Post Implementation Review

Cameron Road Cycle Lanes

Tauranga City Council

September 2014

The purpose of NZ Transport Agency Post Implementation Reviews are to:

- assess how well a project (or package) has delivered its expected benefits
- explain any variation between actual results and expected benefits and costs
- identify any lessons learned that can be used to improve future projects

Executive summary

This project constructed cycle lanes on Cameron Road, one of Tauranga City's main arterial roads connecting to the central business district. The cycle lanes were predicted to improve safety for cyclists and generate health benefits derived from substantially increased numbers of cyclists.

Summary assessment of project outcomes

Overall, the project has successfully introduced a good quality cycling facility that helps separate cyclists from other motor vehicle traffic for improved safety. It also provides good connectivity and a generally consistent speed environment for cyclists biking to and from the central business district and other key facilities on Cameron Road. These include the hospital, several major schools and numerous businesses and employment locations.

However, the magnitude of actual benefits from the cycle lanes has not been as large as predicted when the project was approved and funded.

Safety outcomes

Cyclist safety has improved as a result of the cycle lanes. The lanes have effectively reduced injury crashes involving cyclists on Cameron Road. This review was unable to conclude however that the cycle lanes have helped reduce *all* crashes involving cyclists. But significant under-reporting of non-injury cyclist crashes (which are included in the all crashes grouping) means it is problematic to draw definitive conclusions on trends for all crashes involving cyclists.

Predictions that the cycle lanes would reduce specific crash types involving cyclists at intersections or manoeuvring on the road by 80% were overly optimistic. The actual reduction in these crash types has been significantly less. More recent research and current Transport Agency guidance generally suggests a 10% to 35% reduction in cyclist crashes overall is more realistic as a result of cycle lanes.

Health benefits from increased cycling

The predicted health benefits from the cycle lanes were based on predictions that between 400 and 600 cyclists would ride them each day. The actual number of cyclists using the lanes has been much lower. Snapshot cycle count monitoring indicates less than 280 cyclists use the cycle lanes on a fine day. Reasons for this lower-than-expected uptake of cycling on the cycle lanes may include: limited incentives for Tauranga residents to switch from commuting by car to biking, ongoing significant use by many cyclists of a pre-existing shared cycle/walking path, or the original demand forecasts not being based on suitably realistic evidence or assumptions.

Project delivery

The cycle lanes were progressively introduced in stages over several years, mostly between 2003 and 2008. Deferral of some construction work within this time period increased construction costs and resulted in a higher tender cost for construction work than budgeted. These factors, plus an unexpected need to relocate a water main to widen the road to fit the lanes, meant the final project cost of $2.2 million was 29% higher than originally budgeted.

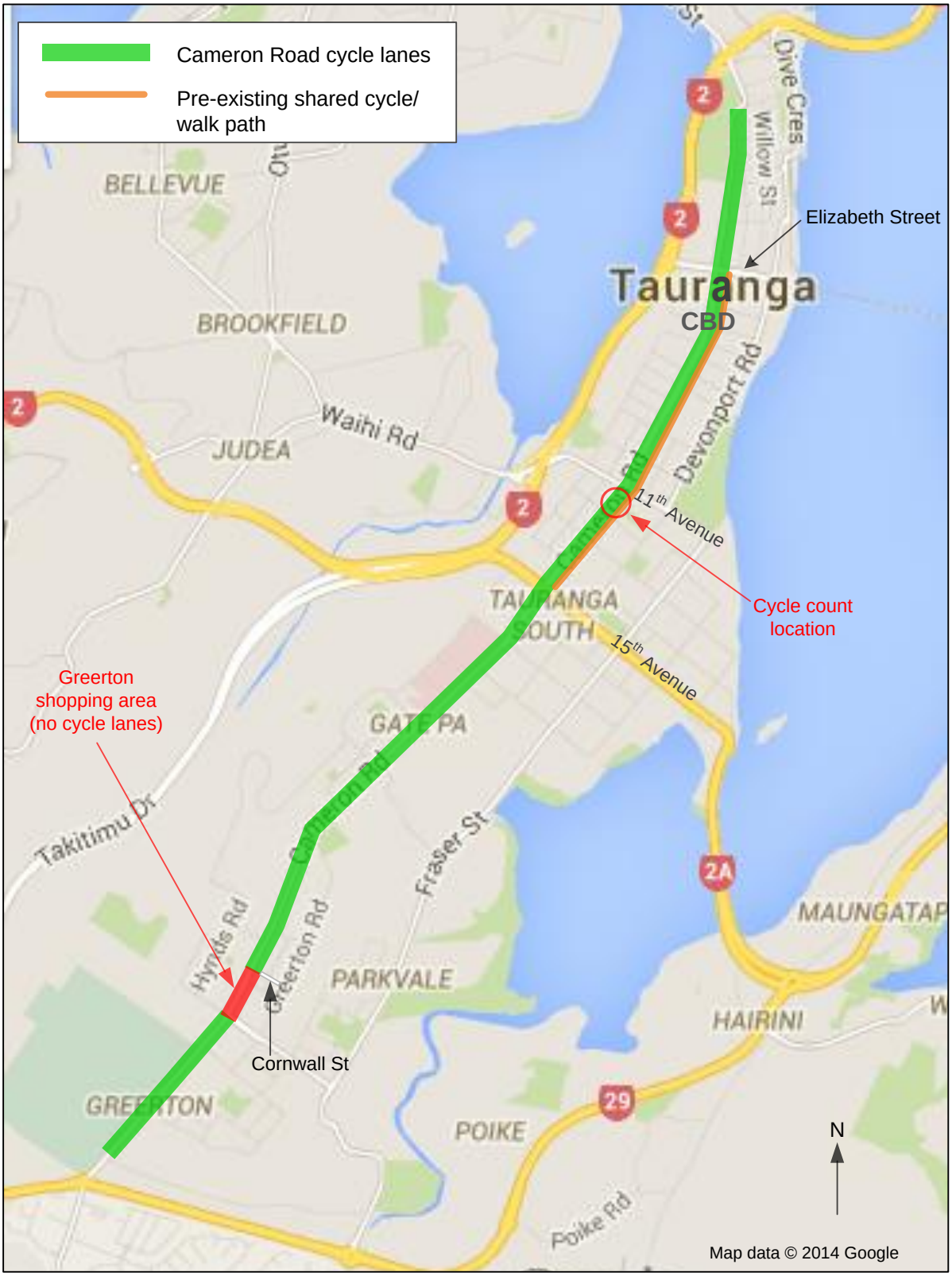
It should be noted provision of cycle lanes along the whole length of Cameron Road is not finished. Funding to complete this is included in Tauranga City Council's draft Long Term Plan (2015-25), with a supporting application to the Transport Agency for a funding subsidy.

