Road or in the Yarra Ranges were examined separately from other sites, it was found that the treatment of eight sites on the Great Ocean road lead to a 46% reduction in casualty crashes involving all types of vehicles at these sites and a 55% reduction in casualty motorcycle crashes. However, both
these measures of effectiveness were only significant at the 10% level. If it was assumed that these estimates of effectiveness were representative of the true underlying levels of effectiveness, based on the crash history at these sites, the treatments were estimated to have prevented four casualty motorcycle crashes per annum along the Great Ocean Road, which is equivalent to 36 casualty motorcycle crashes over the life of the treatments.

For the sixteen sites located in the Yarra Ranges, the point estimate for the reduction in the number of casualty motorcycle crashes was 21%, however this estimate was not significant (p=0.3). When casualty crashes involving all types of vehicles were considered, the treatment of Yarra Ranges sites was estimated to reduce crashes by 13%, but yet again this estimate was not significant (p=0.3). The lack of statistical significance at the Yarra Ranges sites is most likely a reflection of inadequate crash data for analysis rather than a reflection that the treatments were ineffective given the similarity in point estimates of effectiveness compared to the program as a whole.

Excluding sites located in the Yarra Ranges or on the Great Ocean Road reduced the estimated effectiveness of the program in reducing casualty motorcycle crashes to 20% (from the previous estimate of 24% when Yarra Ranges and Great Ocean Road sites were included). Furthermore, the estimated reduction was no longer statistically significant (p=0.13), reflecting the decreased quantities of data on which the estimate was based. When considering casualty crashes involving all types of vehicles, the estimated effectiveness of treatments at the 61 sites not located on the Great Ocean Road or in the Yarra Ranges was estimated to be similar to that when all 85 sites were considered, i.e. 14% (p=0.09) compared with 16% (p=0.02) respectively, again the weaker significance value reflecting the reduced data quantities.

4.1.1.2 Serious casualty crashes

The outcomes discussed in the previous section were based on analysis of 18,051 casualty crashes at treated sites or their matched control sites. Of these casualty crashes, 6,669 were serious casualty crashes. Similarly, of the 3,623 casualty motorcycle crashes that occurred at treated or control sites, 1,716 were serious casualty motorcycle crashes. These serious casualty (motorcycle) crash data were used to estimate the effect that the Motorcycle Blackspot Program had on serious casualty (motorcycle) crashes at treated sites when compared to changes in crash frequency at matched control sites.

Table 4.2 shows that the Motorcycle Blackspot Program was estimated to have reduced the number of serious casualty crashes involving all types of vehicles at treated sites by 17% (equivalent to a saving of seventeen serious casualty crashes per annum). However, this estimated reduction was only marginally statistically significant (p=0.09). For serious casualty motorcycle crashes, it was estimated that the program was effective in preventing 25% of such crashes at treated sites (equivalent to a saving of thirteen casualty crashes per annum). However, the estimated reduction was also only marginally significant (p=0.1), ranging from a 5% increase in serious casualty motorcycle crashes to a 46% reduction with 95% certainty. Based on the point estimates for the effect of the program as a whole, the 17% reduction in serious casualty crashes would be expected to result in 197 serious casualty crashes being prevented over the life of the program. Similarly, the 25% reduction in serious casualty motorcycle crashes would translate to 158 serious casualty motorcycle crashes being prevented over the program’s life.
Table 4.2: Estimated serious casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for the whole program, Great Ocean Road sites and Yarra Ranges sites

|                          | Estimated serious casualty crash reduction (%) | Statistical significance | Lower 95% confidence limit (%) | Upper 95% confidence limit (%) | Annual serious casualty crash frequency at treated sites before treatment | Annual serious casualty crash saving |
|--------------------------|-----------------------------------------------|--------------------------|--------------------------------|--------------------------------|------------------------------------------------|---------------------------------
| Whole program (85 sites) |                                               |                          |                                |                                |                                                |                                   |
| MC Involved              | 24.7                                          | 0.0967                   | -5.2                           | 46.2                           | 53                                            | 13*                              |
| All Vehicles             | 16.8                                          | 0.0876                   | -2.8                           | 32.6                           | 100                                           | 17*                              |
| Whole program excluding G.O.R and Y.R. sites (61 sites) |                                               |                          |                                |                                |                                                |                                   |
| MC Involved              | 25.9                                          | 0.1566                   | -12.2                          | 51.0                           | 33                                            | 9*                               |
| All Vehicles             | 11.0                                          | 0.3534                   | -13.8                          | 30.4                           | 71                                            | 8*                               |
| Great Ocean Road sites (8 sites) |                                               |                          |                                |                                |                                                |                                   |
| MC Involved              | 47.6                                          | 0.2415                   | -54.5                          | 82.2                           | 4                                             | 2*                               |
| All Vehicles             | 42.0                                          | 0.1990                   | -33.2                          | 74.7                           | 5                                             | 2*                               |
| Yarra Ranges sites (16 sites) |                                               |                          |                                |                                |                                                |                                   |
| MC Involved              | 8.4                                           | 0.7934                   | -76.8                          | 52.6                           | 16                                            | 1*                               |
| All Vehicles             | 25.9                                          | 0.2077                   | -18.1                          | 53.4                           | 24                                            | 6*                               |

* Based on non-significant (p ≥ 0.05) estimates of effectiveness

When the effects of the treatments in the Yarra Ranges and on the Great Ocean Road were separated from those in other parts of the State, it was estimated that treatments on the Great Ocean Road reduced the number of serious casualty crashes by 42%, however this reduction was not significant (p=0.2). Similarly, Great Ocean Road treatments were estimated to have reduced serious casualty motorcycle crashes by 48%, yet this point estimate ranged from a 55% increase in crashes to an 82% reduction with 95% certainty. Reductions for sites located in the Yarra Ranges and sites in other locations in Victoria were not significant for serious casualty crashes involving all types of vehicles or for serious casualty motorcycle crashes. The possible influence of speed enforcement programs operating in the Yarra Ranges and along the Great Ocean Road on all these estimates is examined in the discussion section of this report. Reduction in statistical analysis power in the disaggregated serious casualty analyses is again a reflection of the small data quantities and does not necessarily indicate that the treatments were ineffective in reducing serious casualty crashes. Instead, the small data quantities did not allow a statistically reliable effect to be established.

4.1.2 Effectiveness by type of treatment

The Motorcycle Blackspot Program involved applying three broad types of treatments to eligible sites. The three types of treatments were run-off road treatments (referred to as “blacklengths”), intersection treatments and long route treatments. Appendix A contains a list of which sites belonged to which category.

Blacklength and intersection treatments were identified through analysis of crash data. Each site was reviewed by experienced motorcyclists and the site’s deficiencies were
noted. Treatments to address these deficiencies were then applied at each site. Using treatment data provided by VicRoads, the following problems were commonly listed for the 72 blacklength projects that had been completed by April 2007:

- slippery or uneven surface;
- obstruction of sight-lines when entering curves;
- roadside hazards;
- poor delineation of curves;
- insufficient warning signs; and
- hilly terrain and steep drop-offs.

At one blacklength, poor lighting when approaching curves was also noted as a deficiency. Most blacklengths had more than one of the above deficiencies listed and for many blacklengths, several treatments were used to address a single deficiency. The following treatments were commonly used to treat blacklengths:

- removal of roadside hazards;
- resurfacing;
- sealing or repairing shoulders;
- hazard removal, including extending culverts or installing culverts with drivable end walls;
- line-marking and installing raised reflective pavement markers (RRPMs);
- improving warning signs or installing advisory speed signs;
- installing chevron alignment markers (CAMs) and guideposts; and
- clearing the road surface of debris.

Treatments less-commonly employed at blacklengths included curve widening, adding a rub rail to existing guardrails, installing guard fences, installing frangible poles and lightweight signs and improving street lighting. Most of the treatments completed along blacklengths were designed to prevent run-off road crashes.

There was only one intersection treatment completed as part of the Motorcycle Blackspot Program. This site was located at the intersection of Seaford Road and Ti-Tree Crescent in Seaford. The problem at this site involved the design of the intersection that allowed illegal traffic manoeuvres to be made that in turn resulted in dangerous conflicts between road users. This problem was treated using various treatments designed to channelise traffic movements to reduce opportunities to complete illegal manoeuvres.

The types of work completed as part of the long route treatments were engineering treatments along the length of the route. These treatments aimed to make the conditions, delineation, advised speeds and warnings along the route more consistent so that riding
along the route was more predictable and riders were less likely to be surprised by the road conditions. Examining VicRoads’ treatment data, the following treatments were commonly implemented along the 18 sites treated using long route treatments:

- installing curve alignment markers (CAMs) on all curves;
- installing warning signs and advisory speed signs;
- installing frangible guideposts at consistent intervals;
- line-marking over the entire length of the road; and
- re-evaluation of the speed advised on signage approaching bends using GIPSITRAC road geometry data.

As was the case at blacklength sites, most long route treatments employed several of the above treatments.

The fact that for both blacklength sites and long route sites, several different treatments were usually applied at the one site meant that it was difficult to evaluate the effectiveness of individual treatments. For this study, separate estimates of effectiveness were only derived for the three broad treatment categories, i.e. blacklength projects, long route projects and intersection projects. However, evaluations of individual sites were completed (see Section 4.1.3) and reasons why the treatment of some sites was more effective than treatments at other sites have been explored in the discussion section of this report.

Of the 85 sites that contributed data for the analysis of the Motorcycle Blackspot Program, 54 contributed data for the evaluation of blacklength treatments, while 30 contributed data for the evaluation of the long route treatments. Even though of the 101 treated sites that VicRoads originally provided data for, only eighteen were long route treatments, eight of these long route treatments overlapped one or more blacklength sites. In such circumstances, overlapping sites were redefined as a single distinct site and these blacklength sites were redefined as long route treatments, which enabled a model to evaluate effectiveness by treatment type to be developed. Section 5.4.2 provides discussion of why this method of classifying overlapping sites was adopted in the current evaluation and how the use of an alternative method of classifying overlapping treated sites would affect the results presented in the following sections.

### 4.1.2.1 Casualty crashes

Table 4.3 shows the estimated effect of the three broad treatment categories on all casualty crashes and on casualty crashes involving motorcycles. It can be seen that blacklength treatments reduced casualty motorcycle crashes by a statistically significant 40%. Similarly, blacklength projects reduced casualty crashes involving all types of vehicles by 24%. The estimated 24% reduction in casualty crashes at the 54 blacklength sites was equivalent to 26 casualty crashes being prevented per year and 294 being prevented over the life of the program, while the 40% reduction in casualty motorcycle crashes was estimated to be equivalent to twenty casualty motorcycle crashes being prevented per year and 228 over the life of the program.

From Table 4.3 it can be seen that for long route treatments, the estimated reductions for both casualty motorcycle crashes and casualty crashes involving all types of vehicles were
not significant. The point estimates of effectiveness for both casualty motorcycle crashes and all casualty crashes involving all types of vehicles were both negative indicating an estimated crash increase. This should not be interpreted as meaning that long route treatments increased the risk of crashes occurring, as the statistical significance values are high indicating the estimate could have been obtained through chance variation in the data when no underlying effect due to the treatment was present.

Table 4.3: Estimated casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for blacklengths, long route treatments and intersection treatments

<table>
<thead>
<tr>
<th></th>
<th>Estimated casualty crash reduction (%)</th>
<th>Statistical significance</th>
<th>Lower 95% confidence limit (%)</th>
<th>Upper 95% confidence limit (%)</th>
<th>Annual casualty crash frequency at treated sites before treatment</th>
<th>Annual casualty crash saving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blacklengths (54 sites)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Involved</td>
<td>40.3</td>
<td>0.0011</td>
<td>18.6</td>
<td>56.3</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>24.4</td>
<td>0.0028</td>
<td>9.2</td>
<td>37.1</td>
<td>107</td>
<td>26</td>
</tr>
<tr>
<td><strong>Long route treatments (30 sites)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Involved</td>
<td>-12.8</td>
<td>0.5188</td>
<td>-62.9</td>
<td>21.8</td>
<td>52</td>
<td>-7*</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>-1.3</td>
<td>0.9114</td>
<td>-26.2</td>
<td>18.8</td>
<td>148</td>
<td>-2*</td>
</tr>
<tr>
<td><strong>Intersection treatments (1 site)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Involved</td>
<td>51.3</td>
<td>0.6411</td>
<td>-899.8</td>
<td>97.6</td>
<td>1</td>
<td>&lt;1*</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>60.8</td>
<td>0.5221</td>
<td>-590.8</td>
<td>97.8</td>
<td>1</td>
<td>1*</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness

Similarly, for the single intersection treatment, the estimates of effectiveness were not significant, an artefact of the very limited crash data at this single site. In fact no casualty crashes were recorded as having occurred at the site in the after treatment period, with eight occurring in the before treatment period. The length of the post-treatment period at this site was less than two years, while the pre-treatment period was six years. Only with a longer post-treatment period would it be possible to accurately estimate the effectiveness of the intersection treatment at the site.

4.1.2.2 Serious casualty crashes

It can be seen from Table 4.4 that no statistically significant effects of the long route treatments and the intersection treatment for serious casualty crashes involving all types of vehicles or motorcycles could be found. However, it was found that the 54 blacklength treatments did have a statistically significant effect on both types of crashes. Specifically, it was estimated that blacklength treatments reduced the number of serious casualty crashes involving all types of vehicles by 33%, ranging from 12% to 50% with 95% confidence. This was equivalent to 16 serious casualty crashes being prevented per year across the 54 sites, or 176 serious casualty crashes prevented over the life of the program. Similarly, blacklength treatments were estimated to reduce the number of serious casualty motorcycle crashes by 43% (ranging from 11% to 63% with 95% confidence). This reduction was
equivalent to 11 serious casualty motorcycle crashes being prevented per year or 127 such crashes being prevented over the life of the program.

Table 4.4: Estimated serious casualty (motorcycle) crash reductions attributed to the Motorcycle Blackspot Program for blacklengths, long route treatments and intersection treatments

<table>
<thead>
<tr>
<th></th>
<th>Estimated serious casualty crash reduction (%)</th>
<th>Statistical significance</th>
<th>Lower 95% confidence limit (%)</th>
<th>Upper 95% confidence limit (%)</th>
<th>Annual serious casualty crash frequency at treated sites before treatment</th>
<th>Annual serious casualty crash saving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blacklengths (54 sites)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Involved</td>
<td>42.6</td>
<td>0.0135</td>
<td>10.9</td>
<td>63.1</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>33.3</td>
<td>0.0050</td>
<td>11.5</td>
<td>49.7</td>
<td>48</td>
<td>16</td>
</tr>
<tr>
<td><strong>Long route treatments (30 sites)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Involved</td>
<td>-18.0</td>
<td>0.5304</td>
<td>-97.9</td>
<td>29.7</td>
<td>26</td>
<td>-5*</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>-14.0</td>
<td>0.4127</td>
<td>-56.1</td>
<td>16.7</td>
<td>52</td>
<td>-7*</td>
</tr>
<tr>
<td><strong>Intersection treatments (1 site)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Involved</td>
<td>34.4</td>
<td>0.7919</td>
<td>-1,398.6</td>
<td>97.1</td>
<td>1</td>
<td>&lt;1*</td>
</tr>
<tr>
<td>All Vehicles</td>
<td>22.1</td>
<td>0.8689</td>
<td>-1,416.5</td>
<td>96.0</td>
<td>1</td>
<td>&lt;1*</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness

4.1.3 Effectiveness by site

4.1.3.1 Casualty crashes

Table 4.5 shows the estimated casualty crash reduction for individual treated sites. Only the five of the 71 distinct sites for which the estimated crash reduction was significant at the p<0.05 are included in the table. These sites have been listed in order of the estimated magnitude of their effect. Table B.1 of Appendix B contains results where the criterion for statistical confidence has been made less conservative (to p<0.2). This information has been provided for VicRoads' internal auditing purposes and should not be considered as conclusive proof that particular treatments were successful or unsuccessful.

From Table 4.5 it can be seen that, for treatments that were effective in reducing casualty crashes to the p<0.05 significance level, the most effective treatment involved roadworks along the Healesville-Koo-Wee-Rup Road in Cardinia. These road works were completed as part of three overlapping projects (42TG, 42NU and AI984), one of which was a long route treatment (AI984). It was estimated that the treatment of this site reduced crashes by 89% (p<0.03). Re-surfacing and removing hazards and sight obstructions along Montague Street, South Melbourne was the next most-effective treatment, with casualty crashes being reduced by 67% at this site (p=0.02).

The reason why only a few of the 85 sites were found to significantly reduce casualty crashes while the program as a whole was shown to significantly reduce casualty crashes was that disaggregating crash counts by the individual treated locations dramatically reduced the statistical power of the analyses. If the post-treatment periods were of a longer
duration, it is likely that more of the sites would have shown significant reductions. Consequently, many of the estimates in Table 4.5 should be treated with caution.

Table 4.5: Estimated casualty crash reductions for sites at which the estimates of effectiveness were significant to the p<0.05 level only

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Description</th>
<th>Est. crash reduction</th>
<th>Stat. sig.</th>
<th>95% conf. limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>42TG 42NU, AI984*</td>
<td>Warning signs, CAMs, guideposts, repair edges, line marking &amp; GIPSITRAC test along Healesville-Koo-Wee-Rup Rd</td>
<td>89.4%</td>
<td>0.03</td>
<td>21.7% 98.6%</td>
</tr>
<tr>
<td>413UPI1</td>
<td>Re-surface and remove hazard/sight obstructions along Montague St, Sth Melb</td>
<td>67.0%</td>
<td>0.02</td>
<td>13.9% 87.4%</td>
</tr>
<tr>
<td>42YFH7</td>
<td>Repair surface, warning signs and CAMs on Mt Dandenong Tourist Rd, Kalorama</td>
<td>59.6%</td>
<td>0.03</td>
<td>8.8% 82.1%</td>
</tr>
<tr>
<td>AI760*</td>
<td>Install CAMs along Heidelberg-Kinglake Rd, Cottles Bridge</td>
<td>-188.2%</td>
<td>0.05</td>
<td>-710.9% -2.4%</td>
</tr>
<tr>
<td>42YFH6</td>
<td>Seal shoulder, surface repair, edgelines, CAMs and signs on Yarra Junction-Noojee Rd</td>
<td>-202.9%</td>
<td>0.04</td>
<td>-787.6% -3.4%</td>
</tr>
</tbody>
</table>

* Long Route Treatment

See Table B.1 of Appendix B for estimated casualty crash reductions for sites at which the estimates of effectiveness were significant to the p<0.02 level only

Table 4.6 shows the estimated effect of treatments on casualty motorcycle crashes at individual treated sites. Again, only sites that were found to have a significant effect on casualty motorcycle crashes to the p<0.05 level have been included in the table, however results significant to the p<0.2 certainty level have been presented in Table B.2 of Appendix B.

Table 4.6: Estimated casualty motorcycle crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Description</th>
<th>Est. crash reduction</th>
<th>Stat. sig.</th>
<th>95% conf. limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI783*</td>
<td>Seal driveways &amp; shoulders along Deans Marsh-Lorne Rd</td>
<td>95.0%</td>
<td>0.048</td>
<td>2.3% 99.7%</td>
</tr>
<tr>
<td>AI978*</td>
<td>Install signs, CAMs, edgelines and guideposts and GIPSITRAC test on Arthurs Seat Rd</td>
<td>-700%</td>
<td>0.023</td>
<td>-4,667.0% -34.0%</td>
</tr>
</tbody>
</table>

* Long Route Treatment

See Table B.2 of Appendix B for estimated casualty motorcycle crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only

It can be seen from Table 4.6 that only two of the 71 distinct sites had a significant (p<0.05) effect on casualty motorcycle crashes. When the significance criterion was relaxed to p<0.2, it was found that seven of the 71 distinct sites were estimated to have had an effect on casualty motorcycle crashes. The only project found to significantly (p<0.05) reduce the number of casualty motorcycle crashes at the treated site was project AI783, which involved sealing shoulders and driveways along Deans Marsh-Lorne Road in the...
Surf Coast Shire. It was estimated that these countermeasures reduced casualty motorcycle crashes by 95.0%, varying from 2.3% to 99.7% with 95% certainty. This treatment also reduced casualty crashes involving all types of vehicles by 86.4%, however this estimate of effectiveness was not significant (p=0.06), varying from a 12.3% increase to a 98.4% reduction with 95% certainty (see Table B.1 in Appendix B).

Project AI978 was estimated to significantly (p=0.02) increase the number of casualty motorcycle crashes along Arthurs Seat Road. When crashes involving all types of vehicles were considered, it was found that the point estimate of the effect of the treatments completed as part of this project was also negative (indicating an increase in crashes at the treated site in the post treatment period). However, the point estimate was not significant (p=0.3) when crashes involving all types of vehicles were considered. Table B.2 of Appendix B also shows that three projects completed along the Northern Grampians Road (AI975, 46DUA02 and 46DUA03), which were considered a single site for the purpose of the analysis, were also estimated to have also increased the number of casualty motorcycle crashes at the treated sites. However the point estimate of the effect on casualty motorcycle crashes for this group of projects was only significant to the p<0.1 level. Again, the general lack of high statistical significance and limited quantities of data on which the estimates of Table 4.6 are based mean the results should be viewed with caution.

It is difficult to speculate why treatment works associated with sites on Northern Grampians Road and Arthurs Seat Road were both estimated to have increased motorcycle crashes occurring at these sites. Both sites were treated using long route treatments and both involved installing edge-lines, warning signs, guideposts and chevron alignment markers (CAMs). Project 4560006 is an example of a project that used similar types of treatments to reduce the number of casualty motorcycle crashes along the treated section of road. Although, the estimated reduction at project 4560006 was not significant (p=0.13).

4.1.3.2 Serious casualty crashes
As described in Section 3.6, due to low crash counts at some of the treated sites, effectiveness at the site-specific level was not estimated for serious casualty motorcycle crashes. Therefore, this section only presents the results of the effect of treatments on serious casualty crashes involving all types of vehicles at individual sites. The three sites at which treatments significantly (p<0.05) affected the number of serious casualty crashes involving all types of vehicles are presented in Table 4.7. Table B.3 of Appendix B lists projects in which it was estimated with 80% certainty that treatments affected serious casualty crashes involving all types of vehicles.

It can be seen from Table 4.7 that the only project estimated to have significantly reduced serious casualty crashes was the treatment of the Mt Dandenong Tourist Road, which was estimated to have resulted in an 80.1% (p=0.04) reduction in serious casualty crashes. Table B.3 of Appendix B shows that while the point estimates of other projects suggested the treatments associated with these projects reduced serious casualty crashes by more than 80%, none of these reductions reached the required level of significance (p<0.05).

Finally, the treatment of some sites was estimated to increase the number of serious casualty crashes. For two projects (414DU2 and AI981), the estimated increases in serious casualty crashes at treated sites was significant at the p<0.05 level. Possible reasons why treatments completed as part of the Motorcycle Blackspot Program were shown to have a negative influence on safety at some sites have been explored in the Discussion section of this report.
Table 4.7: Estimated serious casualty crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Description</th>
<th>Est. crash reduction</th>
<th>Stat. sig.</th>
<th>95% conf. limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>42YFH7</td>
<td>Repair surface, warning signs and CAMs on Mt Dandenong Tourist Rd, Kalorama</td>
<td>80.1%</td>
<td>0.04</td>
<td>5.0% 95.8%</td>
</tr>
<tr>
<td>414DU2</td>
<td>Install 25 drivable concrete end walls at culverts along Whittlesea-Yea Rd,</td>
<td>-275.0%</td>
<td>0.02</td>
<td>-1,075% -19.7%</td>
</tr>
<tr>
<td></td>
<td>Humevale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI981*</td>
<td>Install signs, CAMs, edgelines and guideposts (120) and do GIPSITRAC test</td>
<td>-1,266.7%</td>
<td>0.04</td>
<td>-15,751% -17.8%</td>
</tr>
<tr>
<td></td>
<td>along Gembrook Rd, Gembrook</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Long Route Treatment
See Table B.3 of Appendix B for estimated serious casualty crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only

4.2   ECONOMIC WORTH

The previous section presented evaluations of the Motorcycle Blackspot Program in its entirety as well by different groups of sites where effectiveness was measured in terms of estimated reductions in the numbers of (serious) casualty crashes and (serious) casualty motorcycle crashes. In this section, these estimates of effectiveness have been converted into measures of economic worth. Measures of economic worth presented in this section include cost-effectiveness in preventing different types of crashes, the benefit-to-cost ratio of treatments and the present value of the savings that can be expected from future reductions in crashes at treated sites. All measures of cost and savings presented in this and following sections are in year 2005 Australian dollar values.