Lessons learned and recommendations

Some lessons learned for other projects and the Transport Agency's own processes were identified with this post implementation review. These are summarised here and discussed in more detail in Section 3 of this report, *Lessons learned*:

- Before and after performance monitoring of major projects is good practice for effective evaluation of project outcomes. More comprehensive 'before and after' monitoring of cyclist numbers on Cameron Road would have helped Tauranga City understand how well the cycle lanes are being used, and possibly help identify ways to encourage more people to use them.
- There is scope for the Transport Agency to review the crash reduction factors given in its Economic Evaluation Manual to ensure they take account of up-to-date safety research findings. Time periods should also be required to be stated when percentage reductions in crash rates are forecast. This would aid effective post implementation review of safety outcomes.
- The 'journey approach' being adopted by the Transport Agency should be applied when assessing and investing in cycling projects. This would help ensure cycle lanes or routes are coherent and direct enough to encourage people to use them well.

Figure 1: Location of Cameron Road Cycle Lanes
(Showing completed coverage of lanes as at October 2014)



1. Project benefits

This project constructed cycle lanes along both sides of Cameron Road, Tauranga. Cameron Road is one of Tauranga's main arterial roads. It extends for 7.5 km north to south along Tauranga's main peninsula and connects the city's southern suburbs with the central business district. Several major schools, Tauranga Hospital and many retail and commercial businesses are located along Cameron Road. Figure 1 shows the location of the Cameron Road cycle lanes.

The cycle lanes were progressively introduced onto Cameron Road from 2003 as funding became available, and to coincide with other upgrade work. The lanes now extend for most of the length of Cameron Road, except for a block through the Greerton shopping area (near the southern end of Cameron Road). A combination of existing side car parking facilities, lack of available road width, and roundabouts at either end of this block made it impractical to fit cycle lanes. Options to complete this 'missing link' are currently being explored by Tauranga City Council

The cycle lanes were predicted in the project's Funding Submission to produce two main 'tangible' benefits:

- Safety benefits from reduced crashes involving cyclists along Cameron Road, and
- Health benefits arising from a predicted increase in people cycling.

In terms of the benefit cost ratio (BCR) used to support the project's funding, two scenarios were presented in the Funding Submission. These were based on alternate forecasts of daily usage of the cycle lanes that changed the expected health benefits. In the first scenario, safety benefits made up 62% of the predicted benefits in the BCR, and health benefits the remaining 38% based on an assumption of 600 cyclists using the lanes per day. In the second scenario, lower forecast daily cyclist numbers of 400 per day reduced health benefits to 29% of expected benefits, with safety benefits making up the remaining 71% of predicted benefits. The funding submission also mentioned "intangible benefits for cycling facilities such as recreational, environmental and tourism aspects" but these did not contribute to the BCR.

General assessment of the cycle lanes

The installation of the Cameron Road cycle lanes has provided a high quality cycling facility. They provide a safer environment for cyclists using this busy road, and good direct connectivity for cyclists to and from the central business district.

In general, the cycle lanes have created a good degree of separation of cyclists from motor vehicles along most of the length of Cameron Road. There are a couple of exceptions to this, including the block through Greerton, and also at a roundabout at the intersection with 9th Avenue. Roundabouts are notoriously difficult to safely accommodate cycle lanes and at this intersection cyclists either have to enter into the traffic lanes or move off onto the footpath (see photo 1 in Appendix 1). This latter option is unlikely to be used by experienced commuter or utility cyclists using the lanes as it interrupts the consistent speed they can generally maintain along the rest of the cycle lanes. It was also observed that this roundabout is a significant congestion point in the afternoon peak, making it difficult for cyclists (and also other vehicles from some directions) to ride through without delays.[1]

The cycle lane widths are 1.5m, which meets the desirable widths recommended by *Austroads* for urban roads with posted speed limits of up to 60km/h.[2] Safety strips between the cycle lanes and parts of Cameron Road where there is parallel parking are also mostly within the recommended widths of 0.4m to 1.0m recommended by *Austroads* to protect cyclists from opening car doors. A couple of situations were noted where lack of available street width reduced the safety strips to a minimum (see photo 2 in Appendix 1). It was also observed that some poor parking by motorists

[1] Tauranga City Council have included funding in their draft Long Term Plan (2015-25) to replace this roundabout with traffic signals. This project includes the provision of on-road cycle lanes.
[2] Austroads (2014), 'Cycling Aspects of Austroads Guides,' Australia, Table 4.3 page 31.

too far out from the kerb across the safety strip removed its safety buffer for cyclists from opening doors. But this is not a reflection on the design of the cycle lanes.