The savings that can be expected from the treatments completed as part of the Motorcycle Blackspot Program were derived using the crash reduction results of the previous section and unit crash costs that were derived in Section 2.3. Throughout the results section of this report, the p<0.05 significance level has been used to determine whether results are statistically significant. The following sections provide measures of the economic benefits of all groups of treatments, irrespective of whether these estimates of effectiveness are based on significant estimates of crash reduction. However, for the reader’s benefit economic measures based on non-significant point estimates of crash reduction have been marked with an asterisk. The reader should be wary of drawing conclusions on the benefits of different groups of treatments when measures of economic effectiveness were derived using non-significant estimates of crash reduction.

4.2.1   Treatment costs

As explained in Section 2.1.1, two methodologies for evaluating the economic worth of treatments were employed. In the first methodology, the future costs of maintaining treatments were not included in the cost of the treatments, i.e. only the capital costs of the program were considered as costs associated with the program. In the second methodology, costs associated with treatments included the future differential costs of maintaining treatments as well as the capital costs of the program. Table 4.8 summarises the costs associated with the program as a whole and for different groups of sites for both methodologies.
Since there was uncertainty over the accuracy of data pertaining to the predicted future cost of maintaining treatments, and because such costs are unlikely to be funded within the program’s budget but rather from the maintenance budget of individual VicRoads regions, the economic measures of effectiveness presented in the following sections do not include future maintenance costs in the costs associated with treatments. However, Appendix C contains measures of economic worth where the present value of future maintenance costs was included in the cost of completing treatments.

By providing these two estimates of cost, this evaluation allows the reader to make their own conclusions on the economic benefits of the program based on their assumptions of the level of accuracy of the assumed annual maintenance costs and their view with regard to whether maintenance costs should be considered as costs associated with the program.

The estimates of the effect of treatments completed as part of the Motorcycle Blackspot Program (see Section 4.1) on crash frequencies were based on crash data from 85 of the 101 treated sites meeting the inclusion criteria. Of the excluded sites, there were two sites for which no crashes were recorded in either the before or after periods, meaning there was no potential for crashes to be reduced at these sites. Although these sites were excluded from the crash analysis because there was no potential for a crash reduction, the costs of treating these sites has been included in the economic assessment since program money was expended to treat these sites. As the effect on crash frequencies of treatments at the remaining fourteen treated sites were not considered when estimating the effect of the program, it was decided that the costs associated with these fourteen sites should not be included in the costs of the program when evaluating the effectiveness of the program using economic measures.

Table 2.1 on page 9 shows that the capital cost of completing the 101 treatments was $6,894,901. The aggregated capital cost of completing treatments at the fourteen sites excluded from the analysis was $1,303,506 which means that the aggregated capital cost of completing the remaining 87 treatments was $5,591,395. This was the capital cost value that was used in economic analyses presented in the following sections and included the cost of treating the two sites (project numbers 44UAA5 and BMUAA1) for which no crash data were recorded as occurring in either the before or after treatment period. As noted, the cost of these two projects was included because the fact that there were no crash data at these two sites before and after treatments had been completed indicated that these two treatments had no effect on crashes. By contrast, the effect of treatments at the fourteen excluded sites was unknown, so their costs were not included in the economic evaluation.

Table 4.8 presents the aggregated capital cost of treating the 87 sites included in the economic evaluation, as well as the capital costs disaggregated by location and treatment type. It can be seen that the cost of completing the eight sites on the Great Ocean Road was $526,967, while the cost of completing the sixteen treatments in the Yarra Ranges was $574,888. Completing treatments at the 56 blacklength sites cost nearly $3.6M, compared to $2.0M for the 30 long route treatments.
Table 4.8: Summary of the costs associated with treatments completed as part of the Motorcycle Blackspot Program

<table>
<thead>
<tr>
<th>Capital Costs</th>
<th>Differential Maintenance Cost</th>
<th>Present value of life-time costs with discount rate of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>Whole Program (87 sites)</td>
<td>$5,591,395</td>
<td>$326,382</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td>$4,489,540</td>
<td>$264,362</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td>$526,967</td>
<td>$4,900</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td>$574,888</td>
<td>$57,120</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td>$3,552,086</td>
<td>$77,981</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td>$2,011,208</td>
<td>$248,340</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td>$28,101</td>
<td>$60</td>
</tr>
</tbody>
</table>

Table 4.8 also presents the estimated annual differential cost of maintaining treatments at the 87 sites included in the analysis. It can be seen from this table that it was estimated that $326,382 per year would be required to maintain the 87 treatments. By assuming a particular discount rate, the estimated per annum maintenance cost and the estimated project life of each of the 87 treatments can be used to estimate the present value of all future maintenance costs. These present value maintenance costs were estimated for discount rates of 4%, 6% and 8% and each were added to the capital costs of the treatments to give the present value of the total life time cost of the program for each assumed discount rate. These total life time costs have been presented in the last three columns of Table 4.8 and were calculated for sites disaggregated by location and treatment type as well as for the program as a whole. It can be seen from Table 4.8 that if a discount rate of 4% was assumed, the life time cost of the program was estimated to be $8.8M, however if a discount rate of 8% was assumed, the cost would be approximately $8.1M.

4.2.2 Present value of savings associated with treatments

Using the average casualty crash costs derived in Section 2.3 (Table 2.7) and the estimates of crash reduction estimated in Section 4.1, the present value of savings due to reductions in the frequency of casualty (motorcycle) crashes were derived. These savings represent the present value of all crashes prevented over the life of the projects that formed part of the Motorcycle Blackspot Program. The average project life of the 87 treatments included in the economic evaluation was 12.6 years.

It can be seen from Table 4.9 that a 15.6% reduction in casualty crashes at the 87 treated sites resulted in a present value saving of $84.5M over the life of the program if a discount rate of 4% was assumed. This decreased to a saving of $67.6M if a discount rate of 8% was assumed.
Table 4.9: Summary of the present value of estimated savings due to treatments completed as part of the Motorcycle Blackspot Program

<table>
<thead>
<tr>
<th>Region</th>
<th>Present value of life-time savings with discount rate of</th>
<th>4%</th>
<th>6%</th>
<th>8%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (15.6% reduction, p=0.02)</td>
<td>$84,513,687</td>
<td>$75,280,253</td>
<td>$67,573,742</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (23.9% reduction, p=0.02)</td>
<td>$69,028,644</td>
<td>$61,189,300</td>
<td>$54,699,322</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>81.68%</td>
<td>81.28%</td>
<td>80.95%</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.6% reduction, p=0.09)</td>
<td>$53,583,333*</td>
<td>$47,869,712*</td>
<td>$43,071,734*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (20.0% reduction, p=0.13)</td>
<td>$36,157,676*</td>
<td>$32,122,199*</td>
<td>$28,764,785*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>67.48%</td>
<td>67.10%</td>
<td>66.78%</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (46.0% reduction, p=0.07)</td>
<td>$8,251,673*</td>
<td>$7,481,611*</td>
<td>$6,817,590*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (54.7% reduction, p=0.09)</td>
<td>$8,879,150*</td>
<td>$8,037,976*</td>
<td>$7,314,526*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>107.60%</td>
<td>107.44%</td>
<td>107.29%</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.3% reduction, p=0.33)</td>
<td>$17,273,469*</td>
<td>$15,210,381*</td>
<td>$13,523,280*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (21.4% reduction, p=0.30)</td>
<td>$19,701,203*</td>
<td>$17,322,949*</td>
<td>$15,382,286*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>114.05%</td>
<td>113.89%</td>
<td>113.75%</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (24.4% reduction, p=0.003)</td>
<td>$53,876,658</td>
<td>$48,100,064</td>
<td>$43,261,690</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (40% reduction, p=0.001)</td>
<td>$53,973,486</td>
<td>$48,101,661</td>
<td>$43,195,028</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>100.18%</td>
<td>100.00%</td>
<td>99.85%</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (-1.3% reduction, p=0.91)</td>
<td>-$3,994,175*</td>
<td>-$3,554,661*</td>
<td>-$3,188,242*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (-12.8% reduction, p=0.52)</td>
<td>-$19,544,122*</td>
<td>-$17,257,594*</td>
<td>-$15,376,418*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>489.32%</td>
<td>485.49%</td>
<td>482.29%</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (60.8% reduction, p=0.52)</td>
<td>$2,595,209*</td>
<td>$2,190,297*</td>
<td>$1,874,874*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (51.3% reduction, p=0.64)</td>
<td>$1,420,548*</td>
<td>$1,198,910*</td>
<td>$1,026,256*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>As a proportion of cost for all crashes</td>
<td>54.74%</td>
<td>54.74%</td>
<td>54.74%</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness

The estimated reduction in casualty motorcycle crashes at treated sites was greater than that for casualty crashes involving all types of vehicles (the estimated reduction for casualty motorcycle crashes was 23.9%, compared with 15.6% for all casualty crashes). A 23.9% reduction in the frequency of casualty motorcycle crashes translated into present value savings of $69.0M if a discount rate of 4% was assumed or $54.7M if a discount rate of 8% was assumed.

Although both these estimates of crash reduction for casualty crashes involving all types of vehicles and casualty motorcycle crashes were significant, they were not significantly different from each other, as can be seen by the fact that their confidence intervals overlap (see Table 4.1 on page 30). However, if it was assumed that these point estimates of crash
reduction represented the true effect of the program on casualty crashes and casualty motorcycle crashes respectively, the present value savings due to reductions in motorcycle crashes represented about 81% of the savings due crashes involving all types of vehicles, which was a much greater proportion than estimated for previous blackspot programs. For example Scully, Newstead et al. (2006a), estimated that the present value of savings due to the reduction of casualty motorcycle crashes at sites treated as part of the Accident Blackspot Component of the $240M Statewide Blackspot Program was only 13% of the savings due to the reduction in the number of crashes involving all types of vehicles at these sites. The same report found that for an earlier blackspot program implemented from 1992 to 1996 at a cost of $85M, savings due to reductions in the casualty motorcycle crashes at treated sites were 11% of savings due to reductions in crashes involving all types of vehicles. Possible reasons why savings due to reductions in motorcycle crashes were estimated to represent a much greater proportion of the total savings for the sites treated as part of the Motorcycle Blackspot Program when compared to other blackspot programs have been explored in the discussion section of this report.

As shown in Table 4.1 on page 30, when sites located in the Yarra Ranges or the Great Ocean Road were evaluated separately to sites located in other parts of Victoria, none of the estimates of crash reduction were significant to the p<0.05 criterion. However Table 4.9 shows the present value of the savings that could be expected if the point estimates for each group of sites represented the true effect of the treatments on casualty motorcycle crashes and casualty crashes involving all types of vehicles. For example, in Section 4.1.1.1, it was estimated that the eight treatments along the Great Ocean Road resulted in a 46% decrease in casualty crashes at these sites after the treatments had been completed. Even though this estimate was not significant (p=0.07), if it was assumed a 46% reduction represented the true effect on casualty crashes at these sites, this reduction in casualty crashes over the lives of the projects represented a saving with a present value of $8.3M if a discount rate of 4% was assumed or $6.8M if a discount rate of 8% was assumed.

Table 4.9 also shows the present value savings for sites grouped by the type of treatments completed. Table 4.3 on page 35 showed that of the three types of treated sites, only blacklengths resulted in significant reductions in casualty crashes or casualty motorcycle crashes. Specifically, it was estimated that the 56 blacklength treatments resulted in a 24% (p=0.003) reduction in casualty crashes involving all types of vehicles and a 40% (p=0.001) reduction in casualty motorcycle crashes. A 40% reduction in motorcycle crashes at blacklength sites over the project life of these treatments is equivalent to a life time saving with a present value of $54.0M if a discount rate of 4% was assumed or $43.2M if a discount rate of 8% was assumed. These monetary savings for reductions in casualty motorcycle crashes were almost exactly equal to those expected if the same treatments reduced casualty crashes involving all types of vehicles by 24.4%, i.e. the present value of savings for casualty crashes involving all types of vehicles was $53.9M when a discount rate of 4% was assumed or $43.3M if a discount rate of 8% was assumed.

It may seem counter-intuitive that groups of treatments such as the 56 blacklength sites resulted in almost the same or slightly greater savings due to crashes involving motorcycles than crashes involving all types of vehicles (including motorcycles). To reconcile this it should be noted that the two point estimates of crash reductions used to generate these savings values were derived from separate analyses. Furthermore, there is an element of imprecision in each of these point estimates as can be seen from Table 4.3 where the 40% reduction in casualty motorcycle crashes at blacklength sites could have varied from 18.6% to 56.3% with 95% certainty, while for casualty crashes involving all types of vehicles, these same treatments were estimated to result in reductions of 24.4%,
varying from 9.2% to 37.1 with 95% certainty. Because of the wide confidence limits on the estimates of crash reduction effects in the disaggregated analysis, the economic benefits estimated from these should be treated with some caution, particularly when comparing effects based only on motorcycle crashes to effects on all types of crashes.

4.2.3 Benefit-cost ratio of treatments

The benefits from treatments completed as part of the Motorcycle Blackspot Program have been compared to the costs of implementing these treatments. The benefits of treatments have been defined as the economic savings due to the prevention of casualty crashes at treated sites over the project life of the treatments. These benefits of the program and different groups of treated sites were estimated in Section 4.2.2. The costs of completing treatments were estimated in Section 4.2.1. As explained previously, two methodologies were used to estimate costs: one which included the present value of the costs of maintaining treatments in the future, and one that did not include these future costs. Table 4.10 presents the benefit-cost ratio derived using the methodology where future maintenance costs are not included in the costs of each project. However, analogous benefit-cost ratio estimates where future maintenance costs are included in the costs associated with each project are presented in Table C.1 of Appendix C. It can be seen from Table 4.10 and Table C.1 that the estimated benefit-cost ratio was also dependent on the assumed discount rate.

Table 4.10: Benefit-cost ratio of treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are not included in project costs

<table>
<thead>
<tr>
<th>Benefit-cost ratio</th>
<th>Discount Rate:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (15.6% reduction, p=0.02)</td>
<td>15.1</td>
</tr>
<tr>
<td>- Casualty MC crashes (23.9% reduction, p=0.02)</td>
<td>12.3</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.6% reduction, p=0.09)</td>
<td>11.9*</td>
</tr>
<tr>
<td>- Casualty MC crashes (20.0% reduction, p=0.13)</td>
<td>8.1*</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (46.0% reduction, p=0.07)</td>
<td>15.7*</td>
</tr>
<tr>
<td>- Casualty MC crashes (54.7% reduction, p=0.086)</td>
<td>16.8*</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.3% reduction, p=0.33)</td>
<td>30.0*</td>
</tr>
<tr>
<td>- Casualty MC crashes (21.4% reduction, p=0.30)</td>
<td>34.3*</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (24.4% reduction, p=0.003)</td>
<td>15.2</td>
</tr>
<tr>
<td>- Casualty MC crashes (40.3% reduction, p=0.001)</td>
<td>15.2</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (-1.7% reduction, p=0.91)</td>
<td>-2.0*</td>
</tr>
<tr>
<td>- Casualty MC crashes (-12.8% reduction, p=0.52)</td>
<td>-9.7*</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (60.8% reduction, p=0.52)</td>
<td>92.4*</td>
</tr>
<tr>
<td>- Casualty MC crashes (51.3% reduction, p=0.64)</td>
<td>50.6*</td>
</tr>
</tbody>
</table>

See Table C.1 of Appendix C for BCR estimates where future maintenance costs are included in project costs

* Based on non-significant (p ≥ 0.05) estimates of effectiveness
In Section 4.1.1.1 it was estimated that the program as a whole resulted in a 15.6% reduction in casualty crashes involving all types of vehicles. As explained in the previous section, the present value of such a saving was estimated to be $84.5M if a discount rate of 4% was assumed or $67.6M if a discount rate of 8% was assumed. From Table 4.8 in Section 4.2.1, if future maintenance costs were not included in the cost of completing the entire program, the estimated cost of completing these treatments was $5.6M. Therefore, if future maintenance costs were not included in the cost of completing the program, the estimated reduction in casualty crashes of 15.6% for the entire program would translate into a cost-benefit ratio of 15.1 assuming a discount rate of 4% or 12.1 if a discount rate of 8% was assumed.

Benefit-cost ratios can also be calculated where benefits were defined as savings due to reductions in casualty motorcycle crashes only. Estimating benefit-cost ratios by relating casualty motorcycle crash savings alone to the full cost of treatments completed as part of the Motorcycle Blackspot Program ignores the most of the benefits that the program provides to occupants of vehicles other than motorcycles. However, for completeness, benefit-cost ratios based on savings due to reduction in motorcycle crashes are presented in Table 4.10 (and Table C.1 when future maintenance costs were included in project costs). It can be seen that, for the program as a whole, even when savings due only to reductions in casualty motorcycle crashes were considered, the benefit-cost ratios for the entire program were only marginally less than those estimated when benefits were defined as savings due to reductions in casualty crashes involving all types of vehicles. This should not be interpreted as meaning that the estimated benefits of the Motorcycle Blackspot Program are mostly due to reductions in casualty motorcycle crashes. The two point estimates of crash reduction used to generate the benefit-cost ratio values for casualty crashes involving all vehicles and casualty motorcycle crashes were derived from separate analyses and there is an element of imprecision in each of these point estimates. Therefore, there is also an element of imprecision in each estimate of benefit-cost ratio presented in Table 4.10. The degree to which the actual benefits due to reductions in casualty crashes involving all types of vehicles differ to the actual benefits due to reductions in casualty motorcycle crashes could be greater than that suggested by the BCR estimates presented in Table 4.10.

Table 4.10 also shows benefit-cost ratio estimates for sites grouped by location and treatment type. The table presents benefit-cost ratio estimates based on savings due to reductions in casualty crashes involving all types of vehicles as well as savings due to reductions in casualty motorcycle crashes only. Each estimated benefit-cost ratio was derived from the point estimate of the reduction in casualty crashes at each group of sites, which were derived in Section 4.1. Some of these estimates of crash reduction were not significant, yet benefit-cost ratios have been calculated for each group of treated sites. Therefore, care should be taken when interpreting estimates of benefit-cost ratios that were based on non-significant estimates of crash reduction. The first column of Table 4.10 shows the point estimate of crash reduction and the level of significance of this point estimate for each group of sites analysed.

4.2.4 Cost-effectiveness of treatments

Tables 4.11 and 4.12 present estimates of the cost-effectiveness of the Motorcycle Blackspot Program and groups of sites treated as part of the program. Cost-effectiveness is a measure of the amount of expenditure required to reduce the number of times that a particular event occurs by one unit and is calculated by dividing expenditure by the number of units by which the event has been reduced because of this expenditure. Table 4.11
provides measures of the expenditure required to reduce the number casualty (motorcycle) crashes by one, while Table 4.12 gives measures of the expenditure required to reduce the number of serious casualty (motorcycle) crashes at treated site by one. Each table provides measures of cost-effectiveness where expenditure was defined as the capital cost required to complete treatments. Cost-effectiveness estimates where expenditure was defined as capital costs plus the present value of future maintenance costs are presented in Tables C.2 and C.3 of Appendix C.

Table 4.11: Cost-effectiveness of preventing a casualty crash for treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are not included in project costs

<table>
<thead>
<tr>
<th></th>
<th>Crashes prevented over program life</th>
<th>Cost-effectiveness (casualty crashes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (15.6% reduction, p=0.02)</td>
<td>465</td>
<td>$12,036</td>
</tr>
<tr>
<td>- Casualty MC crashes (23.9% reduction, p=0.02)</td>
<td>296</td>
<td>$18,914</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.6% reduction, p=0.09)</td>
<td>292*</td>
<td>$15,367*</td>
</tr>
<tr>
<td>- Casualty MC crashes (20.0% reduction, p=0.13)</td>
<td>154*</td>
<td>$29,182*</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (46.0% reduction, p=0.07)</td>
<td>43*</td>
<td>$12,157*</td>
</tr>
<tr>
<td>- Casualty MC crashes (54.7% reduction, p=0.086)</td>
<td>36*</td>
<td>$14,623*</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.3% reduction, p=0.33)</td>
<td>98*</td>
<td>$5,874*</td>
</tr>
<tr>
<td>- Casualty MC crashes (21.4% reduction, p=0.30)</td>
<td>86*</td>
<td>$6,668*</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (24.4% reduction, p=0.003)</td>
<td>294</td>
<td>$12,063</td>
</tr>
<tr>
<td>- Casualty MC crashes (40.3% reduction, p=0.001)</td>
<td>228</td>
<td>$15,583</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (-1.3% reduction, p=0.91)</td>
<td>-22*</td>
<td>-$91,411*</td>
</tr>
<tr>
<td>- Casualty MC crashes (-12.8% reduction, p=0.52)</td>
<td>-85*</td>
<td>-$23,793*</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (60.8% reduction, p=0.52)</td>
<td>16*</td>
<td>$1,732*</td>
</tr>
<tr>
<td>- Casualty MC crashes (51.3% reduction, p=0.64)</td>
<td>7*</td>
<td>$4,112*</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness

It can be seen from Table 4.11 that over the life of treatments completed as part of the Motorcycle Blackspot Program, it was estimated that 465 casualty crashes involving all types of vehicles and 296 casualty motorcycle crashes would be prevented. If expenditure was measured in terms of capital costs only, these estimated savings translated to an average expenditure of $12,036 per casualty crash prevented and $18,914 per casualty motorcycle crash prevented. From Table C.2 in Appendix C, if future maintenance costs were included in expenditure estimates, the cost-effectiveness of preventing casualty crashes would increase from $12,036 to between $17,000 and $19,000, depending on the assumed discount rate. Similarly, including future maintenance costs in the expenditure meant the cost-effectiveness of preventing a casualty motorcycle crash increased from $18,914 to between $27,000 and $30,000. All of these results were derived using significant estimates of casualty (motorcycle) crash reduction across the entire program.
Table 4.12 shows the cost-effectiveness of preventing serious casualty (motorcycle) crashes. It can be seen that over the life of the treatments completed as part of the Motorcycle Blackspot Program, it was estimated that 197 serious casualty crashes involving all types of vehicles and 158 serious casualty motorcycle crashes would be prevented. It should be noted that these estimates of the number of crashes prevented were both based on serious crash reduction estimates that were only significant to the p<0.1 criterion. However, if each of these point estimates of crash reduction were assumed to be true, the capital expenditure required to prevent a serious casualty crash involving any type of vehicle would be $28,336, compared with $35,373 for a serious casualty motorcycle crash. Table C.3 in Appendix C shows that if future maintenance costs, discounted to present values, were included in the expenditure, the cost-effectiveness for serious casualty crashes would be between $41,000 and $45,000, depending on the assumed discount rate, while cost-effectiveness for serious casualty motorcycle crashes would be $55,670 if a discount rate of 4% was assumed or $51,306 if a discount rate of 8% was assumed.

Table 4.12: Cost-effectiveness of preventing a serious casualty crash for treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are not included in project costs

<table>
<thead>
<tr>
<th>Treatments Completed</th>
<th>Crashes prevented over program life</th>
<th>Cost-effectiveness (serious casualty crashes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (16.8% reduction, p=0.09)</td>
<td>197*</td>
<td>$28,336*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (24.7% reduction, p=0.097)</td>
<td>158*</td>
<td>$35,373*</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (11.0% reduction, p=0.35)</td>
<td>90*</td>
<td>$49,888*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (25.9% reduction, p=0.16)</td>
<td>101*</td>
<td>$44,384*</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (42.0% reduction, p=0.20)</td>
<td>22*</td>
<td>$24,295*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (47.6% reduction, p=0.24)</td>
<td>20*</td>
<td>$26,577*</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (25.9% reduction, p=0.21)</td>
<td>78*</td>
<td>$7,331*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (8.4% reduction, p=0.79)</td>
<td>17*</td>
<td>$33,058*</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (33.3% reduction, p=0.005)</td>
<td>176</td>
<td>$20,221</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (42.6% reduction, p=0.01)</td>
<td>127</td>
<td>$27,861</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (-14.0% reduction, p=0.41)</td>
<td>-89*</td>
<td>-$22,633*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (-18.0% reduction, p=0.53)</td>
<td>-59*</td>
<td>-$34,185*</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (22.1% reduction, p=0.87)</td>
<td>3*</td>
<td>$9,531*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (34.4% reduction, p=0.79)</td>
<td>5*</td>
<td>$6,131*</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness

Tables 4.11 and 4.12 also give estimates of cost effectiveness for treated sites grouped by location and type of treatment. Some of these estimates of cost-effectiveness were based on non-significant estimates of crash reduction, as can be seen by examining the first column of each table.
5.0 DISCUSSION

5.1 GENERAL DISCUSSION AND INTERPRETATION

The aim of the present evaluation was to determine the crash reduction effect and the economic benefits of the first 91 treatments completed as part of the Motorcycle Blackspot Program implemented in Victoria. The evaluation was comprehensive in that it evaluated the effect of treatments at 87 of the 91 treated sites for which data were available. Data from four sites were excluded from the sample analysed because each of these treated sites overlapped with one of ten sites that were not completed in time for the collection of after treatment crash data. Omitting the four sites from the analysis avoided potential biasing effects of treatment works at the excluded sites. The capital cost of these 87 treatments was $5,591,395, which represented 81% of the total expenditure of the program.

Section 1.1 introduced the four null hypotheses that were tested in the present evaluation. Each of these null hypotheses have been listed below along with a brief discussion about whether they should be accepted or rejected based on the results of the evaluation. However, before reviewing decisions to accept or reject these null hypotheses, it is appropriate to introduce some terminology to aid interpretation of the results.

In the results section of the report, measures of the effectiveness with which treatments reduced the number of crashes at treated sites were referred to as “statistically significant” if there was less than a one in twenty (p<0.05) probability that the estimated treatment crash effect occurred by chance variation in the data when there was no actual underlying treatment effect. As can be seen from the results section, some null hypotheses will not be rejected using this criterion. However, in order assist VicRoads in its task of using the outcomes of the present evaluation to plan future infrastructure improvement programs, different levels of confidence in a decision to reject a null hypothesis have been prescribed.

In this report, the level of confidence with which a null hypothesis was rejected is reflected in the level of significance attained by statistical test used to test the null hypothesis. This way of describing results is similar to that used by the Bureau of Transport Economics in their evaluation of the 1992-1996 Federal Blackspot Program (BTE, 2001).

In the present report, a decision to reject a null hypothesis was said to be based on strong evidence where there was a one in one hundred probability that the estimated treatment effect occurred by chance when there is no real effect (i.e. where p<0.01). The term reasonable evidence was reserved for a decision to reject a null hypothesis where there was a one in twenty chance (i.e. 0.01≤p<0.05). Finally, the term weak evidence was used to describe a decision to reject a null hypothesis where there is a one in ten chance (i.e. 0.05≤p<0.1). On this basis, the following hypotheses tested by the study have been interpreted:

**H1: That the Motorcycle Blackspot Program had no effect on the frequency of casualty crashes involving motorcycles at treated sites**

Table 4.1 on page 30 showed that treatments at the 85 Motorcycle Blackspot sites included in the analysis resulted in reasonable evidence (p=0.02) of a reduction in the number of casualty motorcycle crashes occurring at these sites. Specifically, the number of casualty motorcycle crashes occurring in the post-treatment period at these sites was 23.9% less
than that expected, ranging from a 3.7% reduction to a 39.9% reduction with 95% confidence.

As described in Section 3.6, VicRoads was concerned that speed reduction and enforcement programs operating on the Great Ocean Road and in the Yarra Ranges could have affected the crash counts at treated sites in these areas. Twenty-four of the 85 Motorcycle Blackspot sites used in the analysis were associated with sites either on the Great Ocean Road or in the Yarra Ranges. When the remaining 61 sites were analysed separately to the Great Ocean Road and Yarra Ranges sites, it was found that the point estimate of the motorcycle casualty crash reduction at these sites was less than that previously estimated for all 85 sites (i.e. a 20.0% reduction instead of a 23.9% reduction). Furthermore, the estimated casualty crash reduction for these 61 sites was not statistically significant (p=0.13).

Therefore, when sites for which crash counts may have been contaminated by the effect of local speed reduction and enforcement programs were included in the sample, there was reasonable evidence that the program reduced casualty motorcycle crash counts. However, when these sites were excluded from the sites analysed, the resulting reduction in statistical power meant there was no longer clear evidence that the treatments reduced casualty motorcycle crashes at the remaining sites. Further discussion of whether crash data from the Great Ocean Road and the Yarra Ranges should be used to derive an overall estimate of effectiveness is provided after hypothesis H2 has been addressed, as the issue affects hypotheses H1 and H2.

**H2: That the Motorcycle Blackspot Program had no effect on the frequency of serious casualty crashes involving motorcycles at treated sites**

Table 4.2 on page 32 showed weak evidence that the treatment of the 85 Motorcycle Blackspot reduced serious casualty crashes involving motorcycles by an estimated 24.7%. The estimated 95% confidence limit ranged from a 5.2% increase to a 46.2% reduction.

When sites associated with crashes in either the Yarra Ranges or the Great Ocean Road were analysed separately, it was found that the point estimate of the effect on the number of crashes at the remaining 61 sites was similar to that derived when data from all sites were included. Specifically, when sites associated with the Yarra Ranges or the Great Ocean Road were not included in the data used to evaluate the program, it was estimated that the program reduced serious casualty motorcycle crashes by 25.9%, varying from a 12.2% increase to a 51.0% decrease with 95% certainty. However, excluding the Yarra Ranges and Great Ocean Road sites from the analysis weakened the evidence that the reduction in serious casualty crashes was due to the effect of the treatments and not due to chance variation in the data (i.e. p=0.157).

Therefore, when sites associated with the Yarra Ranges and the Great Ocean Road were included in the sample, there was weak evidence that the program reduced casualty crash counts. However, when these sites were excluded, there was no longer clear evidence that the treatments reduced crashes at the remaining sites due to the reduction in statistical power of the analysis.

If a one-sided significance test was used to test the hypothesis that the program had no effect on the frequency of serious casualty crashes involving motorcycles, the alternative hypothesis would be that the program decreased the frequency of serious casualty crashes involving motorcycles at treated sites. Furthermore, if sites in the Yarra Ranges or on the
Great Ocean Road were included in the evaluation of the program, there would be *reasonable evidence* that the null hypothesis should be rejected in favour of this one-sided alternative hypothesis (under a two-sided test, the evidence was only *weak*). Specifically, Table 4.2 on page 32 showed that the p-value of the two-sided significance test of whether the program affected the number of serious casualty motorcycle crashes at the 85 treated sites was less than 0.1 (p=0.097), meaning that the one-side test would be significant (p=0.048). Similarly, if sites associated with the Yarra Ranges and the Great Ocean Road were excluded from the analysis of the effectiveness of the whole program there would be *weak evidence* that the program reduced serious casualty motorcycle crashes. That is, Table 4.2 shows that the significance of the two-sided test was p=0.157, meaning that the significance of the one-sided test would be p=0.0783.

The decision to employ two-sided tests of significance when testing each of the null hypotheses was made prior to the crash data being prepared for analysis. The main reason why two-sided tests were used was the existence of instances where treatments were expected to deliver benefits in terms of crashes prevented, but when tested using statistically rigorous techniques, were actually estimated to lead to an increase in crashes. Using two-sided tests of significance makes no a-priori assumptions about whether the treatment will decrease or increase crash frequency at the treated site.

Furthermore, all recent evaluations of programs to improve road infrastructure that have been conducted by MUARC have employed two-sided tests. In these previous evaluations strong evidence for the overall effectiveness of programs has been obtained when using two-sided tests. For example, two-sided tests were employed to show that the Accident Blackspot Component of the $240M Statewide Blackspot Program (Scully, Newstead et al., 2006b) resulted in highly significant (p<0.0001) reductions in casualty crashes (a 31% reduction was estimated) and serious casualty crashes (a 35% reduction) at treated sites. Likewise, a two-sided test was employed to conclude that the 1992-1996 TAC-funded Blackspot Program was effective in reducing crashes at treated sites by 26% (p<0.0001). The Bureau of Transport Economics also used two-sided tests of significance in their evaluation of the 1996-2002 Federal Blackspot Program (BTE, 2001). It would be inconsistent to compare the results of the present evaluation with those of previous programs where the criteria to judge effectiveness differed between programs.

For these reasons, it was deemed more appropriate to use a more-conservative two-sided alternative hypothesis when reporting the results of the present evaluation. However, having stated the reasons why a two-sided test was adopted in the present report, if the reader believes it is appropriate to assume that treatments will lead to a reduction in crash frequency, a one-sided alternative hypothesis can be tested by halving the statistical significance values of the two-sided test. Changing from a two-sided alternative hypothesis to a one-sided hypothesis only affects the calculated statistical significance values and does not alter the point estimates of the program effects on crash frequency.

*The effect of treatments on the Great Ocean Road and in the Yarra Ranges on hypotheses H1 and H2*

As demonstrated in the previous discussions concerning hypotheses H1 and H2, when evaluating the effect of the program on motorcycle crashes, there was uncertainty about whether data from sites located in the Yarra Ranges or on the Great Ocean Road should be included when evaluating the program. VicRoads was concerned that enforcement programs undertaken in these regions during the data collection period could have affected after treatment crash counts and, to a lesser extent, before treatment crash counts.
Including data from the Yarra Ranges and the Great Ocean Road did not affect the point estimates of the effect of the program on casualty motorcycle crashes and serious casualty motorcycle crashes; however it did affect significance of these point estimates. For example, when data from the Yarra Ranges and the Great Ocean Road were included in the analysis, the program was estimated to reduce casualty crashes involving a motorcycle by 23.9% with a level of significance of p=0.023. However, when data from the Great Ocean Road and the Yarra Ranges were excluded, the estimated effect of the program decreased to 20.0%, but the level of significance of this estimate was p=0.13. Therefore, including the data from the Great Ocean Road and the Yarra Ranges resulted in reasonable evidence that the program was effective in reducing casualty motorcycle crashes at treated sites, while removing the data resulted in no clear evidence of an effect.

Similarly for serious casualty crashes involving a motorcycle: if data from the Great Ocean Road and the Yarra Ranges were included, the point estimate of the effect of the program was a 24.7% reduction with a significance of p=0.097, while removing the data resulted in a similar point estimate (25.9%) but a reduced level of significance (p=0.157). Therefore, including data from the Great Ocean Road and the Yarra Ranges resulted in weak evidence that the program reduced serious casualty motorcycle crashes, while removing the data meant that there was no clear evidence of an effect.

It is not easy to say to what extent enforcement programs along the Great Ocean Road and in the Yarra Ranges affected crash counts at treated sites in these localities. Whether they increased or decreased traffic flow to and / or crash counts on treated sections of road would depend on a number of factors, including the level of publicity afforded to the enforcement programs, the duration of the enforcement programs and the proximity of the locations where enforcement activities occurred to the roads treated as part of the Motorcycle Blackspot Program. Such data were not available.

The confounding effect of other road safety programs is an issue that must be overcome in all case-control, before-after evaluations of programs to improve the safety of road infrastructure. The methodology employed in the present evaluation adjusted for these potential biases by matching treated sites to similar untreated control sites in the nearby area. Furthermore, pre-treatment and post-treatment crash data were collected over the same time periods at control sites and at treated sites. However, if crash data at a control site were influenced by another road safety program, such as an enforcement program, and the data collected at the treated site were not affected by the enforcement program, the estimated effectiveness at the treated site will be biased by the effects of the enforcement program. However, Bruhning and Ernst’s (1985) technique for estimating aggregate treatment effectiveness across groups of treated sites, enables the Poisson model to adjust for biasing effects so that the estimate of the overall level of effectiveness is not disproportionately affected by a bias that exists at a small number of sites. This feature of the methodology was demonstrated when the inclusion of the data from the Great Ocean Road and the Yarra Ranges did not drastically affect the point estimates of the effect of the program on the number of casualty and serious casualty crashes involving motorcycles. The fact that the point estimates for the effectiveness of the program as a whole did not change very much when data from the Great Ocean Road and Yarra Ranges were included suggested that the technique adequately adjusted for any biasing influences of the enforcement programs in these localities.

Crash data from the twenty-four treated sites in these two localities represents 36% of the crashes occurring at the sites treated by the program. An increase in the quantity of data available for analysis increases the statistical power of the analyses, which in this case has
meant that a greater degree of statistical confidence in the estimated effectiveness of the program could be obtained.

Therefore, for hypothesis H1, it is appropriate to conclude that there was reasonable evidence \( (p<0.05) \) that the Motorcycle Blackspot Program reduced casualty crashes involving a motorcycle at treated sites, while there was weak evidence \( (p<0.1) \) to conclude that the program reduced serious casualty crashes involving a motorcycle at treated sites.

It is possible that there would be strong evidence to reject hypotheses H1 and H2 if more post-treatment crash data were collected. All point estimates of the effect of the program on (serious) casualty motorcycle crashes derived when testing hypotheses H1 and H2 suggested the program reduced the number of crashes at treated sites. If a longer post-treatment period were set aside for collecting data, the power of the statistical tests would be further increased and the opportunities for obtaining significant results robustly indicating a true effect existed would have been greater. In the present evaluation the average length of the after treatment period for the 49 pairs of treatment-control groups was 2.4 years, compared with 2.8 years in the evaluation of the Accident Blackspot Component of the $240M Statewide Blackspot Program (Scully, Newstead et al., 2006b). However, the average number of crashes occurring in the after treatment periods were much lower for the Motorcycle Blackspot Program, where there was an average of 1.8 casualty motorcycle crashes occurring in the after treatment period at each treated site, compared with 4.0 casualty crashes involving all types of vehicles for the Accident Blackspot Component of $240M the Statewide Blackspot Program (Scully, Newstead et al., 2006b). The fact that the Motorcycle Blackspot Program was evaluated on the degree to which it prevented crashes involving motorcycles, and because these crashes occurred less frequently than crashes involving all types of vehicles, meant that longer post-treatment periods would be required to achieve statistical significance than the post-treatment periods used for previous blackspot programs that were evaluated based on reductions involving all types of vehicles.

**H3: That the effect of treatments on the frequency of casualty crashes involving motorcycles at treated sites did not differ for different types of treatments completed at sites**

Table 4.3 on page 35 showed the estimated levels of effectiveness for the three different types of treatments analysed in the present evaluation. There was strong evidence that blacklength treatments reduced casualty crashes involving motorcycles at the 54 blacklength sites included in the analysis. It was estimated that such treatments reduced the casualty motorcycle crashes by 40.3%, ranging from 18.6% to 56.3% with 95% confidence. By comparison, long route treatments did not have a significant effect on casualty motorcycle crashes at the 30 sites where they were applied. Similarly, the treatment of the single site where an intersection treatment was employed did not significantly reduce casualty motorcycle crash counts.

When deciding whether to reject this null hypothesis, it must be decided whether the different types of treatments had significantly different effects on casualty motorcycle crashes from each other. Examining the 95% confidence intervals of the estimated effect of each type of treatment revealed that the confidence intervals for the effect of each treatment overlapped the confidence intervals for the other treatment types. Therefore, if there was evidence that the effects of the different types of treatments differed from each other, the evidence cannot be classified as either strong evidence or reasonable evidence. To test whether there was weak evidence to accept an alternative hypothesis, the 90%
The confidence interval of the point estimate for each of the three treatment categories was calculated.

Table 5.1 shows the 90% confidence intervals of the effect of each of the three types of treatments on the number casualty crashes involving motorcycles. It can be seen that 90% confidence interval of the intersection treatment overlapped the confidence intervals of the other two types of treatments. Therefore, there was not even weak statistical evidence that this type of treatment differed from the other types of treatments. Only one site was treated using an intersection treatment and only four crashes occurred at this site. More data are required before the effectiveness of intersection treatments completed as part of the Motorcycle Blackspot Program can be confidently compared against the two other types of treatments. Furthermore, there is some danger that the single intersection treatment carried out under this program is not necessarily representative of the potential for motorcycle blackspot intersection treatments in general. Hence more intersection treatments would need to be carried out and evaluated before recommendations on the general value of intersection treatments for motorcycle safety could be made.

Table 5.1: Point estimates and 90% confidence intervals of the effect of blacklength, long route and intersection treatments on casualty crashes involving a motorcycle

<table>
<thead>
<tr>
<th>Treatment type</th>
<th>Estimated reduction (%)</th>
<th>Lower 90% confidence limit (%)</th>
<th>Upper 90% confidence limit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection</td>
<td>51.3</td>
<td>-515.3</td>
<td>96.1</td>
</tr>
<tr>
<td>Blacklength</td>
<td>40.3</td>
<td>22.6</td>
<td>54.0</td>
</tr>
<tr>
<td>Long Route</td>
<td>-12.8</td>
<td>-53.5</td>
<td>17.1</td>
</tr>
</tbody>
</table>

It can also be seen from Table 5.1 that the 90% confidence intervals for the blacklength treatments do not overlap with the 90% confidence intervals of the long route treatments. That is, blacklength treatments were estimated to have reduced the casualty motorcycle crashes by 40%, ranging from 23% to 54% with 90% confidence, while long route treatments were estimated to increase such crashes by 13%, ranging from a 17% reduction to a 53% increase with 90% certainty. Therefore, there was weak evidence that the reduction in casualty motorcycle crashes was greater for blacklength treatments than long route treatments.

**H4: That the effect of treatments on the frequency of serious casualty crashes involving motorcycles at treated sites did not differ for different types of treatments works completed at sites**

Table 4.4 on page 36 showed the estimated effects of treatments on serious casualty motorcycle crashes where sites were grouped by the type of treatment completed. It shows that the 54 sites where blacklength treatments were applied resulted in a significant (p=0.014) 42.6% reduction in serious casualty crashes involving a motorcycle, ranging from 10.9% to 63.1% with 95% certainty. It was estimated that the single intersection treatment did not significantly affect serious casualty crashes involving a motorcycle. The same was true of the thirty sites that were classified as long route treatments, where it was estimated that serious casualty motorcycle crashes at these sites increased by 18.0%, ranging from a 97.9% increase to a 29.7% reduction with 95% certainty.
The fact that the 95% confidence intervals for the effect of three types of treatments on serious casualty motorcycle crashes overlapped means that the three point estimates were not significantly (p<0.05) different from each other.

Table 5.2 shows the 90% confidence intervals for the point estimate of each treatment category. It can be seen that the confidence intervals of each treatment type still overlapped the other confidence intervals, meaning that there was not even weak evidence that the different types of treatments differed in their effect on serious casualty crashes involving a motorcycle.

Table 5.2: Point estimates and 90% confidence intervals of the effect of blacklength, long route and intersection treatments on serious casualty crashes involving a motorcycle

<table>
<thead>
<tr>
<th>Treatment type</th>
<th>Estimated reduction (%)</th>
<th>Lower 90% confidence limit (%)</th>
<th>Upper 90% confidence limit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intersection</td>
<td>34.4</td>
<td>-806.5</td>
<td>95.3</td>
</tr>
<tr>
<td>Blacklength</td>
<td>40.3</td>
<td>17.0</td>
<td>60.4</td>
</tr>
<tr>
<td>Long Route</td>
<td>-12.8</td>
<td>-82.2</td>
<td>23.6</td>
</tr>
</tbody>
</table>

One possible reason why the point estimates of effectiveness for long route treatments were less than those estimated for blacklength treatments could be differences between the two types of treatments in the proportion of the site that was modified under each type of treatment. If a greater proportion of road length was modified by treatment works at blacklength sites than for long route sites, the effectiveness (in terms of percent crash reduction) of the long route treatments may be diluted when compared the effectiveness at the blacklengths. This is because if infrastructure improvements are only employed along specific segments of a site, these treatments may have little or no impact on the risk of crashes occurring at untreated sections of the site. However before and after treatment crash data are collected from the entire site and these data are used in the evaluation of the treatments employed at only a small proportion of the road length defining the site. If before and after treatment crash counts were only collected from sections of the road that were actually treated, the resulting estimate of effectiveness would be closer to the true effect of the treatments. However, data on the works completed at treated sites generally did not provide information on what parts of the site were actually treated or what proportion of the treated site were actually modified as part of the works program (see Table A.3 of Appendix A).

5.2 SUCCESSFULLY TREATED SITES

Due to low counts of serious casualty motorcycle crashes at many of the treated sites, the degree of effectiveness that individual sites prevented crashes involving motorcycles was only measured in terms of reductions in casualty motorcycle crashes. There were insufficient data to estimate effectiveness in terms of reductions in serious casualty motorcycle crashes. Table 4.6 on page 37 showed that there was only one site that reduced casualty motorcycle crashes involving a motorcycle to the p<0.05 level of confidence, while Table C.2 of Appendix C showed that there were five treated sites that reduced casualty motorcycle crashes to the p<0.2 level of confidence. The types of treatment works completed at these five sites varied from improvements to the road surface, installing advisory speed signs and warning signs, removal of hazards, improving delineation by
installing Curve Alignment Markers (CAMs) and adding edgelines as well as installing guardrails.

Table B.2 in Appendix B showed that all five sites for which it was estimated that casualty motorcycle crashes were reduced to the p<0.2 confidence level also reduced casualty crashes involving all types of vehicles to the same level of confidence (see Table B.1). This begs the question: do motorcycle blackspot projects that successfully reduce the risk of crashes involving motorcycles also have safety benefits for other road users? Unfortunately there were insufficient crash data available to confidently answer this question. Tables B.1 and B.2 of Appendix B also revealed that not all treatments that reduced casualty crashes involving all types of vehicles to the p<0.2 level of confidence reduced casualty crashes involving motorcycles to the same level of confidence. This was likely due to small quantities of casualty motorcycle crash data at some of these sites. However it does raise the question: what are the characteristics of projects that are effective at reducing casualty crashes in general, but not effective at reducing casualty motorcycle crashes. Again, there were insufficient data to confidently answer this question.

As well as identifying successful treatments, Table B.2 of Appendix B also showed that it was estimated that treatments at some sites were estimated to increase casualty motorcycle crashes. It can be seen that the treatment of three sites on the Northern Grampians Road was estimated to increase casualty motorcycle crashes by 256%, however the significance of this estimate was weak (p=0.092). Similarly, treatment of the Arthur’s Seat Road was estimated to significantly (p<0.05) increase casualty motorcycle crashes by 700%. Many of the countermeasures employed at both these locations were similar to those employed at sites in which it was estimated that treatments reduced crashes. It is possible that such results were due to random variation. When testing 85 sites, it is likely that some will show benefits just due to chance, while others will show poor results due to chance. As a result, all findings regarding the level of effectiveness (or ineffectiveness) of individual sites should be interpreted with caution. However, there is a case for exploring whether the types of treatments implemented at these sites were likely to have attracted additional riders and therefore increased exposure.

5.3 **ECONOMIC EVALUATION**

As well as estimating the effect of treatments on the number of casualty motorcycle crashes and the number of serious casualty motorcycle crashes, the present evaluation also measured the economic benefits of the program. When evaluating the economic benefits of the program and the treatments completed as part of the program, the benefits to all road users, and not just motorcyclists, have been considered.

5.3.1 **Present value of savings and benefit-cost ratios**

In Section 5.1 it was concluded that crash data from sites located on the Great Ocean Road and in the Yarra Ranges should be used when estimating the effect of the program as a whole. It was therefore concluded that there was *reasonable evidence* that the program reduced casualty motorcycle crashes. From Table 4.1 on page 30, the extent of the reduction was estimated to be 24%, ranging from 4% to 40% with 95% certainty. If it was also assumed that data from these sites should also be included when assessing the effect of the program on the number of casualty crashes involving all types of vehicles, it would be concluded that there was also *reasonable evidence* that the program reduced casualty crashes involving all types of vehicles and that the best estimate of the extent of the reduction was a 16% decrease, ranging from 3% to 27% with 95% certainty.
Table 4.9 on page 42 showed that a reduction in casualty crashes involving all types of vehicles of 16% across the 87 treated sites over the life of the program was equivalent to a saving of $84.5M, where future savings were discounted to present value using a discount rate of 4%. A saving of such a magnitude translated to a benefit-cost ratio of 15.1. If future differential maintenance costs were included in the costs associated with the program, the benefit-cost ratio would decrease to 9.6 (see Table C.1 in Appendix C).

If the economic benefits of the Motorcycle Blackspot Program were restricted to the benefits derived from reducing the number of casualty motorcycle crashes and the benefits in terms of preventing all other types of crashes were ignored, the present value of all the savings expected over the life of the program would be $69.0M if a discount rate of 4% was assumed. This estimate was calculated by assuming that the program resulted in a 24% reduction in casualty crashes involving a motorcycle (see Table 4.9 on page 42). As previously mentioned, it was estimated that when the benefits of the program for all road users were considered, the present value of savings over the life of the program was $84.5M. Therefore, the estimated savings due to the prevention of casualty motorcycle crashes accounted for 82% of the savings due to the prevention of all types of crashes. Compared to an evaluation of two previous blackspot programs (Scully, Newstead et al., 2006a), where savings due to prevention of motorcycle crashes accounted for about 13% of savings due to the prevention of all crashes, the 82% estimate for the Motorcycle Blackspot program was very large. This was not because casualty motorcycle crashes were estimated to be more costly in the evaluation of the Motorcycle Blackspot Program. In fact, in the evaluation of the two previous blackspot programs, the average cost of a casualty motorcycle crash occurring at a treated site was assumed to be 46% higher than the average cost of a casualty crash involving all types of vehicles, while in the present evaluation of the Motorcycle Blackspot Program, the cost of casualty motorcycle crashes occurring at treated sites was assumed to be 30% higher than the cost of casualty crashes involving all types of vehicles. Rather, two factors have been identified as causing this disparity in the proportion of total savings that can be attributed to reductions in casualty motorcycle crashes.