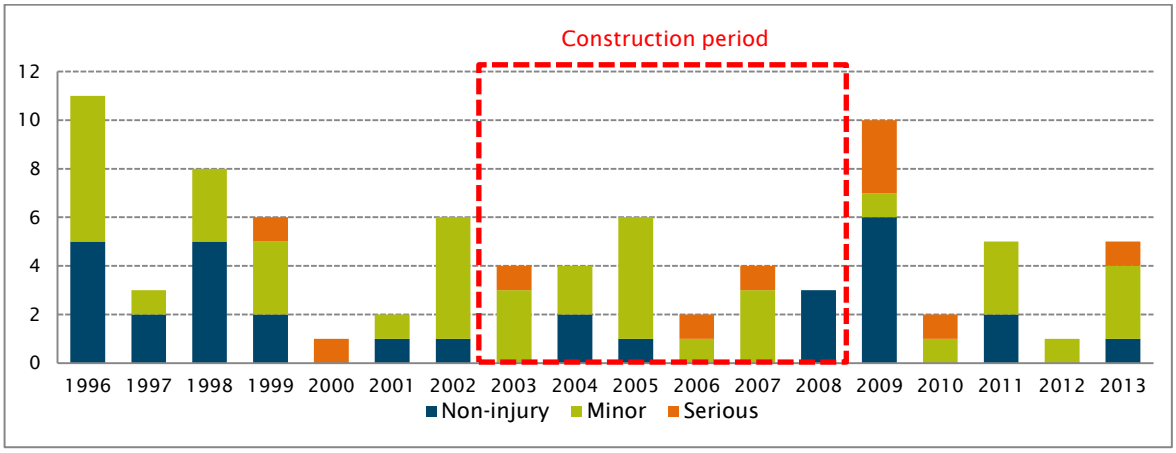
The rest of this section discusses in more detail this review's assessment of how well the cycle lane project has achieved its main expected benefits of improved safety and health benefits from increased cycling activity.

Safety outcomes

Overall, the cycle lanes along Cameron Road have improved safety for cyclists, but not to the extent originally predicted when the project was submitted for funding.

Figure 2 shows that there has been no obvious trend in the incidence of crashes involving cyclists on Cameron Road. The relatively low incidence of these crashes has tended to fluctuate from year to year, both before the cycle lanes (pre- 2003), during their progressive introduction between 2003 and 2008, and in the five years 2009-13 after they were completed.

Figure 2: Crashes on Cameron Road involving cyclists by severity, 1996-2013



A detailed crash analysis was undertaken with this review to test for statistically significant changes in cyclist crashes as a result of the cycle lanes and to try and assess actual safety outcomes against predicted crash reductions. The results of this analysis are summarised below, with more detail provided in Appendix 2.

Injury crashes involving cyclists

Fourteen *injury crashes* involving cyclists were reported in the five years 2009-2013 after the cycle lanes were fully operational. This compares with an estimated 22 crashes that might have been expected based on the crash history for the seven years before installation of the cycle lanes started (in 2003). This is a statistically significant reduction in injury crashes. This means it can be concluded with a high level of confidence that the cycle lanes have contributed to the reduction in injury crashes.

This reduction of injury crashes involving cyclists was adjusted for possible wider trends with the incidence of cyclist crashes using a control group of all cyclist injury crashes in Tauranga City. It is important to do this trend adjustment to help remove the effect of other wider factors that may be influencing the observed crash reduction other than the expected safety improvements from the

cycle lanes.[3] This trend adjustment still resulted in a statistically significant reduction in injury crashes involving cyclists on Cameron Road.

All crashes involving cyclists

All crashes covers both injury crashes plus the added category of non-injury crashes. There has been a small reduction in all crashes involving cyclists on Cameron Road since the lanes were completed. Twenty-three were reported between 2009-13 compared with 26 that might have been expected based on the pre-cycle lane crash history. It cannot be concluded with sufficient confidence that the observed reduction in all crashes involving cyclists can be attributed to safety improvements from the cycle lanes. Instead, the reduction may at least partly be attributable to the random fluctuation that tends to occur with crashes from year to year.

This finding needs to be treated with caution. There is significant under-reporting of cyclist crashes in general, and especially for non-injury crashes. It is highly likely the actual incidence of non-injury cyclist crashes has been higher than reported. But there is no way of determining if the cycle lanes have reduced the incidence of these unreported crashes.

Crashes involving cyclists by type

It was predicted in the project's Funding Submission that the cycle lanes would reduce *crossing manoeuvre* crashes and *manoeuvring* crashes by 80% (and *other* crashes by ten percent). Examples of *crossing manoeuvre* crashes include cyclists being side-swiped by a turning vehicle, or colliding with another vehicle crossing at an intersection. *Manoeuvring* crash examples include cyclists hitting opening doors from parked cars, rear-ending other vehicles, or colliding with other vehicles when changing lanes.

More recent safety research suggests these predictions were overly optimistic. This research has found that cycle lanes reduce overall crashes by between around 10 and 30 percent depending on design standards of the lanes (especially their widths).[4] Ten percent is currently the "typical accident reduction" of cycle lanes used in the Transport Agency's *Economic Evaluation Manual* to guide the evaluation of proposed activities submitted for funding.

Evaluating the actual percentage change in these crash types on Cameron Road was problematic because there was no predefined time period with which to make the percentage change comparison. The actual incidence of these crash types, as apparent from Figure 3, is low overall. This means small changes in crash numbers can produce large variations in percentage changes. It is not apparent from Figure 3 that an 80% reduction in manoeuvring and crossing manoeuvre crashes has occurred.