Firstly, 40% of casualty crashes that occurred at sites treated as part of the Motorcycle Blackspot Program were casualty crashes involving a motorcycle, compared with 10% of crashes occurring at sites treated by the two blackspot programs evaluated by Scully, Newstead et al. (2006a). Secondly, the point estimate of the effectiveness in preventing casualty motorcycle crashes for treatments completed as part of the Motorcycle Blackspot Program were greater than the point estimate for casualty crashes involving all types of vehicles. This was not the case for the two earlier blackspot programs, where the estimates of effectiveness for motorcycle crashes did not differ from crashes involving all types of vehicles. Therefore, for the Motorcycle Blackspot Program, the economic benefits due to the prevention of casualty motorcycle crashes represented a much greater proportion of the overall economic benefits of the program than that seen for previous blackspot programs because the Motorcycle Blackspot Program targeted high-risk motorcycling locations with treatments specifically designed for motorcycle safety.

5.3.2 Cost-effectiveness

The cost-effectiveness of treatments completed as part of the Motorcycle Blackspot Program was also estimated. Table 4.11 on page 46 showed a 16% reduction in casualty crashes involving all types of vehicles was equivalent to 465 casualty crashes being prevented over the life of the program. Since the capital expenditure of the program was estimated to be $5.6M, the expenditure per casualty crash prevented was approximately
$12,000. If the cost of future maintenance works, discounted to present values using a rate of 4%, were included in the program’s costs, the cost-effectiveness in preventing a casualty crash was estimated to be about $19,000.

Table 4.11 on page 46 also showed that if the Motorcycle Blackspot Program reduced casualty motorcycle crashes by 24% over the life of the 87 treated sites, 296 casualty motorcycle crashes would be prevented. Therefore, the cost-effectiveness of preventing a casualty motorcycle crash would be approximately $19,000 if the present value of future maintenance costs were not included in the program costs or about $30,000 if future maintenance costs were included in the costs of completing the program (assuming a discount rate of 4%).

From Table 4.12 of page 47, a 17% reduction in serious casualty crashes involving all types of vehicles was equivalent to 197 such crashes being prevented over the life of the program. It should be recalled that this estimate of serious casualty crashes prevented was based on an estimated reduction that was only weakly significant (p=0.09). Despite this, if the program did result in a 17% reduction in such crashes, the cost-effectiveness of the program in terms of serious casualty crashes prevented would be about $28,000, which does not include future maintenance costs.

It can also be seen from Table 4.12 that an estimated 25% reduction in serious casualty crashes involving a motorcycle was predicted to result in 158 such crashes being prevented over the life of the program. Again, this estimate of the effect of treatments on serious casualty motorcycle crashes was only weakly significant (p=0.097). If the program did result in a 25% reduction in such crashes, the cost-effectiveness in preventing a serious casualty motorcycle crash would be almost $35,000 if future differential maintenance costs were not included in the program costs or about $56,000 if future differential maintenance costs were included in the program costs (assuming a discount rate of 4%).

Comparison with results from previous blackspot programs

In the evaluation of the effect of previous blackspot programs on motorcycle safety (Scully, Newstead et al., 2006a), cost-effectiveness was measured in terms of the expenditure required to reduce the number of road users seriously injured or killed by one unit. Cost-effectiveness estimates were derived for two previous programs: the Accident Blackspot Component of the $240M Statewide Blackspot program (completed between 2000 and 2004) and the $85M Victorian Blackspot Program which was funded by the Transport Accident Commission (TAC) from 1992 to 1996.

The units of the cost-effectiveness estimates presented in Table 4.12 on page 47 of the present report were different to those used in the evaluation of previous programs by Scully, Newstead et al. (2006a). The present report presented cost-effectiveness estimates in terms of the expenditure required to reduce the number of crashes by one unit, while Scully, Newstead et al. (2006a) presented the expenditure required to reduce the number of injured road users by one unit. Therefore, to compare the cost-effectiveness estimates of the Motorcycle Blackspot Program with the cost-effectiveness estimates derived by Scully, Newstead et al. (2006a), the cost-effectiveness estimates of Table 4.12 were translated so that they were in units that represented the expenditure required to reduce the number of serious casualties by one unit.

It was found that of the 739 serious casualty crashes involving all types of vehicles that occurred in either the before period or the after period of sites treated as part of the
Motorcycle Blackspot Program, 58 road users were killed and 798 were seriously injured. Therefore, it was estimated that on average 1.16 road users were killed or seriously injured per serious casualty crash occurring at a site treated as part of the Motorcycle Blackspot Program. Of the 739 serious casualty crashes, 376 were serious casualty motorcycle crashes. These crashes resulted in 31 road users being killed and 370 being seriously injured. Therefore, it was estimated that on average, 1.07 road users were killed or seriously injured per serious casualty motorcycle crash occurring at a site treated as part of the Motorcycle Blackspot Program.

Dividing the estimates of cost-effectiveness shown in Table 4.12 by 1.16 (for cost-effectiveness estimates of reductions in serious casualty crashes involving all types of vehicles) or 1.07 (for cost-effectiveness estimates of reductions in serious casualty motorcycle crashes) resulted in estimates of cost-effectiveness for the Motorcycle Blackspot Program where the units of measurement were the expenditure required to reduce the number of seriously injured or killed road users by one. Table 5.3 summarises the results of transforming the units of Table 4.12 where future maintenance costs were not included in the program costs. The table also reproduces cost-effectiveness estimates for the two previous programs evaluated by Scully, Newstead et al. (2006a). Analogous results where future maintenance costs were included in the expenditure for each program are shown in Table C.4 of Appendix C.

Table 5.3: Comparison of estimates of the cost-effectiveness of preventing serious casualties† with those of previous programs where future maintenance costs were not included in program costs

<table>
<thead>
<tr>
<th></th>
<th>Est. red.</th>
<th>Sig.</th>
<th>Cost-effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motorcycle Blackspot Program‡</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness ($/Serious Casualties)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vehicles</td>
<td>17%</td>
<td>(p&lt;0.1)</td>
<td>$24,428</td>
</tr>
<tr>
<td>Motorcycle crashes only</td>
<td>25%</td>
<td>(p&lt;0.1)</td>
<td>$33,183</td>
</tr>
<tr>
<td><strong>$240M Blackspot program</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness ($/Serious Casualties)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vehicles</td>
<td>35%</td>
<td>(p&lt;0.0001)</td>
<td>$60,924</td>
</tr>
<tr>
<td>Motorcycle crashes only</td>
<td>36%</td>
<td>(p&lt;0.0001)</td>
<td>$534,841</td>
</tr>
<tr>
<td><strong>$85M Blackspot program</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness ($/Serious Casualties)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vehicles</td>
<td>26%</td>
<td>(p&lt;0.0001)</td>
<td>$33,489</td>
</tr>
<tr>
<td>Motorcycle crashes only</td>
<td>19%</td>
<td>(p&lt;0.1)</td>
<td>$413,112</td>
</tr>
</tbody>
</table>

† A serious casualty is defined as a road user who was seriously injured or killed
‡ Using Motorcycle Blackspot Program costs presented in Section 4.2.1 (AUS$2005)
* Using VicRoads Program crash costs (AUS$2000)

The reader should be aware that some of the cost-effectiveness estimates presented in Table 5.3 were based on non-significant (p ≥ 0.05) estimates of effectiveness. For example, it was estimated that an average of $33,183 was spent as part of the Motorcycle Blackspot Program to reduce by one unit the number of serious casualties due to a crash involving a motorcycle. This estimate of cost-effectiveness was based on the assumption that the Motorcycle Blackspot Program would reduce serious casualty motorcycle crashes at treated sites by 25%. However, as shown in Table 4.1 on page 30, this estimate of effectiveness was only significant to the 10% level. Table 5.3 provides the point-estimate
and level of significance of the estimated crash reduction used to derive each cost-effectiveness estimate.

Under the assumption that each of the point estimates of crash reduction listed in Table 5.3 are accurate, Table 5.3 shows that the expenditure required to prevent a road user being seriously injured or killed in a crash involving any type of vehicle were similar for the Motorcycle Blackspot and the $85M Blackspot programs. The analogous cost-effectiveness estimates for the $240M Blackspot program were higher than the estimates for the other two programs (i.e. the treatments in the latter program were less cost-effective).

Applying the same assumption, but restricting comparisons to crashes involving a motorcycle, the Motorcycle Blackspot Program returned estimates of cost-effectiveness in preventing a road user being seriously injured or killed that were much lower than those of the other two blackspot programs. For example, the average capital expenditure required to reduce by unit the number of road users seriously injured or killed due to involvement in a serious casualty motorcycle crash over the life of the program was estimated to be about $33,000 for the Motorcycle Blackspot Program, compared to nearly $535,000 for the $240M Blackspot program and $413,000 for the $85M Blackspot Program.

Therefore, if the point estimates of crash reduction listed in Table 5.3 are accurate, substantially less money was required to reduce the number of seriously injured or killed road users who were involved in a crash involving a motorcycle under the Motorcycle Blackspot Program than previous programs that did not specifically focus on motorcycle safety. These differences in the estimated cost-effectiveness of the programs resulted from the fact that, as discussed in Section 5.3.1, a greater proportion of crashes at sites treated by the Motorcycle Blackspot Program involved a motorcycle than crashes at sites treated by the other two programs. This result suggests the Motorcycle Blackspot Program was well targeted at sites with high motorcycle crash problem, as would be expected.

When interpreting the results of Table 5.3, the reader should be aware that cost-effectiveness estimates for serious injuries or fatal injuries suffered by roads users injured in crashes involving motorcycles ignore any parallel benefits of the program to road users involved in other types of crashes.

5.4 LIMITATIONS AND POSSIBLE FUTURE RESEARCH

This evaluation of the Motorcycle Blackspot Program used a methodology that employed the best-available statistical techniques that could be used with the data available. In order to employ the methodology, a number of assumptions had to be made. These assumptions have been presented in Appendix D and should be referred to when drawing conclusions based on the results of the evaluation.

After completing the evaluation, a number of limitations were noted. These limitations have also been addressed in Appendix D. However, one particular limitation is discussed in detail below. This limitation concerns the possibility that estimates of effectiveness presented in the results section of this report may be influenced to a small degree by the effect of treatments previously completed by earlier blackspot programs.
5.4.1 Effect of previous blackspot programs on data

When crash data used to evaluate the Motorcycle Blackspot Program were compared to crash data used to evaluate the Accident Blackspot Component of the $240M Statewide Blackspot program (Scully, Newstead et al., 2006b), it was found that 26 of the 71 distinct sites that contributed crash data for the evaluation of the Motorcycle Blackspot Program overlapped sites treated under the earlier program. Of the 49 matched pairs of treated sites and control sites from the evaluation of the Motorcycle Blackspot Program, 36 (73.5%) contained some crashes that were identified as having occurred at a site treated in the previous blackspot program. This means that the results of the present evaluation could be affected by the effects of the previous blackspot program. How the previous blackspot program affected the estimates of effectiveness presented in this report depends on how data from sites treated as part of the previous program were distributed amongst groups of treatments and controls and across before and after periods used in the present evaluation.

Thirty-one of the 49 treatment-control pairs contained control sites that were treated as part of the previous blackspot program. It was not surprising that nearly two-thirds of the treatment-control pairs contained some control sites that were treated as part of the previous blackspot program because data for each control group were sourced from a relatively large area (i.e. a post-code region) and many of the treatments completed as part of the Motorcycle Blackspot Program were in the same regions as treatments completed as part of the Accident Blackspot Component of the $240M Statewide Blackspot program.

In their evaluation of the effect of previous blackspot programs on motorcycle safety, Scully, Newstead et al. (2006a) estimated that the Accident Blackspot Component of the $240M Statewide Blackspot program reduced both casualty crashes and casualty crashes involving motorcycles by about 31%. Therefore, if control sites defined for the present evaluation contained segments of road treated as part of the $240M program, it is likely that the crash counts at these control sites will be lower than expected because of the effect of the previous blackspot program on crash counts. If this is the case, it is likely that the crash counts in the after period of a control site will be affected to a greater extent than crash counts in the before period. This is because most of the treatments completed as part of the previous blackspot program were completed prior to the start of the after treatment periods for sites treated as part of the Motorcycle Blackspot Program. Therefore, for groups of treated sites that were matched to a group of control sites that contained locations treated as part of the previous blackspot program, the crash counts at the control sites will be affected by the previous program for the entire after treatment period. However crash counts at control sites will only be affected for a relatively small part of the before treatment period (i.e. the period between the completion of the treatment at the site treated as part of the previous blackspot program and the date on which treatment works began at the site treated as part of the Motorcycle Blackspot Program).

If the after treatment crash counts at these control sites were substantially affected by treatments completed under previous blackspot programs, this would affect the accuracy of the estimated effect of the Motorcycle Blackspot Program at treated sites. Specifically, the estimates of effectiveness presented in the results section of the present report would underestimate the actual effect at treated sites that were matched to a group of control sites that contained sites treated as part of a previous blackspot program. This could also mean that the overall estimates of effectiveness presented in this report underestimate the true effectiveness of the program.
The extent to which after treatment crash counts at control sites were affected by treatments completed under previous programs was dependent on two factors: the proportion of control sites that were treated by the previous blackspot program; and the magnitude of the effect of the previous blackspot program, estimated at 31%. For most control sites that were found to contain some sites that were treated under the previous blackspot program, sites treated by the previous blackspot program only represented a very small proportion of the locations that contributed control data. For the 31 groups of control sites that contained sites treated as part of the previous blackspot program, only 8% of crashes were identified as occurring at a location treated by the previous program. This suggests that although two-thirds of the 49 groups of control sites contained some sites previously treated, these sites represented only a small percentage of the road network that contributed crash data to the control groups. Assuming that the previous blackspot program reduced crashes by 31%, it can be estimated that the effect of the previous blackspot program would have reduced counts of the numbers of crashes occurring in the after treatment period at the 31 control sites that contained sites treated under the previous program by at most about 4%. There would also have been a smaller reduction in the number of before treatment crash counts at these control sites as treatments completed as part of the previous program would only have been completed after the beginning of the before treatment periods of the Motorcycle Blackspot Programs.

As well as affecting crash counts at control sites, treatments completed in the previous blackspot program can also have an effect on the number of crashes at sites treated as part of the Motorcycle Blackspot Program. As explained below, the fact that some sites treated as part of the Motorcycle Blackspot Program were also treated as part of the Accident Blackspot Component of the $240M Statewide Blackspot program sites will have the opposite effect of control data being contaminated by sites previously treated by an earlier blackspot program: that is the effects of the Motorcycle Blackspot Program might be over-estimated.

At least twenty (40.9%) of the 49 treatment-control pairs contained sites treated as part of the Motorcycle Blackspot Program that were also treated as part of the previous blackspot program. Furthermore, for these twenty groups of treated sites that contained sites treated as part of a previous blackspot program, 19.4% of crashes at these sites were identified as occurring at a location treated by the previous program. This means that where a Motorcycle Blackspot Program site overlapped a site treated as part of the previous blackspot program, a greater proportion of crashes at the treated site occurred at the location on the road network where the overlap occurred than was the case when the overlap involved a control site and a site treated as part of the previous blackspot program. This means that at these treated sites, the previous blackspot program would have had a greater effect on after treatment crash counts than the effect previously estimated for control sites. It is estimated that if the effect of the previous blackspot program on after treatment crash counts at these twenty groups of treated sites were removed, the after treatment crash counts at these sites could increase by up to 22% on average (compared with an average increase of only 4% for control sites). This increase would only occur at sites treated as part of the Motorcycle Blackspot Program that belonged to one of the twenty treatment-control matched pairs where a treated site overlapped a previously treated site. Furthermore, the 22% bias would only be realised in full where the time of treatment under the $240M program was coincident with the time of treatment under the motorcycle blackspot program. Examination of the installation dates for the two programs shows that treatments under the $240M program were generally completed well before (on average 3 years) those under the Motorcycle Blackspot Program. Hence the real level of
contamination at Motorcycle Blackspot Program sites in the after treatment period relative to the before period will be significantly less that the maximum 22%

As removing the effects of the previous blackspot program will increase the net after treatment crash counts at treated sites by some proportion, the estimates of effectiveness derived for treated sites that overlapped sites treated as part of the previous program overestimate the true effect of the Motorcycle Blackspot Program at these sites (which counters the effect of the previous blackspot program on the crash counts at control sites). Since controlling for the effects of the previous blackspot program is likely to increase the after treatment crash counts at treated sites to a greater extent than after treatment crash counts at control sites, it is likely that controlling for the effects of the previous program would have actually decreased estimates of effectiveness both at sites affected by the previous program and to a lesser extent for the program as a whole.

The point estimates of effectiveness presented in the results section of this report represent the combined effect of the Motorcycle Blackspot Program and other treatments previously completed at the Motorcycle Blackspot sites in the six years prior to the initiation of treatment works. However, the effect of the previous blackspot program is likely to be small when compared to the effect of the Motorcycle Blackspot Program because only a small proportion of crashes at treated sites occurred at the point of overlap between the two programs. Furthermore, estimates of effectiveness would only be inflated at 26 of the 71 distinct sites, i.e. those which overlapped sites treated in the previous blackspot program. The Poisson model used to estimate the effectiveness of the Motorcycle Blackspot Program controls for variability within and between matched pairs of treated and control groups, which means that small changes in estimates of effectiveness at 26 of the 71 treatment-control groups should not result in large changes in estimates of the effectiveness for the overall program.

Although controlling for the effects of previous blackspot programs on estimates of effectiveness for the Motorcycle Blackspot Program was beyond the scope of the present report, some basic assumptions could be made about the likely effect of the previous program on after treatment crash data. The effect of altering after treatment crash data in this way decreased the estimates of effectiveness for the overall program, which were presented in Tables 4.1 and 4.2 of the results section, by a maximum of 4 percentage points if treatments were implemented at the same time under both programs. Because treatments under the previous blackspot program were completed much earlier than those under the Motorcycle Blackspot Program, on average 3 years, the actual bias estimated in the current study due to contamination by treatments under previous programs is likely to be well less than 2 percent. It is unlikely that such an effect on the estimates of overall effectiveness would have changed the conclusions reached in Section 5.1.

As described above, some preliminary investigations of the effect of the Accident Blackspot Component of the $240M Statewide Blackspot program on the estimated effectiveness of the Motorcycle Blackspot Program were completed. However, it is possible that sites treated as part of the Motorcycle Blackspot Program also overlapped sites treated in programs other than the Accident Blackspot Component of the $240M Statewide Blackspot Program. Therefore, to properly control for the influence of previous blackspot programs on the results presented in this report, it would be necessary to obtain and analyse data from sites that were treated as part of these other programs and also later treated under the Motorcycle Blackspot Program. It was beyond the scope of this report to complete such analyses. However, this would be an interesting subject for further research as the literature shows that the previous decade has seen considerable infrastructure
improvement throughout Victoria. Until now, the effects of different programs have only been measured separately. If the data from previous evaluations are still available, a methodology could be developed to separate the effects of different infrastructure improvement programs that were completed in the same locality in different time periods.

5.4.2 An alternative approach to evaluating different types of treatments when treated sites overlap

Section 2.2.2.1 described how ten of the eighteen long route treatments overlapped (either partially or fully) segments of road treated as blacklengths. In order to use Poisson regression to evaluate the effectiveness of different types of treatments, it is necessary that when a crash occurs at a treated site, it only contributes to the before or after treatment crash count of one treatment category. It was therefore necessary to decide whether crashes at sites where two different treatments overlapped should be added to the crash counts for blacklengths or long route treatments. Several approaches could have been adopted.

One option would be to analyse all eighteen long route treatments, but exclude crash data from sections of road that were also treated using blacklength treatments. This would mean that crash data from sections of road treated as both blacklengths and long route treatments would not contribute to the estimates of crash reduction at the sites being analysed. This would mean that the before and after treatment crash counts at sites treated as long route treatments would probably be reduced and so the statistical power of the analysis of the effectiveness of long route treatments would also be slightly reduced. However, the resulting estimate of effect would better reflect the effectiveness of long route treatments than the method adopted in the current report, as the observed crash counts would not have been contaminated by the effect of the blacklength treatments. This begs the question, if this approach was adopted, how would the estimates of the effectiveness for long route treatments change?

From Table 5.1, there was weak evidence (p<0.1) to suggest that blacklength treatments were more effective than long route treatments. Therefore, removing the contaminating effect of the blacklength treatments from the data used to evaluate long route treatments would be unlikely to increase the power of analyses of the effectiveness for long route treatments. Therefore, excluding crash data from segments of road where overlap with blacklength treatments occurred would not have changed the conclusions regarding long route treatments that were presented in Section 5.1. Using this alternative methodology also has a disadvantage in that valid economic analysis would not be possible since the proportion of implementation costs of long route treatments on the uncontaminated sections would be almost impossible to estimate.

Another alternative would be to derive estimates of effectiveness of long route treatments only using data from the ten long route treatments that were not contaminated by blacklength sites. With this approach, it would be possible to derive economic measures of effectiveness such as benefit-cost ratio as all the costs associated with a site would either be included or not included, depending on whether crash data from the site were included in the analysis sample. However, the estimates of crash effects would be based on significantly less data, so it is unlikely that the crash reduction estimates would be robust in terms of being statistically significant, particularly noting that the non-significant results derived using the methodology described in Section 2.2.2.1, in which crash data from all eighteen long route treatments were used.
As explained in Section 2.2.2.1, neither of the above options was used to evaluate long route treatments. Instead, the eight long route treatments that overlapped blacklength treatments were redefined as eight separate treatments, each of which included data from the road segments that were also treated as blacklengths. For each of the eight treatments, the cost of the treatment was assumed to be equal to the cost of completing the long route treatment plus the cost of completing the blacklength treatments that were either partially or fully contained within the long route treatment. The before and after treatment periods for each of the eight sites were defined using the commencement and completion dates of the treatment works for both the long route treatment and the blacklength treatments that occurred at the site. This enabled economic analyses of long route treatments to be completed and also increased the statistical power of the analyses. However, the resulting estimate of effectiveness did not purely represent the effect of long route treatments on crash numbers. This is because data at the eighteen long route sites that were analysed would potentially have been affected by the effects of the blacklength treatments completed at road lengths that overlapped eight of the eighteen long route treatments.

As previously explained, because there was weak evidence (p<0.1) that blacklength treatments were more effective at reducing casualty motorcycle crashes than long route treatments, it is likely that the estimates of effectiveness for long route treatments that were estimated in Section 4.1.2 actually over-estimated the effectiveness of long route treatments. As long route treatments were not found to significantly reduce casualty motorcycle crashes or serious casualty motorcycle crashes (see Tables 4.3 and 4.4 respectively), it is very unlikely that removing the contaminating influence of the blacklength treatments would result in it being estimated that long route treatments significantly reduced (serious) casualty crashes involving a motorcycle. For the same reasons, it is unlikely that removing the influence of the overlapping blacklength treatments would result in reductions in crashes involving all types of vehicles.

Nevertheless, VicRoads has suggested that future evaluations of programs to improve road network infrastructure should strongly consider using one of the two alternative approaches when two different types of treatments overlap each other. Which of the two alternative options is most suitable would probably depend on the extent to which the different treatments overlap each other. If the extent of the overlap is minimal, data from sections of road where the overlap occurs can perhaps simply be excluded from the analysis of the effectiveness of different treatment types.

If there is substantial overlap between the different types of treatments, it might be a good idea to define the treatments at sites where the overlap occurs as a new type of treatment category, e.g. a “mixed” category, with the uncontaminated sections of road keeping their original treatment classification (i.e. “long route” in the case of the Motorcycle Blackspot Program). The before and after treatment works at these mixed sites would be defined using treatment commencement and completion dates of both sets of treatments (e.g. blacklength and long route). As these mixed categories will be adjacent to the long route categories, it may be necessary to consider the commencement and completion dates of all treatments on the contaminated sections of road when determining the before and after treatment periods for the non-contaminated sections. This approach will give a purer estimate of effect for each treatment type but with reduced statistical power while the estimate of effect at the contaminated site will measure the effect where both types of treatments have been applied at the one site. The extent to which the power of the analysis is reduced will depend on extent of the overlap between the two different types of treatments and possibly the difference in the commencement and completion dates for the two groups of treatments. As explained earlier, using this approach will complicate
economic evaluation of long route treatments as it will not be possible to determine by what proportion of the cost of the long route project cost should be reduced as a result of excluding data from contaminated sections of road. One option would be to assume that the costs of the projects are unchanged. Another option would be to assume the cost of the project is reduced by the same proportion of the road length excluded from the analysis. Both of these costing methodologies will increase the degree of uncertainty of the resulting economic evaluations of the different types of treatments.
6. CONCLUSIONS

Evaluation of the crash effects of the Motorcycle Blackspot Program has shown implementation of the program was associated with a reduction in casualty motorcycle crashes of 24%, varying from 4% to 40% with 95% certainty. There was also some evidence to suggest that program implementation was associated with reduced serious casualty motorcycle crashes, however the estimated reduction of 16% was not statistically significant (p=0.097), varying from a 5% increase to a 33% reduction with 95% certainty. A greater time period of post-treatment crash data than available for this evaluation is required to provide robust estimates of the effect of the program on serious casualty motorcycle crashes.