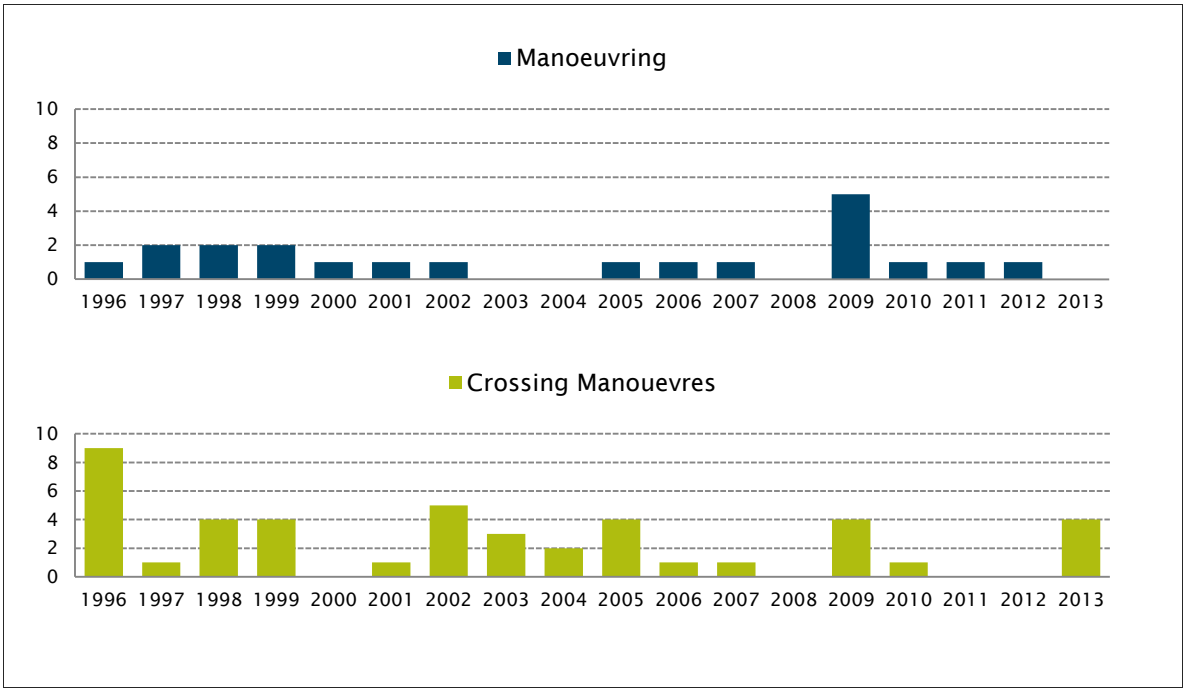
This review therefore compared observed crashes by these types in the post project period with the expected number based on the crash history from 1996-2002. On this basis:

- Manoeuvring type crashes have actually *increased* by a small amount but it is not statistically significant and may be the result of random variation in crashes.
- Crossing manoeuvre crashes have *decreased* by a statistically significant amount. So it can be confirmed with a high level of confidence that the cycle lanes and related treatments of advance stop boxes at some intersections have successfully helped to improve safety for cyclists at Cameron Road's intersections.

[3] For example, there may have been changes in such things as crash reporting rates, vehicle mode shifts, and traffic volume growth, or the influence of road safety and enforcement campaigns which can affect wider trends with cyclist-related crashes.

[4] See Appendix 2 for more information on these research findings.

Figure 3: Crashes involving cyclists on Cameron Road by type



Pedestrian safety on Cameron Road

Cycle lanes can also contribute to improved safety for pedestrians crossing roads because the lanes act as a safety buffer between the kerb and oncoming vehicles in the traffic lane. Crash history involving pedestrians was therefore also evaluated in this review. There were 14 crashes involving pedestrians on Cameron Road between Elizabeth Street and Cornwall Street between 2009 and 2013. This compared with 19 crashes that might have been expected based on the pre-project crash history (1996-2002). This reduction misses out on being statistically significant at the 90% confidence level by only one-too-many crashes. Given that it is a statistically significant reduction using a modestly lower confidence level (such as 80%), it can still be concluded with a sufficient confidence that the cycle lanes have positively contributed to improved pedestrian safety.

Health benefits (from increased cycle usage)

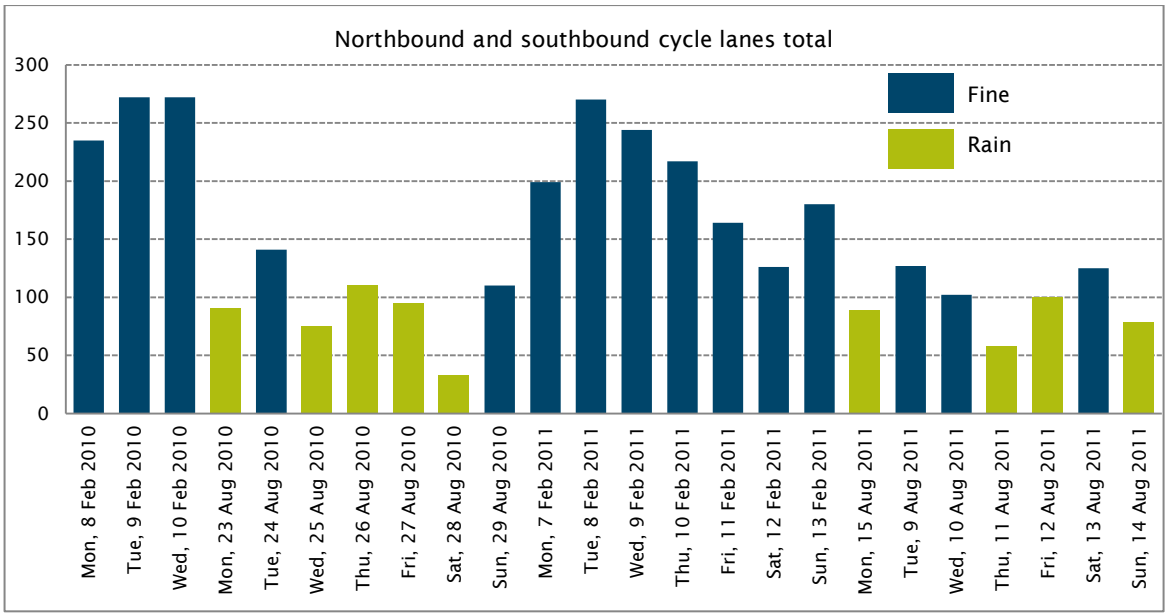
The expected health benefits from the cycle lanes were based on predictions of between 400 and 600 cyclists using the cycle lanes each day. Actual daily cycle lane usage is well below these expected levels and so the predicted health benefits have only at best been partially achieved.