The Motorcycle Blackspot Program was also associated with a statistically significant reduction in casualty crashes involving all types of vehicles of 16%, varying from a 3% reduction to a 27% reduction with 95% certainty. A reduction of a similar magnitude (17%) was estimated for serious casualty crashes involving all types of vehicles. However this reduction was not significant (p=0.088), varying from a 3% increase to a 33% reduction with 95% certainty.

There was an indication that reductions in crashes involving motorcycles associated with the program were greater than those involving all types of vehicles. However, for both casualty crashes and serious casualty crashes, the comparison between the effect of the program on crashes involving motorcycles and crashes involving all types of vehicles was not statistically significantly.

Over the 87 treated sites included in the analysis, based on the estimated percentage crash reductions the annual absolute savings in casualty motorcycle crashes was 24, translating to a saving over the life of the program of 296. For casualty crashes involving all vehicle types, it was estimated that the Motorcycle Blackspot Program was associated with an annual reduction of 40 crashes, translating to 465 crashes over the life of the program.

Benefit to cost ratio estimates showed the program to be highly cost-effective with a BCR of 15.1. This reduced to 9.6 when differential maintenance costs were included. In terms of cost effectiveness it was estimated that the program required $12,036 capital expenditure to reduce one casualty crash when all vehicle types were considered and $18,914 when only motorcycles were considered.

Estimates of program effectiveness by treatment type were less certain because of limited quantities of post-treatment crash data at this level of program disaggregation. There was some indication that the blacklength treatments under the program were most effective although further after treatment crash history or evaluation of additional future treatments would be necessary to confirm this.

Evaluation of the effectiveness of specific sites was generally uninformative at this stage due to limited crash data quantities at each site limiting analysis power.

Overall, the Motorcycle Blackspot Program appears to have been well targeted with treated sites showing a high proportion of motorcycle crashes and treatments implemented being most effective in reducing motorcycle involved crashes.
7. REFERENCES


**APPENDIX A – TREATMENT DATA PROVIDED BY VICROADS**

This Appendix displays data provided by VicRoads for each of the 101 treated sites. Table A.1 displays data related to the location of each site. Individual sites that overlapped with other sites, requiring them to be analysed as one distinct site have been placed in adjacent shaded rows for the reader’s convenience. The dates on which treatment works were started and completed have been presented in Table A.2 on page 75 along with data on the cost of completing each treatment and the expected life of each treatment. Table A.3 on page 79 describes the type of work completed at each site.

Table A.1: Treatment data provided by VicRoads (variables related to the location of treated sites only)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Region</th>
<th>Municipality</th>
<th>Road Name, Locality</th>
<th>Location (chainage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1BBF1</td>
<td>E</td>
<td>Baw Baw</td>
<td>Yarra Junction-Noojee Road, Piedmont</td>
<td>Limberlost Rd to Main Neerim Rd (29987-38057m)</td>
</tr>
<tr>
<td>2 1BDU1</td>
<td>E</td>
<td>Baw Baw</td>
<td>Nayook - Powelltown Road</td>
<td>Between Nayook And Powelltown, 0-6622m</td>
</tr>
<tr>
<td>3 413UDJ1</td>
<td>MNW</td>
<td>Darebin</td>
<td>Plenty Road (Whittlesea Rd.), Preston</td>
<td>Tyler St to Ethel Gr (1706-2049m)</td>
</tr>
<tr>
<td>4 413UNI1</td>
<td>MNW</td>
<td>Nillumbik</td>
<td>Heidelberg-Kinglake Road, St Andrews</td>
<td>Church Rd to St Andrews Rd (17047 - 22555m)</td>
</tr>
<tr>
<td>5 413UNI3</td>
<td>MNW</td>
<td>Nillumbik</td>
<td>Heidelberg-Kinglake Rd, Hurstbridge</td>
<td>Anzac Cl to Gosfield Rd (14319-15703m)</td>
</tr>
<tr>
<td>6 413UPI1</td>
<td>MNW</td>
<td>Port Phillip/Melb.</td>
<td>Montague St, South Melbourne</td>
<td>West Gate Freeway (0-220m)</td>
</tr>
<tr>
<td>7 414DU2</td>
<td>MNW</td>
<td>Whittlesea</td>
<td>Whittlesea-Yea Rd, Humevale</td>
<td>Jacks Creek Road to Mobile Mission Maintenance Centre (5100 to 9000m)</td>
</tr>
<tr>
<td>8 414DU3</td>
<td>MNW</td>
<td>Nillumbik</td>
<td>Kangaroo Ground-Warrandyte Rd, Kangaroo Ground</td>
<td>Yeomans Rd to 1.1km north of Yeomans Rd (4100-5200m)</td>
</tr>
<tr>
<td>9 414UMZ1</td>
<td>MNW</td>
<td>Moonee Valley</td>
<td>Maribyrnong Rd (Ascot Vale-Keilor Rd), Moonee Ponds</td>
<td>Ferguson St to Ascot Vale Rd (270-1261m)</td>
</tr>
<tr>
<td>10 414UPI1</td>
<td>MNW</td>
<td>Port Phillip</td>
<td>Aughie Drive, Albert Park</td>
<td>Albert Rd to Lakeside Dve (0-2300m)</td>
</tr>
<tr>
<td>11 415DU1</td>
<td>MNW</td>
<td>Docklands</td>
<td>Docklands Highway, Docklands</td>
<td>Footscray Road to Dudley Street - Wurundjeri Way (9795-10010m)</td>
</tr>
<tr>
<td>12 415DU2</td>
<td>MNW</td>
<td>Nillumbik</td>
<td>Heidelberg-Kinglake Road, St. Andrews</td>
<td>Ninks Road and Nillumbik Shire boundary (28971-33600m)</td>
</tr>
<tr>
<td>13 413UNI2</td>
<td>MNW</td>
<td>Nillumbik</td>
<td>Heidelberg-Kinglake Road, St Andrews, Mittons Bridge &amp; Kinglake</td>
<td>From Nihill Cr to Region Border (24017-34593m)</td>
</tr>
<tr>
<td>14 415DU3</td>
<td>MNW</td>
<td>Docklands</td>
<td>Docklands Highway (Charles Grimes Bridge), Docklands</td>
<td>Charles Grimes Bridge West of Stadium Drive to north of Lorimer Street (11800-12100m)</td>
</tr>
<tr>
<td>15 42CVB8</td>
<td>MSE</td>
<td>Cardinia</td>
<td>Black Snake Creek Rd, Gembrook</td>
<td>Beenak East Rd to Rocky Ridge Track (0 - 2100m)</td>
</tr>
<tr>
<td>16 42NA</td>
<td>MSE</td>
<td>Cardinia</td>
<td>Beaconsfield-Emerald Rd, Beaconsfield Upper</td>
<td>Stoney Ck Rd to St Georges Rd (6236-9488m)</td>
</tr>
<tr>
<td>17 42NS</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Mount Dandenong Tourist Rd, Sassafras</td>
<td>Mason Gv to Bellavista Cr (7870-9761m)</td>
</tr>
</tbody>
</table>
Table A.1 (continued): Treatment data provided by VicRoads (variables related to the location of treated sites only)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Region</th>
<th>Municipality</th>
<th>Road Name, Locality</th>
<th>Location (chainage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>42TG</td>
<td>MSE</td>
<td>Cardinia Pakenham Road (Healesville-Koo-Wee-Rup Rd)</td>
<td>McBride Sreet to Taylor Road (35332-38510m)</td>
</tr>
<tr>
<td>19</td>
<td>42NU</td>
<td>MSE</td>
<td>Cardinia Healesville-Koo-Wee-Rup Road, Cockatoo</td>
<td>Avon Rd to Mountain Rd (31800 - 33700m)</td>
</tr>
<tr>
<td>20</td>
<td>AI984</td>
<td>MSE</td>
<td>Cardinia Shire Healesville-Koo-Wee-Rup Road, Pakenham Upper</td>
<td>Taylor Road to Princes Highway East (38510 - 52960m)</td>
</tr>
<tr>
<td>21</td>
<td>42YFH5</td>
<td>MSE</td>
<td>Yarra Ranges Mt Dandenong Tourist Rd, Tremont</td>
<td>Jainesleigh Rd to Acacia Track (191-882m)</td>
</tr>
<tr>
<td>22</td>
<td>42YFH6</td>
<td>MSE</td>
<td>Yarra Ranges Yarra Junction-Noojee Rd, Gilderoy</td>
<td>Malletgem Lane to McConachys Rd (11781-15641m)</td>
</tr>
<tr>
<td>23</td>
<td>42YFH7</td>
<td>MSE</td>
<td>Yarra Ranges Mt Dandenong Tourist Rd, Kalorama</td>
<td>Inverness Road to Browns Rd (17780-20200m)</td>
</tr>
<tr>
<td>24</td>
<td>42YFH8</td>
<td>MSE</td>
<td>Yarra Ranges Mt Dandenong Tourist Rd, Ferny Creek</td>
<td>Kallamondah Rd to Belgrave-Ferny Ck Rd (501-5002m)</td>
</tr>
<tr>
<td>25</td>
<td>42YFH9</td>
<td>MSE</td>
<td>Yarra Ranges Emerald-Monbulk Rd, Monbulk</td>
<td>Moxhams Rd to Fairy Dell Rd (5910-8830m)</td>
</tr>
<tr>
<td>26</td>
<td>42YFJ2</td>
<td>MSE</td>
<td>Yarra Ranges / Knox Mountain Hwy (Wanitirna Sassafras Rd), Ferny Creek</td>
<td>Claremont Av to Old Coach Road (12302-16214m)</td>
</tr>
<tr>
<td>27</td>
<td>42YFJ3</td>
<td>MSE</td>
<td>Yarra Ranges Belgrave-Gembrook Rd, Menzies Creek</td>
<td>Grantulla Rd to Church Rd (5408-6774m)</td>
</tr>
<tr>
<td>28</td>
<td>42YFJ4</td>
<td>MSE</td>
<td>Yarra Ranges Yarra Junction-Noojee Road, Powelltown</td>
<td>Mackleys Creek Rd to Baw Baw Shire Boundary (17786-20467m)</td>
</tr>
<tr>
<td>29</td>
<td>43BF2</td>
<td>E</td>
<td>Yarra Ranges Mount Baw Baw Rd, Noojee</td>
<td>Old Fumina Rd to Vesper Rd (6596-11500m)</td>
</tr>
<tr>
<td>30</td>
<td>43DU2</td>
<td>E</td>
<td>Bass Coast Bunurong Road, Inverloch</td>
<td>Seaward Drive to Ullathorrome Drive (8144-18934km)</td>
</tr>
<tr>
<td>31</td>
<td>44UAA1</td>
<td>NE</td>
<td>Murrindindi Lake Mountain Rd, Cambarville/Marysville</td>
<td>900-4100m</td>
</tr>
<tr>
<td>32</td>
<td>44UAA2</td>
<td>NE</td>
<td>Murrindindi Marysville Rd, Marysville</td>
<td>At Anderson's Mill Road (5000-5314m)</td>
</tr>
<tr>
<td>33</td>
<td>44UAA4</td>
<td>NE</td>
<td>Murrindindi Maroondah Hwy, Mt Dom Dom/Narbethong</td>
<td>61440-68096m</td>
</tr>
<tr>
<td>34</td>
<td>4560006</td>
<td>N</td>
<td>Macedon Cameron Drive Rd, Mt Macedon</td>
<td>Full Length (0-3615m)</td>
</tr>
<tr>
<td>35</td>
<td>4760239A</td>
<td>SW</td>
<td>Surf Coast Great Ocean Road, Mt Defiance</td>
<td>Mt Defiance Lookout (54500-54700m)</td>
</tr>
<tr>
<td>36</td>
<td>4760232A</td>
<td>SW</td>
<td>Colac Otway Great Ocean Road, Mt Defiance</td>
<td>52500-55500m</td>
</tr>
<tr>
<td>37</td>
<td>4760242A</td>
<td>SW</td>
<td>Surf Coast Great Ocean Road, Smythes Creek</td>
<td>Smythes Creek Bridge (78964-79164m)</td>
</tr>
<tr>
<td>38</td>
<td>4760243A</td>
<td>SW</td>
<td>Surf Coast Great Ocean Road, Moggs Creek</td>
<td>Old Coach Rd (29439-31923m)</td>
</tr>
<tr>
<td>39</td>
<td>4760244A</td>
<td>SW</td>
<td>Surf Coast Great Ocean Road</td>
<td>Andersons Ck to Herschell Rd (35063-38557m)</td>
</tr>
<tr>
<td>40</td>
<td>4760245A</td>
<td>SW</td>
<td>Colac-Otway Great Ocean Road</td>
<td>West of Grey River including Shrapnel Gully (70719-71715m)</td>
</tr>
<tr>
<td>41</td>
<td>AH874</td>
<td>E</td>
<td>East Gippsland Great Alpine Road, Omeo</td>
<td>Hankshaw Hill Road and Jim and Jack Track (172297-189888m)</td>
</tr>
<tr>
<td>42</td>
<td>AH883</td>
<td>E</td>
<td>Baw Baw Lang Lang-Pooewong Road, Lang Lang to Poowong</td>
<td>South Gippsland Highway to Poowong (0 - 11755m)</td>
</tr>
<tr>
<td>43</td>
<td>AH894</td>
<td>SW</td>
<td>Golden Plains Meredith-Steiglitz Road, Coopers Bridge</td>
<td>Pioneer Ridge Road to Duggan Road (3560-5807m)</td>
</tr>
</tbody>
</table>
Table A.1 (continued): Treatment data provided by VicRoads (variables related to the location of treated sites only)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Region</th>
<th>Municipality</th>
<th>Road Name, Locality</th>
<th>Location (chainage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>44 AH895</td>
<td>SW</td>
<td>Colac-Otway</td>
<td>Great Ocean Road, Maits Rest</td>
<td>Parker Ridge Road to east of Cape Otway Road (103006-107500m)</td>
</tr>
<tr>
<td>45 AH900</td>
<td>SW</td>
<td>Colac-Otway</td>
<td>Great Ocean Road, Johanna Heights</td>
<td>West of Red Johanna Road (128089-137500m)</td>
</tr>
<tr>
<td>46 AI675</td>
<td>E</td>
<td>Sth Gippsland/Baw</td>
<td>Korumburra-Warragul Road</td>
<td>Korumburra to Warragul (0 - 39517m)</td>
</tr>
<tr>
<td>47 1BDU2</td>
<td>E</td>
<td>Baw Baw</td>
<td>Korumburra-Warragul Rd, South of Warragul</td>
<td>Lardners Track to the Grand Ridge Road (19000-28600m)</td>
</tr>
<tr>
<td>48 SYBF1</td>
<td>E</td>
<td>Baw Baw/Sth Gippsland</td>
<td>Korumburra-Warragul Rd, Strzelecki</td>
<td>Ross Witherdons Rd to McDonalds Track (15399-20349m)</td>
</tr>
<tr>
<td>49 AI678</td>
<td>E</td>
<td>LaTrobe and Baw Baw</td>
<td>Tyers-Thomson Valley Road, Tyers to Thomson Valley</td>
<td>Moe-Glengarry Road to Thomson Valley Road (0-40020m)</td>
</tr>
<tr>
<td>50 AI692</td>
<td>E</td>
<td>Baw Baw</td>
<td>Walhalla Road</td>
<td>Tyers-Thomson Valley Rd to North Gardens Reserve (0-12000m)</td>
</tr>
<tr>
<td>51 43DU1</td>
<td>E</td>
<td>Baw Baw</td>
<td>Walhalla Road, Walhalla</td>
<td>Micahs Track to Maiden Town Track (200-9200m)</td>
</tr>
<tr>
<td>52 AI712</td>
<td>NE</td>
<td>Alpine Shire</td>
<td>Great Alpine Road, Harrietville</td>
<td>Commences 6.3 km south of Cemetry Lane (104.2 to 107.1km)</td>
</tr>
<tr>
<td>53 AI718</td>
<td>NE</td>
<td>Alpine Shire</td>
<td>Mount Buffalo Road, Mount Buffalo</td>
<td>Commences 16.98 km south west of roundabout exit (16.98-20.08km)</td>
</tr>
<tr>
<td>54 AI719</td>
<td>NE</td>
<td>Alpine Shire</td>
<td>Bright-Tawonga Rd, Germantown/Tawonga Sth Great Alpine Road and Kiewa Valley Highway</td>
<td>Great Alpine Road and Kiewa Valley Highway (20200-20780m)</td>
</tr>
<tr>
<td>55 AI721</td>
<td>NE</td>
<td>Alpine Shire</td>
<td>Bogong High Plains Road, Bogong</td>
<td>Commences 13.2 km south west of Simmonds Creek Road (13.21 to 16.2km)</td>
</tr>
<tr>
<td>56 AI745</td>
<td>MSE</td>
<td>Frankston</td>
<td>Seaford Road and Ti-Tree Crescent, Seafor</td>
<td>2800-2950m</td>
</tr>
<tr>
<td>57 AI760</td>
<td>MNW</td>
<td>Nillumbik</td>
<td>Heidelberg-Kinglake Road, Cottles Bridge</td>
<td>Between Yan Yeans Road and Lower Road (5197 - 11385m)</td>
</tr>
<tr>
<td>58 AI783</td>
<td>SW</td>
<td>Surf Coast Shire</td>
<td>Deans Marsh-Lorne Rd, Deans Marsh to Lorne</td>
<td>Birregurra-Deans Marsh Road and Great Ocean Road (0 - 22541m)</td>
</tr>
<tr>
<td>59 AI920</td>
<td>MSE</td>
<td>Mornington Peninsula</td>
<td>Rosebud-Flinders Road, Rosebud, Flinders</td>
<td>Pt. Nepean Road and Frankston-Flinders Road (0 - 21962m)</td>
</tr>
<tr>
<td>60 42NV</td>
<td>MSE</td>
<td>Mornington Peninsula</td>
<td>Rosebud-Flinders Road, Flinders</td>
<td>Main Ck Walking Tk to Meakins Rd (14321-15890m)</td>
</tr>
<tr>
<td>61 AI957</td>
<td>NE</td>
<td>Mitchell Shire and Murrindindi Shire</td>
<td>Broadford-Flowerdale Road, Broadford and Flowerdale</td>
<td>Broadford and Whittlesea -Yea Road (2190 to 30453m)</td>
</tr>
<tr>
<td>62 AI963</td>
<td>NE</td>
<td>Murrindindi and Yarra Ranges Shires</td>
<td>Healesville-Kinglake Road, Healesville, Toolangi and Kinglake</td>
<td>Maroonahway Highway and Heidelberg-Kinglake Road (0 - 32500m)</td>
</tr>
<tr>
<td>63 42TH</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Healesville-Kinglake Road, Chum Creek</td>
<td>Eleva Road to Heath Road (1608-7498m)</td>
</tr>
<tr>
<td>64 M4UAA3</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Healesville-Kinglake Rd, Toolangi</td>
<td>Old Toolangi Rd to 2km south of Myers Creek Rd (14600-20217m)</td>
</tr>
<tr>
<td>65 AI967</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Warburton-Woods Point Road, East Warburton</td>
<td>Warburton Highway to Marysville-Woods Point Road (0-40497m)</td>
</tr>
<tr>
<td>66 AI969</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Marysville-Woods Point Road, Saint Fillans</td>
<td>Marysville Road and Warburton-Woods Point Road (0 - 18920m)</td>
</tr>
<tr>
<td>67 44UAA5M</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Marysville-Woods Point Rd, Marysville</td>
<td>Marysville to Lake Mountain Rd (1019-10370m)</td>
</tr>
<tr>
<td>68 AI973</td>
<td>MSE</td>
<td>Manningham</td>
<td>Ringwood-Warrandyte Road, Warrandyte</td>
<td>Mullum Mullum Road to Warrandyte (0 - 10020m)</td>
</tr>
</tbody>
</table>
Table A.1 (continued): Treatment data provided by VicRoads (variables related to the location of treated sites only)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Region</th>
<th>Municipality</th>
<th>Road Name, Locality</th>
<th>Location (chainage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69 AI975</td>
<td>W</td>
<td>Northern Grampians Shire and Horsham Rural City</td>
<td>Northern Grampians Rd, Halls Gap, Wartook, Western Highway</td>
<td>Grampians Road and Western Highway (0 - 40000m)</td>
</tr>
<tr>
<td>70 46DUA02</td>
<td>W</td>
<td>Northern Grampians</td>
<td>Northern Grampians Rd, West of Halls Gap</td>
<td>0.5km west of Halls Gap to Silverbands Rd (500-5002m)</td>
</tr>
<tr>
<td>71 46DUA03</td>
<td>W</td>
<td>Northern Grampians</td>
<td>Northern Grampians Rd, Halls Gap</td>
<td>Mt. Difficult Rd to 800 metres beyond Wartook Rd (10000-18000m)</td>
</tr>
<tr>
<td>72 AI978</td>
<td>MSE</td>
<td>Mornington Peninsula</td>
<td>Arthurs Seat Road, Arthurs Seat</td>
<td>Pt. Nepean Road and Mornington-Flinders Road (0 - 8930m)</td>
</tr>
<tr>
<td>73 AI979</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Old Warburton Road, Warburton</td>
<td>Westburn to Warburton (0 - 7353m)</td>
</tr>
<tr>
<td>74 AI981</td>
<td>MSE</td>
<td>Cardinia</td>
<td>Gembrook Road, Gembrook</td>
<td>Healesville-KooWee Rup Rd to Belgrave-Gembrook Rd (0-8650m)</td>
</tr>
<tr>
<td>75 M4UAA1</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Eildon - Jamieson Rd, Torbreck Station</td>
<td>0-29900m</td>
</tr>
<tr>
<td>76 M4UAA2</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Extons Rd, Kinglake Central</td>
<td>Healesville-Kinglake Rd - Powers Rd (1628-3192m)</td>
</tr>
<tr>
<td>77 M4UAA4</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Whittlesea-Yea Rd, Kinglake West</td>
<td>Kinglake West to Nichols Rd (13600-16750m)</td>
</tr>
<tr>
<td>78 M4UAA5</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Snobs Creek Road, Eildon</td>
<td>Goulburn Valley Highway to Herbs Road (13403 - 20381m)</td>
</tr>
<tr>
<td>79 M4UAA6</td>
<td>NE</td>
<td>Murrindindi</td>
<td>Heidelberg-Kinglake Road, Kinglake</td>
<td>Pinchut Lane to Healesville-Kinglake Road (34300-35618m)</td>
</tr>
<tr>
<td>80 MDUAA2</td>
<td>NE</td>
<td>Mansfield</td>
<td>Mansfield-Woods Point Rd, Jamieson</td>
<td>Jamieson River Bridge to Kevington (33543-42200m)</td>
</tr>
<tr>
<td>81 MXDUA01</td>
<td>W</td>
<td>Moorabool</td>
<td>Myrning - Trentham Rd, West of Blackwood</td>
<td>South of Simons Reef Rd (16000-17500m)</td>
</tr>
<tr>
<td>82 SWUAA1</td>
<td>NE</td>
<td>Strathbogie</td>
<td>Euroa - Mansfield Rd, Gooram</td>
<td>Ch 22km - 25Km (22000-25000m)</td>
</tr>
<tr>
<td>83 THUAA1</td>
<td>NE</td>
<td>Towong</td>
<td>Murray River Road, Granya</td>
<td>Murray Valley Hwy to Granya (0-14000m)</td>
</tr>
<tr>
<td>84 WUDU1</td>
<td>E</td>
<td>Wellington</td>
<td>Licola Road, Glenmaggie</td>
<td>Chesterfield Rd to Kellehers Rd (15958-23329m)</td>
</tr>
<tr>
<td>85 AH869</td>
<td>E</td>
<td>Wellington</td>
<td>Licola Road, Heyfield to Licola</td>
<td>Heyfield to Licola (0 - 52800m)</td>
</tr>
<tr>
<td>86 44UAA5</td>
<td>NE</td>
<td>Towong Shire</td>
<td>Murray Valley Hwy, Towong</td>
<td>1.5 km west of Upper Murray Rd to 2.1km west of Upper Murray Road (3419-4255m)</td>
</tr>
<tr>
<td>87 BMUAA1</td>
<td>NE</td>
<td>Benalla</td>
<td>Lima East Rd, Lima East/Swanpool</td>
<td>12km - 14km</td>
</tr>
<tr>
<td>88 AJ627*</td>
<td>E</td>
<td>Baw Baw Shire</td>
<td>Forest Road, Labertouche</td>
<td>Labertouche Road to end of Shire (0-4800m)</td>
</tr>
<tr>
<td>89 AJ694*</td>
<td>SW</td>
<td>Golden Plains</td>
<td>Meredith-Steiglitz Road, East of Meredith</td>
<td>Duggan Road, Pioneer Ridge Road (3560-5807m)</td>
</tr>
<tr>
<td>90 AK571*</td>
<td>NE</td>
<td>Alpine Shire</td>
<td>Great Alpine Road, Harrietville/Mt Hotham</td>
<td>Harrietvilloe regional boundary (107.1-159.7km)</td>
</tr>
<tr>
<td>91 AI717†</td>
<td>NE</td>
<td>Alpine Shire</td>
<td>Great Alpine Road, Hotham Heights</td>
<td>Starts 0.95 km south of Dargo High Plains Rd (121.9-131.7km)</td>
</tr>
<tr>
<td>92 AH880*</td>
<td>E</td>
<td>East Gippsland</td>
<td>Omeo Hwy, North of Omeo to Glen Valley</td>
<td>11 km north of Omeo to Glen Valley (11000-44000m)</td>
</tr>
<tr>
<td>93 AI1988*</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Donna Buang Road including Acheron Way southern sealed section, Warburton</td>
<td>Maroondah Hwy to Warburton</td>
</tr>
</tbody>
</table>