This conclusion is based on limited 'snapshot' cycle count monitoring done on Cameron Road since the cycle lanes were completed.[5] Figure 4 summarises the findings of this monitoring, which is restricted to cycle count surveys done on Cameron Road between 12th and 13th Avenues over single weeks (or part of weeks) in February 2010, August 2010, February 2011, and August 2011.[6]

[5] The cycle lanes were also biked as part of this review in an inter-peak period and observed in the afternoon peak. Observed cycle lane usage during these times was low.

[6] Aside from these cycle count surveys, the only other monitoring available are a handful of cycle counts done on three days in August 2012 at different locations of Cameron Road. However, these surveys only covered the morning and evening peak periods and therefore cannot be easily extrapolated for assessing total daily volumes.

Figure 4: Daily cyclist numbers using Cameron Road Cycle Lanes



Two main observations about usage of the cycle lane are evident from the cycle counts shown in Figure 4:

- The number of daily cyclists using the cycle lanes on the survey days was well below the predicted volumes of 400-600 per day. The highest number of cyclists on any one day was around 270 cyclists. Given that the cycle counts were only done at the single location on Cameron Road between 12th and 13th Avenues, they will have missed other cyclists using only other parts of the cycle lanes. It is therefore reasonable it surmise that total cyclists using the lanes was higher than the number counted. It is unlikely, however, that these extra uncounted cyclists would be high enough to raise total cycle lane usage above 400 cyclists per day. The monitoring location between 12th and 13th Avenues is adequate to capture the majority of cyclists travelling to and from the central business district.
- Bad weather markedly reduces the number of cyclists using the cycle lanes. Cyclist numbers on rainy days monitored were often well below half the volumes on fine days.

Possible reasons for lower-than-predicted cyclist numbers

Explaining why the Cameron Road cycle lanes have not attracted their predicted numbers of cyclists can only be speculative in the absence of detailed knowledge of the behaviour and preferences of Tauranga City commuters. Nevertheless, some possible contributing factors may be considered:

- **Limited incentive for Tauranga motorists to shift transport modes**.
  The relatively high quality of Tauranga City's road network means it is generally easy to travel around the city by private vehicle. Travel time reliability around the city is high. This convenience factor, coupled with good parking facilities and low parking fees in the central business district, reduces the incentive for motorists to shift to alternate transport modes such as cycling (or walking, and public transport). The 2013 New Zealand Census found 90% of Tauranga City residents travelled to work by private or company motor vehicles, compared with a national proportion of 83%.[7]

[7] Statistics New Zealand (2014), '2013 Census tables about a place: Tauranga City', accessed from website www.stats.govt.nz

- **Ongoing preference to use shared path**
  It is also possible that some cyclists that were expected to use the cycle lanes have continued to prefer using a shared walking/cycle path that is on part of the eastern side of Cameron Road (see Photo 3 in Appendix 1).[8] The same cycle count surveys noted above found comparatively high usage of the path. For example, on many of the fine days surveyed around 180 cyclists were counted using the shared path compared with 200 to 270 using the cycle lanes. On rainy days the reduced cyclist numbers overall were relatively evenly spread between the cycle lanes and path.

- **Overly optimistic demand forecasts**
  A third possible contributing factor for why actual cycle lane usage is significantly below predictions may be that the original forecasts used in the project's Funding Submission were overly optimistic. The forecasts were not strongly evidence-based. The submission instead acknowledged that *"little information is available as no surveys have been undertaken recently."*[9] It instead used intersection movement counts done in peak hours to make *"a crude estimate"* that the existing number of cyclists was 300-400 per day. This baseline was then used to conclude that: *"considering the likely higher numbers during school hours, the recognised high recreational use in evenings and weekends, and the expected increase in cyclist numbers with improved cycle facilities, 600-700 cyclists per day may be realistic."*

2. Project implementation

Project timeframe

The Cameron Road cycle lanes were installed in stages over several years starting in 2003. The staged implementation of different sections of the cycle lanes was sensibly coordinated with other road rehabilitation work done on Cameron Road. Funding availability also influenced the timing of installation of different sections of the cycle lanes. The final sections of cycle lane that were part of the project receiving co-funding from the Transport Agency were completed in mid-late 2008. Tauranga City Council has since completed a remaining section of cycle lane north of Elizabeth Street without Transport Agency funding.

Project cost

The cycle lanes project was completed for $2.243 million.[10] This was $502,000 (+29%) higher than the project's originally funded cost of $1.741 million. Factors that contributed to this cost increase were:

- deferral of some project stages by a couple of years resulted in higher construction costs
- a tender sum was higher than originally estimated, and
- there was an unexpected need to relocate a water main to enable the widening of Cameron Road for the cycle lanes.

[8] This possibility was acknowledged in a study examining the feasibility of putting cycle lanes on Cameron Road. The study noted that the existing shared path was well used especially by school children and elderly cyclists. The study envisaged that some of these cyclists would never be confident using the lanes and recommended the shared path be kept after the lanes were constructed. Source: Beca Carter Hollings & Ferner (2001), 'Bicycle/Carparking Lane Study of Cameron Road, page 5.

[9] Beca Carter Hollings & Ferner Ltd (2002), 'Cameron Road Cycle Lanes: Transfund Funding Submission,' page 1.

[10] This total excludes the cost of the remaining portions of cycle lane installed after 2008 which the Transport Agency did not contribute funding.

The contribution of these price escalations to the final project cost is given in Figure 5.

Figure 5: Description of project cost adjustments

Description and explanation of cost adjustments	Date	Cost implications	Revised total project cost
Project cost estimate when funding approved	2002/03		$1,741,000
1. Construction cost increases from deferred project stages	2007/08	+$175,000	$1,916,000
2. Tendered amount higher than budget	2007/08	+$150,000	$2,066,000
3. Relocation of water main to fit cycle lanes	2007/08	+$177,000	$2,243,000
Total final project cost	**2008/09**		**$2,243,000**

3. Lessons learned

This review of the Cameron Road cycle lanes project has identified some lessons learned which can be applied to future projects. This also includes opportunities for improvement with the Transport Agency's own evaluation processes of project funding applications.

Performance monitoring of project outcomes

It is good practice to complete before and after performance monitoring for new infrastructure. In particular, it is essential for effective project evaluation that baseline measures are set to compare against after project completion. This helps evaluate how well a completed project has achieved its expected benefits.

As was noted in Section 1 above, the forecasts of cyclists expected to use the Cameron Road cycle lanes were based on "crude estimates" of pre-existing cyclist numbers. The results of the limited cycle count surveys done since the cycle lanes were completed suggest these estimates were substantially optimistic.

A lesson from the Cameron Road cycle lanes project for future cycling projects is that stronger estimation of pre-existing cycling numbers would have strengthened the basis for the future growth assumptions made. This baseline measurement can be sufficiently achieved through some well targeted cycle count surveys.

There was also scope for more comprehensive monitoring or surveying to be done after the completion of the cycle lanes. This would have helped give Tauranga City Council a better idea of how well they are being used and possibly help identify ways to encourage more people to cycle them.

Improved guidance for crash reduction predictions

The predictions of 80% reductions of manoeuvring and crossing manoeuvring crashes involving cycling were too optimistic. However, it is unclear whether there was suitable guidance available when the project was developed in the early 2000s to achieve more realistic forecasts. For future projects, the Transport Agency's Economic Evaluation Manual has lists of typical accident reduction factors for a range of treatments, but these have not been reviewed since 2006. They

should be revised to take account of more recent safety research and findings around the effect of different treatments on crash reduction.

The absence of defined time periods with this project over which the crash reductions were forecast to occur also made evaluation of safety outcomes difficult. It would be beneficial for the assessment of safety outcomes of projects if time periods are required to be defined as part of the Economic Evaluation Manual's guidance.

Recommendation: that the Transport Agency, with its next review of the Economic Evaluation Manual:

- evaluates and, if necessary, revises the typical accident reduction factors given for different treatments and improvements, and
- considers requiring time periods to be defined when the accident reduction factors are used in benefit cost ratio calculations.

Adopting a 'journey approach' to evaluation of cycling projects

The Transport Agency contributed funding to Tauranga City Council for the construction of most but not all of the sections of cycle lanes on Cameron Road. Some small sections installed after 2008 have been completed by the council without Transport Agency funding.

The Transport Agency is now working on taking a wider "journey" approach to assessment and evaluation of projects. For cycling networks, coherence (connectivity) and directness of routes are important features. It is important that the Transport Agency takes this into account when assessing its funding contributions to cycling facilities.

4. Tauranga City Council's response to findings

The following comments were provided by Tauranga City Council in response to this post implementation review:

Tauranga City Council acknowledges the support from NZTA which has seen the majority of the project delivered in collaborative manner. It is pleasing to note the project has delivered safety benefits to the wider vulnerable road users group, not just cyclists. However, it is acknowledged the predicted numbers in the original business case were, in hindsight, optimistic. The potential reasons for this are highlighted in the report and will be taken into consideration when developing similar projects in the future.

One of the main lessons learned from this project is to ensure enough robust data is collected to measure the success or otherwise of this type of project. A suggestion to NZTA is to require Approved Organisations, as part of their business cases, to include sufficient funding for 'after' monitoring and reporting so that the success of these schemes can be verified.

We believe the project has added significant value to our transportation network and provided travel mode choices to residents and visitors in line with the Tauranga Transport Strategy.

Appendix 1 – Post construction photos

Photo 1: The cycles are continuous along most of Cameron Road. An exception shown here is at the roundabout at the intersection with 9th Avenue. At this location cyclists are directed onto the footpath to navigate through the intersection or have to move into the traffic lane.

Photo 2: Lack of available street width at some parts of Cameron Road has reduced the safety strips to a minimum and requires care by cyclists with the risk from opening parked car doors.

Photo 3: A pre-existing wide shared cycle/pedestrian path extends from Elizabeth Street to 15th Avenue on the eastern side of Cameron Road.

Photo 4: Some observed poor parking out from the kerb reduced the buffer effect of the safety strips between parallel parks and the cycle lanes

Appendix 2: detailed crash analysis

This appendix discusses in more detail the crash analysis and its findings summarised in Section 1 that were used to assess how well the cycle lanes have achieved their predicted safety benefits.

Expected safety outcomes

The reduction of cyclist crashes along Cameron Road was identified in the project's Funding Submission as the dominant "tangible benefit" of the cycle lanes.

More specific crash history noted in the Funding Submission was:

- A number of crash black spots involving cyclists had been previously identified along Cameron Road, especially between 9th Avenue and 20th Avenue.
- Twenty nine crashes involving cyclists were recorded on Cameron Road between Elizabeth Street and Cornwall Street between 1996 and 2000. Two of these were serious injury crashes, 13 minor injury, and 14 non-injury.
- It was assumed that the actual number of crashes involving cyclists was likely to be worse due to typically significant under-reporting of cyclist crashes.

It was predicted that the cycle lanes would reduce *crossing manoeuvre* type crashes and *manoeuvring* type crashes (including cyclists crashing into opening car doors) by 80%.[11] Other crashes involving cyclists along Cameron Road were predicted to be reduced by ten percent.