* Ineligible: completed after April 2007 † Ineligible: overlapped a site completed after April 2007
<table>
<thead>
<tr>
<th>Project #</th>
<th>Region</th>
<th>Municipality</th>
<th>Road Name, Locality</th>
<th>Location (chainage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>94</td>
<td>NE</td>
<td>Mansfield / Wangaratta</td>
<td>Mansfield-Whitfield Rd, Tolmie/Whitfield</td>
<td>Table Top Rd &amp; Wangaratta Whitfield Rd (11.7-59.4km)</td>
</tr>
<tr>
<td>95</td>
<td>NE</td>
<td>Wangaratta</td>
<td>Mansfield-Whitfield Rd, Toombullup/ Whitlands</td>
<td>37000-40000m</td>
</tr>
<tr>
<td>96</td>
<td>NE</td>
<td>Mansfield</td>
<td>Mansfield-Whitfield Rd, Bridge Ck/Tolmie</td>
<td>20400-23600m</td>
</tr>
<tr>
<td>97</td>
<td>MSE</td>
<td>Mornington Peninsula</td>
<td>Mornington-Flinders Road, Flinders</td>
<td>Bittern-Dromana Rd to Rosebud-Flinders Rd</td>
</tr>
<tr>
<td>98</td>
<td>SW</td>
<td>Colac Otway Shire</td>
<td>Forrest-Apollo Bay Road, Forrest to Haines Junction</td>
<td>Colac-Forrest Road to Beech-Forest Road</td>
</tr>
<tr>
<td>99</td>
<td>E</td>
<td>East Gippsland Shire</td>
<td>Great Alpine Road, Omeo to Bruthren</td>
<td>Hankshaw Hill Road to Bruthen-Nowa Nowa Road (Ch. 190.10 to 281.98)</td>
</tr>
<tr>
<td>100</td>
<td>MNW</td>
<td>Nillumbik/Yarra Ranges</td>
<td>Eltham-Yarra Glen Rd, Kangaroo Ground/Christmas Hill/Yarra Glen</td>
<td>Melba Hwy to Research-Warrandyte Rd</td>
</tr>
<tr>
<td>101</td>
<td>MSE</td>
<td>Yarra Ranges</td>
<td>Eltham-Yarra Glen Rd, Yarra Glen</td>
<td>Mt Wise Rd to Skyline Rd North (1497-3581m)</td>
</tr>
</tbody>
</table>

* Ineligible: completed after April 2007  † Ineligible: overlapped a site completed after April 2007
### Table A.2: Treatment data provided by VicRoads (variables related to cost, project life and the dates on which treatment works were started and finished)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Date Started</th>
<th>Date Finished</th>
<th>Predicted Capital Cost</th>
<th>Actual Capital Cost</th>
<th>Differential Maintenance Cost</th>
<th>Project Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BBF1</td>
<td>3/05/2004</td>
<td>21/06/2004</td>
<td>$53,000</td>
<td>$52,937</td>
<td>$965</td>
<td>15</td>
</tr>
<tr>
<td>2 BDU1</td>
<td>15/05/2004</td>
<td>16/06/2004</td>
<td>$52,000</td>
<td>$52,670</td>
<td>$8,657</td>
<td>15</td>
</tr>
<tr>
<td>3 413UDJ1</td>
<td>18/11/2003</td>
<td>4/12/2003</td>
<td>$13,000</td>
<td>$13,046</td>
<td>$247</td>
<td>10</td>
</tr>
<tr>
<td>4 413UNI1</td>
<td>5/04/2004</td>
<td>18/06/2004</td>
<td>$55,000</td>
<td>$52,011</td>
<td>$2,754</td>
<td>10</td>
</tr>
<tr>
<td>5 413UNI3</td>
<td>5/04/2004</td>
<td>18/06/2004</td>
<td>$69,000</td>
<td>$64,493</td>
<td>$6,924</td>
<td>10</td>
</tr>
<tr>
<td>6 413UPI1</td>
<td>24/07/2003</td>
<td>3/10/2003</td>
<td>$45,000</td>
<td>$26,469</td>
<td>$100</td>
<td>5</td>
</tr>
<tr>
<td>7 414DU2</td>
<td>30/03/2004</td>
<td>15/06/2004</td>
<td>$52,000</td>
<td>$46,413</td>
<td>$5,098</td>
<td>15</td>
</tr>
<tr>
<td>8 414DU3</td>
<td>1/04/2004</td>
<td>30/12/2004</td>
<td>$359,000</td>
<td>$318,272</td>
<td>$1,438</td>
<td>20</td>
</tr>
<tr>
<td>9 414UMZ1</td>
<td>23/03/2004</td>
<td>25/03/2004</td>
<td>$6,000</td>
<td>$4,055</td>
<td>$496</td>
<td>10</td>
</tr>
<tr>
<td>10 414UP1</td>
<td>8/08/2005</td>
<td>22/05/2006</td>
<td>$240,000</td>
<td>$334,708</td>
<td>$1,650</td>
<td>10</td>
</tr>
<tr>
<td>11 415DU1</td>
<td>30/11/2004</td>
<td>23/12/2004</td>
<td>$72,000</td>
<td>$37,600</td>
<td>$281</td>
<td>10</td>
</tr>
<tr>
<td>12 415DU2</td>
<td>15/03/2005</td>
<td>24/06/2005</td>
<td>$330,000</td>
<td>$267,235</td>
<td>$210</td>
<td>10</td>
</tr>
<tr>
<td>13 413UNI2</td>
<td>5/04/2004</td>
<td>18/06/2004</td>
<td>$105,000</td>
<td>$102,616</td>
<td>$5,288</td>
<td>10</td>
</tr>
<tr>
<td>14 415DU3</td>
<td>15/02/2006</td>
<td>28/06/2006</td>
<td>$362,000</td>
<td>$201,848</td>
<td>$1,200</td>
<td>15</td>
</tr>
<tr>
<td>15 42CVB8</td>
<td>17/05/2004</td>
<td>28/05/2004</td>
<td>$20,000</td>
<td>$18,316</td>
<td>$1,000</td>
<td>10</td>
</tr>
<tr>
<td>16 42NA</td>
<td>1/07/2003</td>
<td>18/02/2004</td>
<td>$97,000</td>
<td>$53,693</td>
<td>$210</td>
<td>10</td>
</tr>
<tr>
<td>17 42NS</td>
<td>3/05/2004</td>
<td>1/09/2004</td>
<td>$68,000</td>
<td>$44,554</td>
<td>$230</td>
<td>10</td>
</tr>
<tr>
<td>18 42TG</td>
<td>1/12/2004</td>
<td>30/04/2005</td>
<td>$75,000</td>
<td>$75,149</td>
<td>$3,200</td>
<td>10</td>
</tr>
<tr>
<td>19 42NU</td>
<td>4/05/2004</td>
<td>28/05/2004</td>
<td>$36,000</td>
<td>$8,936</td>
<td>$2,400</td>
<td>10</td>
</tr>
<tr>
<td>20 AI984</td>
<td>20/01/2007</td>
<td>28/02/2007</td>
<td>$180,000</td>
<td>$85,388</td>
<td>$7,250</td>
<td>10</td>
</tr>
<tr>
<td>21 42YFH5</td>
<td>8/08/2003</td>
<td>31/07/2004</td>
<td>$26,000</td>
<td>$27,982</td>
<td>$300</td>
<td>10</td>
</tr>
<tr>
<td>22 42YFH6</td>
<td>1/04/2004</td>
<td>30/06/2004</td>
<td>$63,000</td>
<td>$23,638</td>
<td>$1,300</td>
<td>10</td>
</tr>
<tr>
<td>23 42YFH7</td>
<td>8/08/2003</td>
<td>30/06/2004</td>
<td>$18,000</td>
<td>$18,225</td>
<td>$600</td>
<td>10</td>
</tr>
<tr>
<td>24 42YFH8</td>
<td>8/08/2003</td>
<td>26/04/2004</td>
<td>$13,000</td>
<td>$3,657</td>
<td>$100</td>
<td>10</td>
</tr>
<tr>
<td>25 42YFH9</td>
<td>1/09/2003</td>
<td>22/03/2004</td>
<td>$51,000</td>
<td>$21,323</td>
<td>$3,380</td>
<td>10</td>
</tr>
<tr>
<td>26 42YFJ2</td>
<td>1/05/2004</td>
<td>1/09/2004</td>
<td>$96,000</td>
<td>$55,003</td>
<td>$2,850</td>
<td>10</td>
</tr>
<tr>
<td>27 42YFJ3</td>
<td>1/06/2004</td>
<td>31/07/2004</td>
<td>$36,000</td>
<td>$35,628</td>
<td>$500</td>
<td>10</td>
</tr>
<tr>
<td>28 42YFJ4</td>
<td>15/02/2004</td>
<td>30/06/2004</td>
<td>$38,000</td>
<td>$27,843</td>
<td>$5,720</td>
<td>10</td>
</tr>
</tbody>
</table>

Costs and project life values in red italic print were estimated using the methodology described in Section 2.1.1
<table>
<thead>
<tr>
<th>Project #</th>
<th>Date Started</th>
<th>Date Finished</th>
<th>Predicted Capital Cost</th>
<th>Actual Capital Cost</th>
<th>Differential Maintenance Cost</th>
<th>Project Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>1/12/2003</td>
<td>15/12/2003</td>
<td>$14,000</td>
<td>$14,490</td>
<td>$1,000</td>
<td>15</td>
</tr>
<tr>
<td>30</td>
<td>10/02/2004</td>
<td>14/02/2004</td>
<td>$64,000</td>
<td>$68,185</td>
<td>$14,027</td>
<td>15</td>
</tr>
<tr>
<td>31</td>
<td>12/05/2004</td>
<td>23/06/2004</td>
<td>$25,000</td>
<td>$25,913</td>
<td>$0</td>
<td>15</td>
</tr>
<tr>
<td>32</td>
<td>12/05/2003</td>
<td>30/05/2004</td>
<td>$50,000</td>
<td>$50,005</td>
<td>$100</td>
<td>20</td>
</tr>
<tr>
<td>33</td>
<td>02/02/2004</td>
<td>31/03/2004</td>
<td>$71,000</td>
<td>$71,096</td>
<td>$300</td>
<td>20</td>
</tr>
<tr>
<td>34</td>
<td>10/06/2004</td>
<td>30/06/2004</td>
<td>$28,000</td>
<td>$28,137</td>
<td>$2,750</td>
<td>5</td>
</tr>
<tr>
<td>35</td>
<td>10/12/2003</td>
<td>23/12/2003</td>
<td>$20,000</td>
<td>$12,663</td>
<td>$200</td>
<td>10</td>
</tr>
<tr>
<td>36</td>
<td>10/12/2003</td>
<td>14/12/2003</td>
<td>$8,000</td>
<td>$7,823</td>
<td>$200</td>
<td>10</td>
</tr>
<tr>
<td>37</td>
<td>01/06/2004</td>
<td>30/06/2004</td>
<td>$90,000</td>
<td>$72,357</td>
<td>$500</td>
<td>10</td>
</tr>
<tr>
<td>38</td>
<td>01/06/2004</td>
<td>01/08/2004</td>
<td>$10,000</td>
<td>$2,191</td>
<td>$0</td>
<td>5</td>
</tr>
<tr>
<td>39</td>
<td>01/06/2004</td>
<td>30/06/2004</td>
<td>$52,000</td>
<td>$53,551</td>
<td>$1,000</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>01/06/2004</td>
<td>30/06/2004</td>
<td>$180,000</td>
<td>$184,274</td>
<td>$1,000</td>
<td>10</td>
</tr>
<tr>
<td>41</td>
<td>20/02/2006</td>
<td>23/06/2006</td>
<td>$135,000</td>
<td>$135,153</td>
<td>$1,471</td>
<td>15</td>
</tr>
<tr>
<td>42</td>
<td>18/04/2006</td>
<td>26/04/2006</td>
<td>$47,940</td>
<td>$31,760</td>
<td>$5,878</td>
<td>15</td>
</tr>
<tr>
<td>43</td>
<td>03/04/2006</td>
<td>30/04/2006</td>
<td>$20,000</td>
<td>$19,982</td>
<td>$500</td>
<td>5</td>
</tr>
<tr>
<td>44</td>
<td>07/12/2005</td>
<td>08/12/2005</td>
<td>$123,000</td>
<td>$119,116</td>
<td>$1,000</td>
<td>10</td>
</tr>
<tr>
<td>45</td>
<td>05/12/2005</td>
<td>06/12/2005</td>
<td>$75,000</td>
<td>$74,992</td>
<td>$1,000</td>
<td>10</td>
</tr>
<tr>
<td>46</td>
<td>26/04/2006</td>
<td>01/05/2006</td>
<td>$193,800</td>
<td>$113,463</td>
<td>$80,727</td>
<td>15</td>
</tr>
<tr>
<td>47</td>
<td>11/04/2005</td>
<td>23/06/2006</td>
<td>$145,000</td>
<td>$107,403</td>
<td>$34,600</td>
<td>15</td>
</tr>
<tr>
<td>48</td>
<td>12/04/2006</td>
<td>30/12/2006</td>
<td>$32,000</td>
<td>$24,543</td>
<td>$7,457</td>
<td>15</td>
</tr>
<tr>
<td>49</td>
<td>01/06/2006</td>
<td>16/06/2006</td>
<td>$112,200</td>
<td>$95,694</td>
<td>$16,506</td>
<td>15</td>
</tr>
<tr>
<td>50</td>
<td>17/05/2006</td>
<td>29/05/2006</td>
<td>$25,500</td>
<td>$14,263</td>
<td>$11,237</td>
<td>15</td>
</tr>
<tr>
<td>51</td>
<td>10/02/2006</td>
<td>04/06/2004</td>
<td>$58,000</td>
<td>$69,318</td>
<td>$13,318</td>
<td>15</td>
</tr>
<tr>
<td>52</td>
<td>01/02/2006</td>
<td>30/04/2006</td>
<td>$38,000</td>
<td>$17,759</td>
<td>$20,241</td>
<td>15</td>
</tr>
<tr>
<td>53</td>
<td>02/02/2006</td>
<td>28/02/2006</td>
<td>$9,000</td>
<td>$1,730</td>
<td>$7,270</td>
<td>15</td>
</tr>
<tr>
<td>54</td>
<td>01/02/2006</td>
<td>30/11/2006</td>
<td>$26,000</td>
<td>$26,000</td>
<td>$10</td>
<td>2</td>
</tr>
<tr>
<td>55</td>
<td>01/02/2006</td>
<td>21/06/2006</td>
<td>$140,000</td>
<td>$102,729</td>
<td>$37,271</td>
<td>20</td>
</tr>
<tr>
<td>56</td>
<td>05/02/2006</td>
<td>20/02/2006</td>
<td>$131,000</td>
<td>$28,101</td>
<td>$103,100</td>
<td>20</td>
</tr>
</tbody>
</table>

Costs and project life values in red italic print were estimated using the methodology described in Section 2.1.1
Table A.2 (continued): Treatment data provided by VicRoads (variables related to cost, project life and the dates on which treatment works were started and finished)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Date Started</th>
<th>Date Finished</th>
<th>Predicted Capital Cost</th>
<th>Actual Capital Cost</th>
<th>Differential Maintenance Cost</th>
<th>Project Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>57 A1760</td>
<td>16/03/2006</td>
<td>17/03/2006</td>
<td>$27,540</td>
<td>$23,083</td>
<td>$500</td>
<td>10</td>
</tr>
<tr>
<td>58 A1783</td>
<td>10/03/2006</td>
<td>30/06/2006</td>
<td>$173,502</td>
<td>$169,894</td>
<td>$2,000</td>
<td>10</td>
</tr>
<tr>
<td>59 A1920</td>
<td>5/02/2006</td>
<td>30/06/2006</td>
<td>$153,000</td>
<td>$113,173</td>
<td>$20,805</td>
<td>10</td>
</tr>
<tr>
<td>60 42NV</td>
<td>11/03/2004</td>
<td>19/03/2004</td>
<td>$66,000</td>
<td>$66,637</td>
<td>$120</td>
<td>10</td>
</tr>
<tr>
<td>61 A1957</td>
<td>1/04/2006</td>
<td>21/06/2006</td>
<td>$84,660</td>
<td>$28,272</td>
<td>$100</td>
<td>15</td>
</tr>
<tr>
<td>62 A1963</td>
<td>1/04/2006</td>
<td>30/04/2006</td>
<td>$33,660</td>
<td>$19,280</td>
<td>$100</td>
<td>20</td>
</tr>
<tr>
<td>63 42TH</td>
<td>1/03/2005</td>
<td>30/05/2005</td>
<td>$117,000</td>
<td>$118,249</td>
<td>$7,700</td>
<td>10</td>
</tr>
<tr>
<td>64 M4UAA3</td>
<td>1/06/2004</td>
<td>18/06/2004</td>
<td>$8,000</td>
<td>$8,048</td>
<td>$100</td>
<td>15</td>
</tr>
<tr>
<td>65 A1967</td>
<td>17/04/2006</td>
<td>13/06/2006</td>
<td>$88,740</td>
<td>$58,247</td>
<td>$21,000</td>
<td>10</td>
</tr>
<tr>
<td>66 A1969</td>
<td>17/04/2006</td>
<td>2/06/2006</td>
<td>$76,500</td>
<td>$37,587</td>
<td>$28,950</td>
<td>10</td>
</tr>
<tr>
<td>67 44UAA5M</td>
<td>1/02/2004</td>
<td>30/04/2004</td>
<td>$42,000</td>
<td>$42,710</td>
<td>$710</td>
<td>20</td>
</tr>
<tr>
<td>68 A1973</td>
<td>10/04/2006</td>
<td>30/06/2006</td>
<td>$82,620</td>
<td>$84,647</td>
<td>$2,025</td>
<td>10</td>
</tr>
<tr>
<td>69 A1975</td>
<td>15/04/2006</td>
<td>30/06/2006</td>
<td>$35,037</td>
<td>$34,459</td>
<td>$81,000</td>
<td>5</td>
</tr>
<tr>
<td>70 46DUA02</td>
<td>1/07/2004</td>
<td>23/12/2004</td>
<td>$140,000</td>
<td>$127,999</td>
<td>$2,000</td>
<td>5</td>
</tr>
<tr>
<td>71 46DUA03</td>
<td>20/03/2006</td>
<td>30/06/2006</td>
<td>$80,000</td>
<td>$139,309</td>
<td>$50,000</td>
<td>5</td>
</tr>
<tr>
<td>72 A1978</td>
<td>1/03/2006</td>
<td>30/06/2006</td>
<td>$91,800</td>
<td>$30,368</td>
<td>$61,432</td>
<td>10</td>
</tr>
<tr>
<td>73 A1979</td>
<td>1/03/2006</td>
<td>30/06/2006</td>
<td>$91,800</td>
<td>$32,914</td>
<td>$58,886</td>
<td>10</td>
</tr>
<tr>
<td>74 A1981</td>
<td>17/02/2006</td>
<td>30/06/2006</td>
<td>$96,900</td>
<td>$65,604</td>
<td>$31,316</td>
<td>10</td>
</tr>
<tr>
<td>75 M4UAA1</td>
<td>1/06/2004</td>
<td>30/06/2004</td>
<td>$60,000</td>
<td>$60,125</td>
<td>$125</td>
<td>15</td>
</tr>
<tr>
<td>76 M4UAA2</td>
<td>1/06/2004</td>
<td>18/06/2004</td>
<td>$5,000</td>
<td>$5,017</td>
<td>$0</td>
<td>15</td>
</tr>
<tr>
<td>77 M4UAA4</td>
<td>1/06/2004</td>
<td>18/06/2004</td>
<td>$5,000</td>
<td>$5,017</td>
<td>$0</td>
<td>5</td>
</tr>
<tr>
<td>78 M4UAA5</td>
<td>16/06/2005</td>
<td>30/06/2005</td>
<td>$27,000</td>
<td>$27,749</td>
<td>$749</td>
<td>15</td>
</tr>
<tr>
<td>79 M4UAA6</td>
<td>4/04/2005</td>
<td>21/06/2005</td>
<td>$150,000</td>
<td>$160,556</td>
<td>$10,556</td>
<td>15</td>
</tr>
<tr>
<td>80 MDUAA2</td>
<td>1/06/2004</td>
<td>28/06/2004</td>
<td>$19,000</td>
<td>$17,743</td>
<td>$1,257</td>
<td>15</td>
</tr>
<tr>
<td>81 MXDUA01</td>
<td>22/03/2004</td>
<td>16/04/2004</td>
<td>$138,000</td>
<td>$103,931</td>
<td>$3,069</td>
<td>20</td>
</tr>
<tr>
<td>82 SWUAA1</td>
<td>16/02/2004</td>
<td>15/03/2004</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$300</td>
<td>20</td>
</tr>
<tr>
<td>83 THUAA1</td>
<td>4/10/2004</td>
<td>20/04/2005</td>
<td>$48,000</td>
<td>$58,738</td>
<td>$10,000</td>
<td>15</td>
</tr>
</tbody>
</table>

Costs and project life values in red italic print were estimated using the methodology described in Section 2.1.1
Table A.2 (continued): Treatment data provided by VicRoads (variables related to cost, project life and the dates on which treatment works were started and finished)

<table>
<thead>
<tr>
<th>Project #</th>
<th>Date Started</th>
<th>Date Finished</th>
<th>Predicted Capital Cost</th>
<th>Actual Capital Cost</th>
<th>Differential Maintenance Cost</th>
<th>Project Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>84 WUDU1</td>
<td>10/02/2004</td>
<td>21/06/2004</td>
<td>$52,000</td>
<td>$52,964</td>
<td>$3,686</td>
<td>15</td>
</tr>
<tr>
<td>85 AH869</td>
<td>15/05/2006</td>
<td>1/06/2006</td>
<td>$166,260</td>
<td>$131,847</td>
<td>$26,400</td>
<td>15</td>
</tr>
<tr>
<td>86 44UAA5</td>
<td>1/01/2004</td>
<td>30/04/2004</td>
<td>$58,000</td>
<td>$58,848</td>
<td>$100</td>
<td>20</td>
</tr>
<tr>
<td>87 BMUAA1</td>
<td>1/06/2004</td>
<td>18/06/2004</td>
<td>$2,000</td>
<td>$1,981</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>88 AJ627*</td>
<td>1/03/2007</td>
<td>23/04/2007</td>
<td>$27,000</td>
<td>$18,949</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>89 AJ694*</td>
<td>10/04/2007</td>
<td>22/06/2007</td>
<td>$185,200</td>
<td>$185,200</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>90 AK571*</td>
<td>12/03/2007</td>
<td>30/05/2007</td>
<td>$63,000</td>
<td>$62,998</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>91 AI717†</td>
<td>9/01/2006</td>
<td>21/06/2006</td>
<td>$340,000</td>
<td>$129,853</td>
<td>$200</td>
<td>20</td>
</tr>
<tr>
<td>92 AI1980*</td>
<td>2/05/2006</td>
<td>22/06/2007</td>
<td>$20,400</td>
<td>$3,682</td>
<td></td>
<td></td>
</tr>
<tr>
<td>93 AI1988*</td>
<td>1/04/2007</td>
<td>29/06/2007</td>
<td>$170,000</td>
<td>$139,916</td>
<td></td>
<td></td>
</tr>
<tr>
<td>94 AK570*</td>
<td>15/03/2007</td>
<td>29/06/2007</td>
<td>$78,000</td>
<td>$78,057</td>
<td></td>
<td></td>
</tr>
<tr>
<td>95 M1UAA1†</td>
<td>12/05/2004</td>
<td>30/05/2004</td>
<td>$47,000</td>
<td>$45,113</td>
<td>$200</td>
<td>20</td>
</tr>
<tr>
<td>96 MDUAA1†</td>
<td>1/06/2004</td>
<td>28/06/2004</td>
<td>$6,000</td>
<td>$4,298</td>
<td>$100</td>
<td>15</td>
</tr>
<tr>
<td>97 AI1987*</td>
<td>1/05/2007</td>
<td>30/06/2007</td>
<td>$152,000</td>
<td>$81,253</td>
<td></td>
<td></td>
</tr>
<tr>
<td>98 AI784*</td>
<td>20/11/2006</td>
<td>30/06/2007</td>
<td>$116,519</td>
<td>$116,519</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99 AI694*</td>
<td>30/04/2007</td>
<td>14/09/2007</td>
<td>$380,000</td>
<td>$184,986</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 AI735*</td>
<td>12/11/2007</td>
<td>20/12/2007</td>
<td>$235,000</td>
<td>$236,132</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101 42YFI1†</td>
<td>1/09/2003</td>
<td>22/12/2003</td>
<td>$66,000</td>
<td>$16,550</td>
<td>$210</td>
<td>10</td>
</tr>
</tbody>
</table>

* Ineligible: completed after April 2007
† Ineligible: overlapped a site completed after April 2007
Costs and project life values in red italic print were estimated using the methodology described in Section 2.1.1
### Table A.3: Type of treatment completed at site

<table>
<thead>
<tr>
<th>Project #</th>
<th>Treatment type</th>
<th>Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1BBF1 Blacklength</td>
<td>Shoulder sealing at three intersections including sealing of bellmouths &amp; installation of motorcycle warning signs.</td>
</tr>
<tr>
<td>2</td>
<td>1BDU1 Blacklength</td>
<td>Install drivable end walls for pits and driveway culverts. Install curve alignment markers &amp; advisory speed signs.</td>
</tr>
<tr>
<td>3</td>
<td>413UDJ1 Blacklength</td>
<td>Improve linemarking through intersection.</td>
</tr>
<tr>
<td>4</td>
<td>413UNI1 Blacklength</td>
<td>Improve delineation &amp; install warning signs.</td>
</tr>
<tr>
<td>5</td>
<td>413UNI3 Blacklength</td>
<td>Improve delineation, shoulder sealing &amp; warning signs</td>
</tr>
<tr>
<td>6</td>
<td>413UPI1 Blacklength</td>
<td>Remove obstructions from sight line, re-surface curve (asphalt overlay) to improve skid resistance, remove log fencing &amp; relocate sign.</td>
</tr>
<tr>
<td>7</td>
<td>414DU2 Blacklength</td>
<td>Install 25 drivable concrete end walls at existing culverts along a 3.9km section of road.</td>
</tr>
<tr>
<td>8</td>
<td>414DU3 Blacklength</td>
<td>Install advisory speed signs, curve alignment markers, shoulder sealing, replace culvert end walls with drivable end walls &amp; resurface pavement to improve skid resistance.</td>
</tr>
<tr>
<td>9</td>
<td>414UMZ1 Blacklength</td>
<td>Install concealed intersection sign on the west approach to Moore St &amp; motorcycle warning signs supplemented with signs on the east of Union St &amp; east of Milton St advising of the slippery nature of tram tracks.</td>
</tr>
<tr>
<td>10</td>
<td>414UPI1 Blacklength</td>
<td>Install reflectors on existing bollards, install CAM's on various curves, install 15 new streetlights at various locations. (Note that Parks Victoria will be undertaking works on the bollard frangibility improvements)</td>
</tr>
<tr>
<td>11</td>
<td>415DU1 Blacklength</td>
<td>1. Install curve advisory and speed advisory signs. 2. Lift pit lids and reconstruct side entry pits.</td>
</tr>
<tr>
<td>12</td>
<td>415DU2 Blacklength</td>
<td>1. Installation of Curve Alignment Markers and Curve Advisory signs at every corner along the entire length. 2. Pavement regulation over a 2.5 km length across both lanes including filling corrugations and provision of a high skid resistant surface. 3. Trimming of vegetation from edge lines to be actioned by Nillumbik Shire.</td>
</tr>
<tr>
<td>13</td>
<td>413UNI2 Blacklength</td>
<td>Improve delineation, install warning signs, improve sight lines &amp; remove debris from surface. Note: There have been a total of 30 motorcycle crashes in this section of road over the last five years. This proposal targets 6 crashes where poor delineation attributed to crashes. The remaining crashes will be taken into consideration in a future blackspot bid for the sealing of shoulders.</td>
</tr>
<tr>
<td>14</td>
<td>415DU3 Blacklength</td>
<td>1. Install two electronic &quot;prepare to stop&quot; signs on the outbound lane before the start of the LH curve on the bridge. 2. Attach advanced lane indication signs on existing gantry for all outbound lanes. 3. Install additional speed advisory signs (45 km/h for inbound and 50 km/h for outbound) before the curves and 60 km/h regulatory speed zone repeater signs for inbound and outbound lanes. 4. Apply high skid resistant pavement sealing on steel expansion joints.</td>
</tr>
<tr>
<td>15</td>
<td>42CVB8 Blacklength</td>
<td>Install motorcycle warning signs &amp; curve alignment markers.</td>
</tr>
<tr>
<td>16</td>
<td>42NA Blacklength</td>
<td>Re-surface through curves, shoulder sealing &amp; install motorcycle warning signs.</td>
</tr>
<tr>
<td>17</td>
<td>42NS Blacklength</td>
<td>Install curve advisory signs, advisory speed signs, install curve alignment markers, RRPM’s, resurface road on inside of curve opposite Mason Gv &amp; construct &amp; seal the intersection of Mason Gv.</td>
</tr>
<tr>
<td>18</td>
<td>42TG Blacklength</td>
<td>Install Side Road Ahead warning signs. Repair broken road edges. Linemark edge lines. Install guideposts. Broken mirror to be replaced under maintenance program.</td>
</tr>
<tr>
<td>19</td>
<td>42NU Blacklength</td>
<td>Install curve alignment markers on curves, side road warning signs, linemarking and guideposts. Remove loose stones.</td>
</tr>
<tr>
<td>20</td>
<td>AI984 Long Route</td>
<td>Gipsitrac test(1), Edge lines(11km), CAMS(200), Advisory signs(80), Guideposts(300)</td>
</tr>
<tr>
<td>Project #</td>
<td>Treatment type</td>
<td>Works</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>21</td>
<td>42YFH5</td>
<td>Blacklength  Repair pavement, install motorcycle warning signs &amp; curve alignment markers.</td>
</tr>
<tr>
<td>22</td>
<td>42YFH6</td>
<td>Blacklength  Seal shoulder through curves, repair rough pavement areas, install motorcycle warning signs, curve alignment markers &amp; edgelines.</td>
</tr>
<tr>
<td>23</td>
<td>42YFH7</td>
<td>Blacklength  Re-patch rough pavement areas, install motorcycle warning signs &amp; curve alignment markers.</td>
</tr>
<tr>
<td>24</td>
<td>42YFH8</td>
<td>Blacklength  Install motorcycle warning signs, advisory signs &amp; curve alignment markers.</td>
</tr>
<tr>
<td>25</td>
<td>42YFH9</td>
<td>Blacklength  Install motorcycle warning signs, curve advisory signs, curve alignment markers, edgelines, centrelines &amp; guideposts.</td>
</tr>
<tr>
<td>26</td>
<td>42YFJ2</td>
<td>Blacklength  Install motorcycle warning signs supplemented with &quot;High Risk Area&quot; signs, install curve advisory signs, advisory speed signs, curve alignment markers, repair shoulders &amp; seal inside of curves, construct &amp; seal three slow vehicle turnouts &amp; cut back foliage.</td>
</tr>
<tr>
<td>27</td>
<td>42YFJ3</td>
<td>Blacklength  Repair shoulder, install curve alignment markers, motorcycle warning signs &amp; removal of vegetation.</td>
</tr>
<tr>
<td>28</td>
<td>42YFJ4</td>
<td>Blacklength  Install Motorcyclist Slippery Surface and High Risk Area signs, clean road edges and centre where necessary, renew linemarking, install guide posts and cut back foliage</td>
</tr>
<tr>
<td>29</td>
<td>43BF2</td>
<td>Blacklength  Asphalt regulation.</td>
</tr>
<tr>
<td>30</td>
<td>43DU2</td>
<td>Blacklength  Improve delineation (including curve alignment markers, speed advisory signs and linemarking) along length, culvert extension and safety barrier at Surfe Pde.</td>
</tr>
<tr>
<td>31</td>
<td>44UAA1</td>
<td>Blacklength  Install motorcycle warning signs, curve alignment markers &amp; curve advisory speed signs.</td>
</tr>
<tr>
<td>32</td>
<td>44UAA2</td>
<td>Blacklength  Seal Anderson Mill Road at the intersection of Marysville Road.</td>
</tr>
<tr>
<td>33</td>
<td>44UAA4</td>
<td>Blacklength  Resurface pavement to improve skid resistance, install edgelines, advisory speed signs, curve alignment markers &amp; extend guard fence.</td>
</tr>
<tr>
<td>34</td>
<td>4560006</td>
<td>Blacklength  Install curve warning signs, advisory speed signs, curve alignment markers, motorcycle warning signs &amp; edgelines.</td>
</tr>
<tr>
<td>35</td>
<td>4760239A</td>
<td>Blacklength  Seal shoulder parking areas. Install No U turn and pedestrian warning signs. Extend guard rail through parking area.</td>
</tr>
<tr>
<td>36</td>
<td>4760232A</td>
<td>Blacklength  Sealing of car park entries and traffic control devices on larger car parks.</td>
</tr>
<tr>
<td>37</td>
<td>4760242A</td>
<td>Blacklength  Mill slab to correct level and resurface approach to provide a smooth transition.</td>
</tr>
<tr>
<td>38</td>
<td>4760243A</td>
<td>Blacklength  Rationalise and re-position warning signs.</td>
</tr>
<tr>
<td>39</td>
<td>4760244A</td>
<td>Blacklength  Resurfacing to provide a smoother ride.</td>
</tr>
<tr>
<td>40</td>
<td>4760245A</td>
<td>Blacklength  Asphalt overlay at the selected sites to produce a smooth pavement surface.</td>
</tr>
<tr>
<td>41</td>
<td>AH874</td>
<td>Blacklength  1. Sealing of gravel bellmouths at driveways, for a distance of 2 metres, and at intersections. 2. Surface rejuvenation at selected locations. 3. Install additional motorcycle risk area signs. 4. Install additional curve alignment markers. 5. Review speed advisory signs.</td>
</tr>
<tr>
<td>42</td>
<td>AH883</td>
<td>Long Route  Installation of motorcycle warning signage and speed advisory signage, curve alignment markers, speed advisory signage, replacement of existing rigid guideposts with frangible guideposts and installation of guideposts where none currently exist.</td>
</tr>
<tr>
<td>43</td>
<td>AH894</td>
<td>Blacklength  1. Improved signing on both approaches. 2. Edge lining and installation of curve alignment markers.</td>
</tr>
<tr>
<td>44</td>
<td>AH895</td>
<td>Blacklength  Pavement repairs by asphalt surfacing</td>
</tr>
<tr>
<td>45</td>
<td>AH900</td>
<td>Blacklength  Pavement repairs by asphalt surfacing. Install frangible poles and light weight signs.</td>
</tr>
<tr>
<td>Project #</td>
<td>Treatment type</td>
<td>Works</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>46</td>
<td>AI675 Long Route</td>
<td>Installation of additional curve alignment markers, edge lines over entire route, motorcycle friendly plastic delineators for guard fences, additional speed advisory and motorcycle warning signage.</td>
</tr>
<tr>
<td>47</td>
<td>1BDU2 Blacklength</td>
<td>1. Alert riders to road conditions by installing Motorcycle High Risk signs. 2. Install curve warning signs, curve alignment markers and guide posts along the length. 3. Install CAMs at McDonalds Track. 4. Repair surface irregularities. 5. Install edge lining on the road between Browns Road and 3.6 km south of Grand Ridge Road.</td>
</tr>
<tr>
<td>48</td>
<td>SYBF1 Blacklength</td>
<td>Removal of vegetation, installation of curve warning signs, motorcycle warning signs &amp; edgelines.</td>
</tr>
<tr>
<td>49</td>
<td>AI678 Long Route</td>
<td>Installation of additional curve alignment markers, edge lines over entire route, plastic delineators for guard fences, additional speed advisory and motorcycle warning signage, additional guideposts and relocation of existing frangible guideposts to provide a consistent spacing for the entire length of the road.</td>
</tr>
<tr>
<td>50</td>
<td>AI692 Long Route</td>
<td>Installation of edge lines on the sections of the road remaining without edgelines (2.83 km) and the replacement of guard fence delineators with motorcycle friendly plastic delineators.</td>
</tr>
<tr>
<td>51</td>
<td>43DU1 Blacklength</td>
<td>Install Motorcycle Hazardous Area signs, curve alignment markers, advisory speed signs and linemarking at high risk locations. Resurface to improve skid resistance in high risk locations.</td>
</tr>
<tr>
<td>52</td>
<td>AI712 Blacklength</td>
<td>Shoulder sealing through curves, asphalt regulation and surface improvements through curves, speed and hazard warning signage improvements and guardrail rubbing rail (at accident location) on outside of curve.</td>
</tr>
<tr>
<td>53</td>
<td>AI718 Blacklength</td>
<td>Curve warning signage improvements.</td>
</tr>
<tr>
<td>54</td>
<td>AI719 Blacklength</td>
<td>Shoulder sealing and speed and hazard warning signage improvements.</td>
</tr>
<tr>
<td>55</td>
<td>AI721 Blacklength</td>
<td>Shoulder sealing through curves, asphalt regulation and resurfacing through curves and speed and hazard signage improvements.</td>
</tr>
<tr>
<td>56</td>
<td>AI745 Intersection</td>
<td>Channelisation of movements along Seaford Road, which includes: 1. Construct sheltered right lanes. 2. Construct kerb and paved islands on Seaford Road and at angle parking on service road. 3. Carry out linemarking, paint arrows and 'Keep Clear'. 4. Install/ relocate signs. 5. Relocate 'Give Way' signs to provide priority for traffic entering from Seaford Road. 6. Install zebra crossing at slip lane on SW corner of Dandenong-Frankston Road and Seaford Road. Install chain between existing bollards on northern side of north-side servicew lane separator.</td>
</tr>
<tr>
<td>57</td>
<td>AI760 Long Route</td>
<td>Install curve alignment markers CAMs-at two bends-12 signs (between Yan Yeans Rd and Lower Rd, Wattle Glen).</td>
</tr>
<tr>
<td>58</td>
<td>AI783 Long Route</td>
<td>Reduce gravel on roads by sealing driveways (5), turn out areas (5) and shoulders (4) and kerb and channel on inside of curves.</td>
</tr>
<tr>
<td>59</td>
<td>AI920 Long Route</td>
<td>Gipsitrac test (1) to identify advisory speed, speed, curve advisory and intersection signs (50), CAMs (120), edgelines (15 km).</td>
</tr>
<tr>
<td>60</td>
<td>42NV Blacklength</td>
<td>Resurface to remove corrugations and improve skid resistance, create wide sealed shoulder on curves, cut back foliage, install Motorcyclist Slippery Surface and High Risk Area signs.</td>
</tr>
<tr>
<td>61</td>
<td>AI957 Long Route</td>
<td>Install curve warning speed advisory signage, delineation on 16 curves and link existing inconsistent linemarking (edge lines) to provide continuous edgelines from Broadford to Flowerdale (Total=121 signs, 24.38 km of linemarking).</td>
</tr>
<tr>
<td>Project #</td>
<td>Treatment type</td>
<td>Works</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>62 AI963</td>
<td>Long Route</td>
<td>Install curve warning speed advisory signage and delineation (curve alignment markers) on approximately 20 curves (total 75 signs).</td>
</tr>
<tr>
<td>63 42TH</td>
<td>Blacklength</td>
<td>Install Side Road Ahead and Curve Advisory signs. Repair broken road edges. Line mark edge lines and centre line. Install guide posts and Curve Alignment Markers. Pipe the steep gully and install guard rail at cross culvert.</td>
</tr>
<tr>
<td>64 M4UAA3</td>
<td>Blacklength</td>
<td>Install curve alignment markers, guide posts, curve warning &amp; advisory speed signs. Three curves have been identified for treatment at Ch 13.9km, 15.2km &amp; 19.5km.</td>
</tr>
<tr>
<td>65 AI967</td>
<td>Long Route</td>
<td>Curve alignment markers CAMs (100), guideposts (400).</td>
</tr>
<tr>
<td>66 AI969</td>
<td>Long Route</td>
<td>Curve alignment markers CAMs (60), Advisory signs (24), Guideposts (200).</td>
</tr>
<tr>
<td>67 44UAA5M</td>
<td>Blacklength</td>
<td>Install edgelines, curve warning signs, speed advisory signs &amp; curve alignment markers at selected curves. The section of Marysville-Woods Point Rd east of Lake Mountain Rd was recently treated with edgelines &amp; curve warning signs. This proposal will provide a consistent level of signage &amp; delineation along this route.</td>
</tr>
<tr>
<td>68 AI973</td>
<td>Long Route</td>
<td>Gipsitrack test (1) to identify advisory speed, speed and curve advisory signs (24), curve alignment markers (72), guideposts (180).</td>
</tr>
<tr>
<td>69 AI975</td>
<td>Long Route</td>
<td>Edgelines (20.5 km $20,500) to complete whole length between Halls Gap and Laharum, signing (11 sites $5,400), CAMs (3 sites $2,100) plus administration.</td>
</tr>
<tr>
<td>70 46DUA02</td>
<td>Blacklength</td>
<td>Repair &amp; resurface pavement on curves, inside curve widening, install curve advisory signs, advisory speed signs, curve alignment markers, motorcycle warning signs, guideposts, relocated stop linemarking at Silverbands Rd &amp; painted edgelines where missing.</td>
</tr>
<tr>
<td>71 46DUA03</td>
<td>Blacklength</td>
<td>1. Complete edge lining where it does not exist. 2. Repair surface irregularities, together with some lane seal widening, on curves and install CAM's on downhill curves, fixed on frangible poles. Install 'High Risk Area' motorcycle signs.</td>
</tr>
<tr>
<td>72 AI978</td>
<td>Long Route</td>
<td>Gipsitrac test (1) to identify advisory speed, speed and curve advisory signs (24), CAMs (72), edgelines (5 km), guideposts (120).</td>
</tr>
<tr>
<td>73 AI979</td>
<td>Long Route</td>
<td>Gipsitrack test (1) to identify advisory speed, speed and curve advisory signs (24), tree pruning at bends, guideposts (120).</td>
</tr>
<tr>
<td>74 AI981</td>
<td>Long Route</td>
<td>Gipsitrack test (1) to identify advisory speed, speed and curve advisory signs (24), edge lines (6 km), CAMs (96), guideposts (120).</td>
</tr>
<tr>
<td>75 M4UAA1</td>
<td>Blacklength</td>
<td>Install centreline, guide posts &amp; motorcycle warning signs. Note: Within the 29km section of road a blacklength has been identified from crash data. However, from engineering perspective it is more practical to delineate the entire section of road than an isolated length.</td>
</tr>
<tr>
<td>76 M4UAA2</td>
<td>Blacklength</td>
<td>Install curve alignment markers, curve warning &amp; advisory speed signs on two curves near Powers Rd &amp; additional guide posts.</td>
</tr>
<tr>
<td>77 M4UAA4</td>
<td>Blacklength</td>
<td>Install edgelines to provide a consistent level of delineation.</td>
</tr>
<tr>
<td>78 M4UAA5</td>
<td>Blacklength</td>
<td>Installation of guideposts along the full route and upgrade warning signs at the north end of the road</td>
</tr>
<tr>
<td>79 M4UAA6</td>
<td>Blacklength</td>
<td>Asphalt overlay on approximately 250 metre section to correct surface condition and crossfall, minor batter works to open up curves, improved signing and delineation on five curves and the installation of w beam guardfence on the outside of two curves.</td>
</tr>
<tr>
<td>80 MDUAA2</td>
<td>Blacklength</td>
<td>Install curve warning signs, curve alignment markers &amp; edgelines to match existing linemarking.</td>
</tr>
<tr>
<td>81 MXDUA01</td>
<td>Blacklength</td>
<td>Asphalt regulation, linemarking &amp; installation of signage.</td>
</tr>
<tr>
<td>82 SWUAA1</td>
<td>Blacklength</td>
<td>Install curve warning &amp; advisory speed signs, resurface to improve pavement texture &amp; shape &amp; install motorcycle warning signs.</td>
</tr>
<tr>
<td>83 THUAA1</td>
<td>Blacklength</td>
<td>Complete edgelines and install curve alignment markers &amp; warning signs.</td>
</tr>
<tr>
<td>Project #</td>
<td>Treatment type</td>
<td>Works</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>-------</td>
</tr>
<tr>
<td>84</td>
<td>Blacklength</td>
<td>Install Motorcycle Hazardous Area signs, CAMs, advisory speed signs guideposts and edge lines at high risk locations.</td>
</tr>
<tr>
<td>85</td>
<td>Long Route</td>
<td>Installation of motorcycle warning signage, CAMs, speed advisory signage and replacement of existing rigid guideposts with frangible guideposts and installation of guideposts where currently none.</td>
</tr>
<tr>
<td>86</td>
<td>Blacklength</td>
<td>Install curve warning signs, CAMs, speed advisory signs, seal bellmouth of access road, modify embankment to improve sight lines &amp; shoulder sealing.</td>
</tr>
<tr>
<td>87</td>
<td>Blacklength</td>
<td>Install curve advisory speed signs &amp; curve alignment markers.</td>
</tr>
<tr>
<td>88</td>
<td>Blacklength</td>
<td>Supply and installation of high motorcycle risk area signs, chevron alignment markers, guideposts, speed advisory signs, curve warning signs and advance warning signs.</td>
</tr>
<tr>
<td>89</td>
<td>Blacklength</td>
<td>Install curve alignment markers on frangible poles at curves, seal bellmouth entrances at intersections and dig out and seal shoulders between ch. 1200-1700 to reduce gravel wash. Redo or provide new edge line and centre line marking throughout, install guideposts at specific locations where absent or in poor condition. Remove/trim trees to improve sightlines (minor works).</td>
</tr>
<tr>
<td>90</td>
<td>Long Route</td>
<td>Install curve warning speed advisory signage, delineation on 41 curves. This treatment covers the remaining sections from Harrietville to Omeo that have previously not been treated.</td>
</tr>
<tr>
<td>91</td>
<td>Blacklength</td>
<td>Some shoulder sealing, asphalt crossfall correction on curves, regulation and resurfacing through curves, speed and hazard warning signage improvements and guardrail rubbing rail (at accident location) on outside of curve.</td>
</tr>
<tr>
<td>92</td>
<td>Long Route</td>
<td>Installation of motorcycle warning signage and speed advisory signage.</td>
</tr>
<tr>
<td>93</td>
<td>Long Route</td>
<td>Gipsitrac test(1), Edge lines(17km), CAMS(150), Frangible advisory signs(80), Guideposts(200).</td>
</tr>
<tr>
<td>94</td>
<td>Long Route</td>
<td>Install curve warning speed advisory signage, delineation on 24 curves &amp; link existing linemarking (edgelines) to provide continuous edgelines from Tip Road (24.0km) to Jesses Creek (28.7km). It is also proposed to upgrade centre line to meet current standards. There is also a small amount of shoulder sealing on curves and at intersections.</td>
</tr>
<tr>
<td>95</td>
<td>Blacklength</td>
<td>Install edgelines with raised reflective pavement markers, minor patching &amp; motorcycle warning signs.</td>
</tr>
<tr>
<td>96</td>
<td>Blacklength</td>
<td>Install motorcycle warning signs &amp; edgelines with raised reflective pavement markers. The delineation in the section from Ch 17.6km to 20.4km has already been upgraded. This proposal will provide a consistent level of delineation between Ch 17.6km &amp; 23.6km.</td>
</tr>
<tr>
<td>97</td>
<td>Long Route</td>
<td>Gipsitrac test(1), Edge lines(13km), CAMS (150), Frangible advisory signs(50), Guideposts(260).</td>
</tr>
<tr>
<td>98</td>
<td>Long Route</td>
<td>Install CAM's (20), double centre lines (11.6 km), edge lines (5.2 km), guideposts (300), curve advisory signs (3), and intersection warning signs (1), shoulder, bellmouth and bellmouth sealing.</td>
</tr>
<tr>
<td>99</td>
<td>Long Route</td>
<td>Additional motorcycle risk area signs, additional CAMs, installation of edge lines where road width is greater than 6.2 metres, sealing of gravel bell mouths for intersecting roads, vegetation trimming and removal and replacement of metal delineators by plastic delineators on guard fence.</td>
</tr>
<tr>
<td>100</td>
<td>Long Route</td>
<td>Sealing of bellmouths, sealing of shoulders where they are inadequate, complete edgelines along the route (7km), install CAMs (400), frangible advisory signs (20), and guideposts (50).</td>
</tr>
<tr>
<td>101</td>
<td>Blacklength</td>
<td>Re-surface pavement around curve, install motorcycle warning signs, curve advisory signs &amp; edgelines.</td>
</tr>
</tbody>
</table>

* Ineligible: completed after April 2007 † Ineligible: overlapped a site completed after April 2007
APPENDIX B – ADDITIONAL EFFECTIVENESS BY SITE RESULTS

The effects of treatments completed as part of individual motorcycle blackspot projects were explored in Section 4.1.3. Only results that were significant to the *p*<0.05 level were presented. This section contains tables analogous to those presented in Section 4.1.3, but where there is a less-conservative criterion for statistical confidence. Tables in this section contain results significant to the *p*<0.2 level. This information has been provided for VicRoads’ internal auditing purposes and should not be considered as conclusive proof that particular treatments were successful or unsuccessful.