Crash analysis coverage

It is preferable with analysis of crashes before and after a project to focus on high severity (fatal and serious) crashes. However, with no fatalities and two serious injury crashes involving cyclists, there were too few of these crash types along Cameron Road to enable significant conclusions to be made. Therefore, all injury crashes and all crashes involving cyclists were analysed.[12]

Three periods were used for the crash analysis:

- A pre-project '*before'* period between 1996 and 2000 which the crash data used in the project's Funding Submission was based on;
- A '*between'* period 2001-02 covering the two years between the end of the before period and the start of implementation of the first sections of the cycle lanes (in 2003); and
- A post project *'after'* period from 2009 to 2013 with the cycle lanes in place.

Crashes from the construction period between 2003 and 2008 were excluded as it is impractical to evaluate the safety outcomes of the cycle lanes when they had been only partially introduced. It is also prudent with crash analysis to exclude crashes from the construction period as the construction activity itself can influence observed crash factors and types. However, it is acknowledged that the excluded construction period of six years in this case (2002-2008) is unusually long due to the staged implementation of the cycle lanes.

Two crash datasets were analysed:

- Crashes involving cycles along Cameron Road between its intersection with Elizabeth Street to the north and Cornwall Street to the south. This was the section of Cameron Road used in the project's funding submission.[13]

[11] See Section 1 for examples of these crash types.

[12] All crashes includes reported fatal, serious, minor injury, and non-injury crashes.

[13] This covers around 5km (two-thirds) of Cameron Road's 7.5km length. Excluded is around 900m of Cameron Road at its northern end (north of Elizabeth Street) and about 1.6km of its southern end (south of Cornwall Street). CAS records show that between 1996 and 2013 there were 12 crashes involving cyclists at the excluded northern end of Cameron Road and nine crashes at the southern excluded end.

- All crashes involving cyclists in Tauranga City were used as a control group to assess the potential effect of wider regional crash or reporting trends on the observed number of crashes at the project location.

Injury crashes involving cyclists

Injury crashes and crash rates involving cyclists on Cameron Road are summarised in Figure A1, along with trend correction results using the control group of all crashes involving cyclists in Tauranga City.

Figure A1: Injury crashes involving cyclists on Cameron Road

	Before period (1996-2000)	Between period (2001-2002)	After period (2009-2013)	Expected in after period	Poisson Result*
	5 years	2 years	5 years		
Cameron Road injury crashes	25	6	14	22	0.04
Injury rash rate	5.0	3.0	2.8		
Injury crashes in Tauranga City (control group)	165	40	136		
Cameron Road injury crashes trend corrected using control group				21	0.08

* A Poisson probability distribution of less than 0.1 indicates that the observed reduction in injury crashes is statistically significant at the 90% confidence level.

There were 14 injury crashes involving cyclists on Cameron Road in the five years between 2009 and 2013 after the cycle lanes had been put in place. This is a crash rate of 2.8 crashes per year and compares favourably with a crash rate of 5.0 crashes per year in the before period (1996-2000) and 3.0 in the between period (2000-01).

On the basis of the crash history 1996-2002 before the cycle lanes were started, it was estimated that 22 crashes might have been expected between 2009 and 2013. The actual result of 14 crashes is therefore a positive outcome. This injury crash reduction was tested using the Poisson distribution to determine whether the reduction was large enough that it is likely to be the result of safety improvements from the cycle lanes and not within the normal expected variations in crashes that happen by chance.[14] This confirmed that the reduction in injury crashes involving cyclists is statistically significant at the 90% confidence level.

The reduction of injury crashes since completion of the cycle lanes was also adjusted using all injury crashes involving cyclists in Tauranga City. This was to correct for any wider crash trends with the incidence of crashes involving cyclists that may have influenced the observed crash reduction on Cameron Road. This trend adjustment reduced the expected number of crashes in the 'after' period marginally from 22 to 21. Based on this, the actual number of crashes between 1999 and 2013 is still a statistically significant reduction using the Poisson distribution at the 90% confidence level.

[14] Crashes tend to vary randomly over time in a way that is best represented by the Poisson distribution. The Poisson distribution applies when a relatively small number of uncommon independent events occur over a set time period.

All crashes involving cyclists on Cameron Road

Figure A2 widens the analysis to include *all crashes* involving cyclists on Cameron Road. There were 23 recorded crashes involving cyclists in total between 2009 and 2013 after the cycle lanes were completed. This is a marginal decrease compared to the 26 crashes that might have been expected based on the crash history from 1996-2002 before the cycle lanes started to be introduced. This decrease is not statistically significant at the 90% confidence level. This means the reduction may be at least partly attributed to the chance variation in crash numbers rather than necessarily an improvement resulting from the cycle lanes.

Correcting for any possible wider trends in cyclist-related crashes using the control group of all crashes in Tauranga City involving cyclists also results in the observed reduction in crashes on Cameron Road not being statistically significant.

An important caveat on these findings for all crashes involving cyclists is they are more likely than the injury crashes dataset to be susceptible to the significant effects of under-reporting of cyclist crashes. This is because the all crashes dataset includes non-injury crashes, which is the crash severity type most prone to under-reporting.[15] It is highly likely that there have been more non-injury cyclist crashes on Cameron Road than has been reported. There is no way of determining if the cycle lanes have reduced unreported non-injury cyclist crashes.

Figure A2: All crashes involving cyclists on Cameron Road

	Before period (1996-2000)	Between period (2001-2002)	After period (2009-2013)	Expected in after period	Poisson Result*
	5 years	2 years	5 years		
Cameron Road crashes	29	8	23	26	**0.29**
Crash rate	5.8	4.0	4.6		
Crashes in Tauranga City (control group)	253	60	176		
Cameron Road crashes trend corrected using control group				21	**0.73**

* A Poisson probability distribution result of more than 0.1 indicates that the observed reduction in injury crashes is *not* statistically significant at the 90% confidence level.