In each of the tables presented in this section, results that were significant to the *p*<0.05 level have been highlighted.

Table B.1 presents the estimated effect of individual projects on the number of casualty crashes involving all types of vehicles. Table 4.5 on page 37 presents the same results as Table B.1, except Table 4.5 only presents results that were significant to the *p*<0.05 level of confidence. It can be seen from Table B.1 that, of all the projects estimated to have had an effect on casualty crashes with 80% certainty, 1BBF1 was estimated to have the greatest effect on casualty crashes. The site treated under 1BBF1 was located on the Yarra Junction-Noojee Road in the Baw Baw Shire. It was estimated that the treatment of this site reduced casualty crashes by 92.5%, ranging from a 29.6% increase in the number of crashes to a 99.6% reduction with 95% certainty. Roadworks along the Healesville-Koo-Wee-Rup Road in Cardinia were the next most effective group of treatments, with these treatments reducing crashes by 89% (*p*<0.03).

Table B.2 presents the estimated effect of individual projects on the number of casualty motorcycle crashes. Table 4.6 on page 37 shows the same results restricted to those that were significant to the *p*<0.05 level of confidence. It can be seen from Table B.2 that only seven of the 71 distinct sites had a significant (*p*<0.2) effect on casualty motorcycle crashes. Comparison with Table B.1 reveals that all but two of these seven sites were also effective (*p*<0.2) in preventing casualty crashes involving all types of vehicles.

Project AI978, was estimated to significantly (*p*<0.05) increase the number of casualty motorcycle crashes. When the level of confidence was relaxed to 80% certainty, it was also found that treatment works along the Northern Grampians Road were also estimated to increase the number of casualty motorcycle crashes. The projects along this road (AI975, 46DUA02 and 46DUA03) were evaluated as a single site for the purpose of the analysis.

Finally, Table B.3 presents the estimated effect of individual projects on the number of serious casualty crashes. These results are analogous to those presented in Table 4.7 on page 39 but where the criterion for exclusion has been relaxed to the *p*<0.2 level of confidence. It can be seen from Table B.3 that, of these projects, the project that resulted in the greatest reductions in serious casualty crashes were located at Healesville-Koo-Wee-Rup Road (88.6%), Mt Defiance on the Great Ocean Road (88.4%) and Yarra Junction-Noojee Rd, Piedmont (87.2%). However, reductions at each of these sites were not significant at the *p*<0.05 level, while treatment of the Mt Dandenong Tourist Road (project 42YFH7) did result in a significant (*p*=0.04) 80.1% reduction in serious casualty crashes.
**Table B.1: Estimated casualty crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only**

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Description</th>
<th>Est. crash reduction</th>
<th>Stat. sig.</th>
<th>95% conf. limit Lower</th>
<th>95% conf. limit Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1BBF1</td>
<td>Sealing at intersections, warning signs along Yarra Junction-Noojee Rd, Piedmont</td>
<td>92.5%</td>
<td>0.07</td>
<td>-29.6%</td>
<td>99.7%</td>
</tr>
<tr>
<td>42TG 42NU AI984*</td>
<td>Warning signs, CAMs, guideposts, repair edges, line marking &amp; GIPSITRAC test along Healesville-Koo-Wee-Rup Rd</td>
<td>89.4%</td>
<td>0.03</td>
<td>21.7%</td>
<td>98.6%</td>
</tr>
<tr>
<td>AI783*</td>
<td>Seal driveways &amp; shoulders along Deans Marsh-Lorne Rd</td>
<td>86.4%</td>
<td>0.06</td>
<td>-12.3%</td>
<td>98.4%</td>
</tr>
<tr>
<td>4760239A 4760232A</td>
<td>Warning signs, guardrails, and sealing of carpark and shoulders at Mt Defiance on Great Ocean Road</td>
<td>84.8%</td>
<td>0.07</td>
<td>-15.6%</td>
<td>98.0%</td>
</tr>
<tr>
<td>4560006</td>
<td>Warning signs, CAMs and edgelines along Cameron Rd, Macedon</td>
<td>82.4%</td>
<td>0.1</td>
<td>-36.4%</td>
<td>97.7%</td>
</tr>
<tr>
<td>1BDU1</td>
<td>Driveable culverts, CAMs &amp; advisory speed signs, Nayook-Powelltown Rd</td>
<td>81.8%</td>
<td>0.1</td>
<td>-48.1%</td>
<td>97.8%</td>
</tr>
<tr>
<td>THUAA1</td>
<td>Edgelines, CAMs and warning signs along Murray River Rd, Granya</td>
<td>68.4%</td>
<td>0.1</td>
<td>-45.5%</td>
<td>93.1%</td>
</tr>
<tr>
<td>413UPI1</td>
<td>Re-surface and remove hazard/sight obstructions along Montague St, Sth Melb</td>
<td>67.0%</td>
<td>0.02</td>
<td>13.9%</td>
<td>87.4%</td>
</tr>
<tr>
<td>42YFH8</td>
<td>Warning signs and CAMs along Mt Dandenong Tourist Rd, Ferny Ck</td>
<td>62.5%</td>
<td>0.2</td>
<td>-64.6%</td>
<td>91.5%</td>
</tr>
<tr>
<td>42YFH7</td>
<td>Repair surface, warning signs and CAMs on Mt Dandenong Tourist Rd, Kalaroma</td>
<td>59.6%</td>
<td>0.03</td>
<td>8.8%</td>
<td>82.1%</td>
</tr>
<tr>
<td>AI920 42NV*</td>
<td>Warning signs, CAMs, edgelines, resurface &amp; GIPSITRAC test, Rosebud-Flinders Rd</td>
<td>52.9%</td>
<td>0.06</td>
<td>-2.7%</td>
<td>78.4%</td>
</tr>
<tr>
<td>AI963 42TH M4UAA3*</td>
<td>Warning signs, CAMs, line-marking, edge repair, guide posts, guard rails &amp; remove hazards, Healesville-Kinglake Rd</td>
<td>41.5%</td>
<td>0.2</td>
<td>-22.5%</td>
<td>72.1%</td>
</tr>
<tr>
<td>AI973*</td>
<td>Warning signs, CAMs, guideposts &amp; GIPSITRAC test, Ringwood-Warrandyte Rd</td>
<td>-41.5%</td>
<td>0.1</td>
<td>-124.0%</td>
<td>10.7%</td>
</tr>
<tr>
<td>415DU2 413UNI2</td>
<td>Warning signs, CAMs, surface repair, remove sight obstructions, Heidelberg-Kinglake Rd</td>
<td>-81.8%</td>
<td>0.2</td>
<td>-325.9%</td>
<td>22.4%</td>
</tr>
<tr>
<td>AI678*</td>
<td>CAMs, edgelines, signage and frangible guideposts on Tyers Thomson Valley Rd</td>
<td>-117.3%</td>
<td>0.08</td>
<td>-420.8%</td>
<td>9.3%</td>
</tr>
<tr>
<td>AI760*</td>
<td>Install CAMs along Heidelberg-Kinglake Rd, Cottles Bridge</td>
<td>-188.2%</td>
<td>0.05</td>
<td>-710.9%</td>
<td>-2.4%</td>
</tr>
<tr>
<td>42YFH6</td>
<td>Seal shoulder, surface repair, edgelines, CAMs and signs on Yarra Junction-Noojee Rd</td>
<td>-202.9%</td>
<td>0.04</td>
<td>-787.6%</td>
<td>-3.4%</td>
</tr>
<tr>
<td>413UNI3</td>
<td>Shoulder sealing, delineation and add warning signs on Heidelberg-Kinglake Rd</td>
<td>-233.3%</td>
<td>0.09</td>
<td>-1,218%</td>
<td>15.7%</td>
</tr>
</tbody>
</table>

* Long Route Treatment
Table B.2: Estimated casualty motorcycle crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Description</th>
<th>Est. crash reduction</th>
<th>Stat. sig.</th>
<th>95% conf. limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1783*</td>
<td>Seal driveways &amp; shoulders along Deans Marsh-Lorne Rd</td>
<td>95.0%</td>
<td>0.048</td>
<td>2.3%</td>
</tr>
<tr>
<td>1BDU1</td>
<td>Driveable culverts, CAMs &amp; advisory speed signs, Nayook-Powelltown Rd</td>
<td>89.4%</td>
<td>0.13</td>
<td>-94.8%</td>
</tr>
<tr>
<td>4560006</td>
<td>Warning signs, CAMs and edgelines along Cameron Rd, Macedon</td>
<td>89.3%</td>
<td>0.13</td>
<td>-99.2%</td>
</tr>
<tr>
<td>4760239A &amp; 4760232A</td>
<td>Warning signs, guardrails, and sealing of carpark and shoulders at Mt Defiance on Great Ocean Road</td>
<td>79.4%</td>
<td>0.13</td>
<td>-61.5%</td>
</tr>
<tr>
<td>413UPI1</td>
<td>Re-surface and remove hazard/sight obstructions along Montague St, Sth Melb</td>
<td>79.2%</td>
<td>0.14</td>
<td>-69.1</td>
</tr>
<tr>
<td>A1975</td>
<td>Install edgelines, signs, CAMs, widen curves, repair road surface and install signs on Northern Grampians Rd</td>
<td>-256.5%</td>
<td>0.092</td>
<td>-1,461.5%</td>
</tr>
<tr>
<td>46DUA02 &amp; 46DUA03*</td>
<td>Install signs, CAMs, edgelines and guideposts and GIPSITRAC test on Arthurs Seat Rd</td>
<td>-700%</td>
<td>0.023</td>
<td>-4,667.0%</td>
</tr>
</tbody>
</table>

* Long Route Treatment
Table B.3: Estimated serious casualty crash reductions for sites at which the estimates of effectiveness were significant to the p<0.2 level only

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Description</th>
<th>Est. crash reduction</th>
<th>Stat. sig.</th>
<th>95% conf. limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>42TG 42NU</td>
<td>Warning signs, CAMs, guideposts, repair edges, line marking &amp; GIPSITRAC test along Healesville-Koo-Wee-Rup Rd</td>
<td>88.6%</td>
<td>0.1</td>
<td>-94.6% 99.3%</td>
</tr>
<tr>
<td>AI984*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4760239A 4760232A</td>
<td>Warning signs, guardrails, and sealing of carpark and shoulders at Mt Defiance on Great Ocean Road</td>
<td>88.4%</td>
<td>0.1</td>
<td>-101.6% 99.3%</td>
</tr>
<tr>
<td>1BBF1</td>
<td>Sealing at intersections, warning signs along Yarra Junction-Noojee Rd, Piedmont</td>
<td>87.2%</td>
<td>0.2</td>
<td>-143.2% 99.3%</td>
</tr>
<tr>
<td>42YF7H</td>
<td>Repair surface, warning signs and CAMs on Mt Dandenong Tourist Rd, Kalorama</td>
<td>80.1%</td>
<td>0.04</td>
<td>5.0% 95.8%</td>
</tr>
<tr>
<td>413UNI1</td>
<td>Improve delineation and install warning signs along Heidelberg-Kinglake Rd, St Andrews</td>
<td>78.7%</td>
<td>0.2</td>
<td>-85.5% 97.6%</td>
</tr>
<tr>
<td>AI963 42TH M4UAA3*</td>
<td>Warning signs, CAMs, line-marking, edge repair, guide posts, guard rails &amp; remove hazards, Healesville-Kinglake Rd</td>
<td>62.8%</td>
<td>0.1</td>
<td>-28.2% 89.2%</td>
</tr>
<tr>
<td>43DU2</td>
<td>CAMs, signs, line-marking, culvert extension and safety barrier along Bunurong Rd, Inverloch</td>
<td>64.5%</td>
<td>0.2</td>
<td>-52.2% 90.3%</td>
</tr>
<tr>
<td>AI760*</td>
<td>Install CAMs along Heidelberg-Kinglake Rd, Cottles Bridge</td>
<td>-200.0%</td>
<td>0.09</td>
<td>-969.9% 15.9%</td>
</tr>
<tr>
<td>AI978*</td>
<td>Install signs, CAMs, edgelines and guideposts and GIPSITRAC test on Arthurs Seat Rd</td>
<td>-217.1%</td>
<td>0.1</td>
<td>-1,274% 26.9%</td>
</tr>
<tr>
<td>414DU2</td>
<td>Install 25 drivable concrete end walls at culverts along Whittlesea-Yea Rd, Humevale</td>
<td>-275.0%</td>
<td>0.02</td>
<td>-1,075% -19.7%</td>
</tr>
<tr>
<td>AH883*</td>
<td>Install signs, CAMs, frangible guideposts and guideposts along Lang Lang-Poowong Rd</td>
<td>-700.0%</td>
<td>0.1</td>
<td>-11,965% 47.0%</td>
</tr>
<tr>
<td>AI981*</td>
<td>Install signs, CAMs, edgelines and guideposts (120) and do GIPSITRAC test along Gembrook Rd, Gembrook</td>
<td>-1,266.7%</td>
<td>0.04</td>
<td>-15,751% -17.8%</td>
</tr>
</tbody>
</table>

* Long Route Treatment
APPENDIX C – ADDITIONAL ECONOMIC ANALYSES

Section 4.1 presented estimates of casualty crash reductions and serious casualty crash reductions that can be attributed to the Motorcycle Blackspot Program and groups of treatments completed as part of the program. These estimates of effectiveness were converted into measures of economic worth in Section 4.2.

The economic measures of effectiveness presented Section 4.2 did not include future maintenance costs in the costs associated with treatments completed as part of the Motorcycle Blackspot Program, i.e. the cost of treatments was equal to the capital cost of completing treatments only. However, this appendix contains measures of economic worth where the present value of future maintenance costs was included in the cost of completing treatments.

Throughout the results section of this report, the p<0.05 significance level has been used to determine whether results are statistically significant. This appendix provides measures of the economic benefits of all groups of treatments, irrespective of whether these estimates of effectiveness are based on significant estimates of crash reduction. For the reader’s benefit, economic measures based on non-significant point estimates of crash reduction have been marked with an asterisk. The reader should be wary of drawing conclusions on the benefits of different groups of treatments when measures of economic effectiveness were derived using non-significant estimates of crash reduction.

Table C.1: BCR of treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are included in project costs

<table>
<thead>
<tr>
<th>Discount Rate:</th>
<th>Benefit-cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (15.6% reduction, p=0.02)</td>
<td>9.6</td>
</tr>
<tr>
<td>- Casualty MC crashes (23.9% reduction, p=0.02)</td>
<td>7.8</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.6% reduction, p=0.09)</td>
<td>7.6*</td>
</tr>
<tr>
<td>- Casualty MC crashes (20.0% reduction, p=0.13)</td>
<td>5.1*</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (46.0% reduction, p=0.07)</td>
<td>14.5*</td>
</tr>
<tr>
<td>- Casualty MC crashes (54.7% reduction, p=0.086)</td>
<td>15.6*</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.3% reduction, p=0.33)</td>
<td>15.2*</td>
</tr>
<tr>
<td>- Casualty MC crashes (21.4% reduction, p=0.30)</td>
<td>17.4*</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (24.4% reduction, p=0.003)</td>
<td>12.5</td>
</tr>
<tr>
<td>- Casualty MC crashes (40.3% reduction, p=0.001)</td>
<td>12.5</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (-1.7% reduction, p=0.91)</td>
<td>-0.9*</td>
</tr>
<tr>
<td>- Casualty MC crashes (-12.8% reduction, p=0.52)</td>
<td>-4.4*</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (60.8% reduction, p=0.52)</td>
<td>89.7*</td>
</tr>
<tr>
<td>- Casualty MC crashes (51.3% reduction, p=0.64)</td>
<td>49.1*</td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness
Table C.2: Cost-effectiveness of preventing a casualty crash for treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are included in project costs

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>Crashes prevented over program life</th>
<th>Cost-effectiveness (serious casualty crashes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (15.6% reduction, p=0.02)</td>
<td>465</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (23.9% reduction, p=0.02)</td>
<td>296</td>
<td></td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.6% reduction, p=0.09)</td>
<td>292*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (20.0% reduction, p=0.13)</td>
<td>154*</td>
<td></td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (46.0% reduction, p=0.07)</td>
<td>43*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (54.7% reduction, p=0.086)</td>
<td>36*</td>
<td></td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (13.3% reduction, p=0.33)</td>
<td>98*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (21.4% reduction, p=0.30)</td>
<td>86*</td>
<td></td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (24.4% reduction, p=0.003)</td>
<td>294</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (40.3% reduction, p=0.001)</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (-1.3% reduction, p=0.91)</td>
<td>-22*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (-12.8% reduction, p=0.52)</td>
<td>-85*</td>
<td></td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All casualty crashes (60.8% reduction, p=0.52)</td>
<td>16*</td>
<td></td>
</tr>
<tr>
<td>- Casualty MC crashes (51.3% reduction, p=0.64)</td>
<td>7*</td>
<td></td>
</tr>
</tbody>
</table>

* Based on non-significant (p ≥ 0.05) estimates of effectiveness
Table C.3: Cost-effectiveness of preventing a serious casualty crash for treatments completed as part of the Motorcycle Blackspot Program where future maintenance costs are included in project costs

<table>
<thead>
<tr>
<th>Treatment Description</th>
<th>Crash Prevention (serious casualty crashes)</th>
<th>Discount Rate 4%</th>
<th>Discount Rate 6%</th>
<th>Discount Rate 8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Program (87 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (16.8% reduction, p=0.09)</td>
<td>197*</td>
<td>$44,596*</td>
<td>$42,681*</td>
<td>$41,100*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (24.7% reduction, p=0.097)</td>
<td>158*</td>
<td>$55,670*</td>
<td>$53,279*</td>
<td>$51,306*</td>
</tr>
<tr>
<td>Program excluding G.O.R. and YR sites (63 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (11.0% reduction, p=0.35)</td>
<td>90*</td>
<td>$78,844*</td>
<td>$75,440*</td>
<td>$72,623*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (25.9% reduction, p=0.16)</td>
<td>101*</td>
<td>$70,146*</td>
<td>$67,117*</td>
<td>$64,611*</td>
</tr>
<tr>
<td>Great Ocean Road sites (8 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (42.0% reduction, p=0.20)</td>
<td>22*</td>
<td>$26,254*</td>
<td>$26,053*</td>
<td>$25,883*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (47.6% reduction, p=0.24)</td>
<td>20*</td>
<td>$28,720*</td>
<td>$28,500*</td>
<td>$28,314*</td>
</tr>
<tr>
<td>Yarra Ranges sites (16 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (25.9% reduction, p=0.21)</td>
<td>78*</td>
<td>$14,473*</td>
<td>$13,618*</td>
<td>$12,919*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (8.4% reduction, p=0.79)</td>
<td>17*</td>
<td>$65,259*</td>
<td>$61,403*</td>
<td>$58,252*</td>
</tr>
<tr>
<td>Blacklengths (56 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (33.3% reduction, p=0.005)</td>
<td>176</td>
<td>$24,575</td>
<td>$24,064</td>
<td>$23,642</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (42.6% reduction, p=0.01)</td>
<td>127</td>
<td>$33,859</td>
<td>$33,155</td>
<td>$32,574</td>
</tr>
<tr>
<td>Long route treatments (30 sites)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (-14.0% reduction, p=0.41)</td>
<td>-89*</td>
<td>-$50,123*</td>
<td>-$46,882*</td>
<td>-$44,207*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (-18.0% reduction, p=0.53)</td>
<td>-59*</td>
<td>-$75,706*</td>
<td>-$70,812*</td>
<td>-$66,771*</td>
</tr>
<tr>
<td>Intersection treatments (1 site)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- All serious casualty crashes (22.1% reduction, p=0.87)</td>
<td>3*</td>
<td>$9,808*</td>
<td>$9,765*</td>
<td>$9,731*</td>
</tr>
<tr>
<td>- Serious casualty MC crashes (34.4% reduction, p=0.79)</td>
<td>5*</td>
<td>$6,309*</td>
<td>$6,281*</td>
<td>$6,260*</td>
</tr>
</tbody>
</table>

* Based on non-significant (p≥0.05) estimates of effectiveness
Table C.4: Comparison of estimates of the cost-effectiveness of preventing serious casualties† with those of previous programs where future maintenance costs were included in program costs

<table>
<thead>
<tr>
<th></th>
<th>Est. red.</th>
<th>Sig.</th>
<th>Cost-effectiveness ($/Serious Casualties)</th>
<th>Discount Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8%</td>
</tr>
<tr>
<td><strong>Motorcycle Blackspot Program‡</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness ($/Serious Casualties)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vehicles</td>
<td>17%</td>
<td>(p&lt;0.1)</td>
<td>$38,445*</td>
<td></td>
</tr>
<tr>
<td>Motorcycle crashes only</td>
<td>25%</td>
<td>(p&lt;0.1)</td>
<td>$52,223*</td>
<td></td>
</tr>
<tr>
<td><strong>$240M Blackspot program</strong>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness ($/Serious Casualties)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vehicles</td>
<td>35%</td>
<td>(p&lt;0.001)</td>
<td>$62,587</td>
<td>$62,365</td>
</tr>
<tr>
<td>Motorcycle crashes only</td>
<td>36%</td>
<td>(p&lt;0.0001)</td>
<td>$549,440</td>
<td>$547,490</td>
</tr>
<tr>
<td><strong>$85M Blackspot program</strong>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness ($/Serious Casualties)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vehicles</td>
<td>26%</td>
<td>(p&lt;0.0001)</td>
<td>$35,981</td>
<td>$35,626</td>
</tr>
<tr>
<td>Motorcycle crashes only</td>
<td>19%</td>
<td>(p&lt;0.1)</td>
<td>$443,854*</td>
<td>$439,472*</td>
</tr>
</tbody>
</table>

† A serious casualty is defined as a road user who was seriously injured or killed
‡ Using Motorcycle Blackspot Program costs presented in Section 4.2.1 (AUS2005)
* Based on non-significant (p ≥ 0.05) estimates of effectiveness
** Using VicRoads Program crash costs (AUS2000)
APPENDIX D – ASSUMPTIONS AND QUALIFICATIONS

In evaluating the effectiveness of the Motorcycle Blackspot Program, a number of assumptions were made. These were as follows.

- Descriptions of the treatments provided by VicRoads were accurate with respect to the cost of completing treatments and the dates on which treatments were commenced and completed. Similarly, the descriptions enabled accurate identification of the location of sites where treatments were implemented. No independent audit was undertaken to verify the information supplied by VicRoads regarding the type of treatments completed or the location of sites.

- Extraction of crash data at treated sites carried out by VicRoads was accurate.

- Control sites selected for the analysis accurately and fully represented the effects of non-treatment related factors that may affect casualty crash frequency and casualty crash counts in the before or after period at treated sites.

- The form of the statistical models and error structures chosen was the most appropriate for the analysis and provided accurate and unbiased estimates of program effectiveness.

- Casualty crash costs used in the analysis appropriately reflected the real cost of casualty crashes to the community.

- The economic benefits of the entire program that were presented in Section 4.2 were based on the assumption that the true effects of the program across all treated sites were equal to the estimated magnitude of the effects (i.e. a 15.6% reduction for casualty crashes involving all vehicles and a 23.9% reduction for casualty crashes involving motorcycles). Although these estimates of effectiveness were both significant (p<0.05), they are unlikely to represent the actual effects of the program on casualty (motorcycle) crashes at treated sites; they are merely the best estimates available. It was estimated that the actual effectiveness in preventing casualty crashes involving all types of vehicles could vary from a 4% to 40% with 95% certainty, while the effectiveness for casualty crashes involving motorcycles could vary from 3% to 27% with 95% certainty.

The following qualifications should also be noted

- Statistical analysis presented in this report cannot prove unequivocally that the treatments led to the attributed crash reductions. It is possible that other unrelated but concurrent events led to the effects observed, although this is considered unlikely considering the analysis design employed.

- Evaluations of the effectiveness of individual treatments are not broadly indicative of the effectiveness of these treatments applied at all sites and in all circumstances. In particular, one should be wary of basing conclusions from casualty crash data from a small number of sites. Just because a treatment was not shown to be effective in this evaluation does not mean that the treatment cannot be effectively
used to reduce risk at sites not included in this evaluation. The effectiveness of a treatment is determined in part by how and where it is applied.

- The average after treatment period of time in the present evaluation was 2.4 years. The reader should be aware that with further accumulated after treatment experience, the estimated crash effects at treated sites could change.

- When evaluating of the economic benefits of the program presented in Section 4.2, some of the reported benefits of the program were based on non-significant ($p \geq 0.05$) estimates of crash reduction. The level of significance of the estimated crash reduction that was used to derive each economic measure has been presented in each table of Section 4.2. The reader should be aware of the level of confidence of the estimate of crash reduction that was used to derive each economic measure of benefit.