Cyclist crashes on Cameron Road by type

All crashes on Cameron Road involving cyclists were also grouped by type into crossing manoeuvre, manoeuvring, and other crash types. These were the groupings used in the project's funding submission. As noted earlier, the cycle lanes were predicted to result in the following percentage reductions in these cyclist crash types:

- crossing manoeuvre: 80% reduction
- manoeuvring: 80% reduction, and
- other: 10% reduction.

There are two reasons why it is problematic to evaluate how well actual crash incidence has compared against these reduction forecasts. First, the Funding Submission did not define a time

[15] Except for a few exceptions, the Crash Analysis System (CAS) database only includes crashes that have been reported to the police.

period for which the percentage reductions could be assessed against. The actual percentage changes in crashes by type will therefore vary depending on which time period is used.

Second, the actual incidence of cyclist-related crashes by these types on Cameron Road is relatively low. Therefore small changes in crash numbers can result in wide variation in percentage changes. This is apparent from Figure A3, which shows that based on a comparison of before and after crashes specifically stating cyclists crashing into opened car doors, there was a 50% reduction in these crash types. But had there been one crash of this type between 2009 and 2013 instead of the actual two crashes, the percentage change would change from a 50% to 75% reduction.

Figure A3 shows that using a comparison of the period 2009-2013 after the cycle lanes were completed with the before period 1996-2000 used in the Funding Submission have not produced the predicted percentage reductions in crashes. There was no percentage change in manoeuvring type crashes, a 50% reduction in crossing manoeuvre crashes, and other crashes involving cyclists actually increased by 50% (but this is also based on the low incident of these other crashes and a change of only three crashes).

Cycle safety research done more recently than when the cycle lanes project was planned (in the early 2000s) suggests the predictions of 80% reductions in manoeuvring and crossing manoeuvre crashes were overly optimistic. A research report published in 2009 observed that overseas research found that cyclist crashes reduced from between 35% to 50% with the installation of on-road cycle lanes.[16] But using crash data collected from cycle lane locations at three New Zealand cities (excluding Tauranga), the study also found that locally a much smaller reduction of around ten percent was likely from provision of cycle lanes.

Even more recent local research suggests that the conclusion of a ten percent reduction may be too conservative since it was based on some sites with reasonably substandard cycle lane designs. Cyclist crash reductions of around 30% may be achieved from cycle lanes if they have widths of around 1.7 to 1.8 metres. This is wider than the 1.5m lane width used on Cameron Road, but this width was the recommended standard at the time and remains Austroads' 'desirable' width for exclusive cycle lane dimensions on urban roads with posted speed limits of 60 kmh.[17]

To try and overcome the difficulties with using percentage changes for assessing safety outcomes, the same analysis methodology used for examining injury crashes and all crashes involving cyclists was used (see Figure A3). This produced the following results:

- There has been a marginal *increase* in manoeuvring type crashes involving cyclists, but this is not statistically significant and therefore may be the result of chance variation of crash incidence.
- There has been a statistically significant *decrease* in crossing manoeuvre crashes. This indicates the cycle lanes and related treatments of advance stop boxes at some intersections have successfully improved safety for cyclists at Cameron Road's intersections.
- There has technically been a statistically significant increase in other crash types involving cyclists, but the overall incidence of these crashes is very low (only three crashes recorded since the cycle lanes were completed) that their incidence may be the result of chance variation.

[16] Turner S, Binder S, and Roozenburg A (2009), 'Cycle Safety: Reducing the Crash Risk', NZ Transport Agency research report 389, Wellington.

[17] Austroads (2011), 'Cycling Aspects of Austroads Guides,' Australia, page 26.

Figure A3: Cameron Road crashes involving cyclists by type

	Before period (1996-2000)	Between period (2000-2001)	After period (2009-2013)	Expected in after period	Poisson Result*	% change before period and after period compared
	5 years	2 years	5 years			
Manoeuvring crashes (including crashes into opened vehicle doors)	8	2	8	7.1	0.7	0%
Crashes specifically identified as cyclists crashing into opened vehicle doors	4	1	2	3.6	0.3	-50%
Crossing manoeuvre crashes	18	6	9	17.1	0.02	-50%
Other crashes involving cyclists	3	0	6	2.1	0.99	+50%

- * When there has been a ***reduction*** in crashes compared with what is expected based on previous crash history, a Poisson probability distribution result of less than 0.1 indicates that the reduction is statistically significant at the 90% confidence level. When there has been an ***increase*** in crashes compared with what was expected, a Poisson probability distribution result of more than 0.9 indicates that the reduction is statistically significant at the 90% confidence level.

Crashes on Cameron Road involving Pedestrians

Cycle lanes can also improve pedestrian safety. This is because the cycle lanes can provide a safety buffer between the kerb and the traffic lane for pedestrians stepping out onto a road to cross. In some cases, the provision of cycle lanes has resulted in a bigger reduction in pedestrian crashes than cyclist crashes.

Crashes involving pedestrians on the same stretch of Cameron Road used for the cyclist crash analysis were therefore also analysed to test for any significant safety improvements (Figure A4).

There has been a recorded decrease in crashes involving pedestrians since the cycle lanes were completed. There were 14 pedestrian related crashes between 2009 and 2013, less than the 19 crashes that might have been expected based on the pre-cycle lane crash history. This crash reduction is not statistically significant at the 90% confidence level, but only just. One less crash 2009-13 would have made the reduction statistically significant. It is therefore a borderline conclusion that the cycle lanes may have contributed to improved pedestrian safety on Cameron Road.

Figure A4: All crashes involving pedestrians on Cameron Road

	Before period (1996-2000)	Between period (2001-2002)	After period (2009-2013)	Expected in after period	Poisson Result*
	5 years	2 years	5 years		
Cameron Road crashes involving pedestrians	20	7	14	19.3	**0.14**

* A Poisson probability distribution result of more than 0.1 indicates that the observed reduction in injury crashes is *not* statistically significant at the 90% confidence level.