Post Implementation Review

East Taupo Arterial (Taupo Bypass)

Taupo District Council

2017

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

The East Taupo Arterial project constructed a 16km two lane arterial link bypassing Taupo township. The project was built by Taupo District Council, with agreement with the NZ Transport Agency that it would eventually become part of State Highway 1. Completed in 2010, the bypass was finally designated part of SH1 in 2015.

Taupo bypass objectives have been achieved...

Overall, this post implementation review found the bypass project achieved its expected benefits of improved travel times, reduced heavy vehicle traffic through Taupo, and increased local amenity values.

The bypass has substantially improved travel times for people traveling between south of Taupo and Wairakei, north of the township. Average travel times on the bypass are up to six and a half minutes less than on the previous State Highway route along the Lake Taupo waterfront and through the town's central business district.

Around 4000 less vehicles now travel through Taupo on a daily basis since the bypass opened. This includes around 800 fewer trucks through the CBD each day.

Although difficult to objectively evaluate without the availability of baseline performance indicators, this review has concluded that amenity values in Taupo (that is, how pleasant and appealing the local environment is) have improved as a result of the project. Observational evidence for this includes a quieter environment for people staying at the many motels and hotels along the lakefront, and reduced CBD traffic making the area a more pleasurable experience for pedestrians.

Safety was not a defined objective of the East Taupo Arterial project, but this review found crashes have reduced significantly on the old SH1 route since the bypass opened. However, a relatively high crash rate on the bypass itself has generated concern. This has prompted plans for safety improvements on the arterial. These improvements are likely to include a wire rope median barrier along its full length. It is important to note, however, that the bypass was originally designed and constructed to the safety standards used at the time.

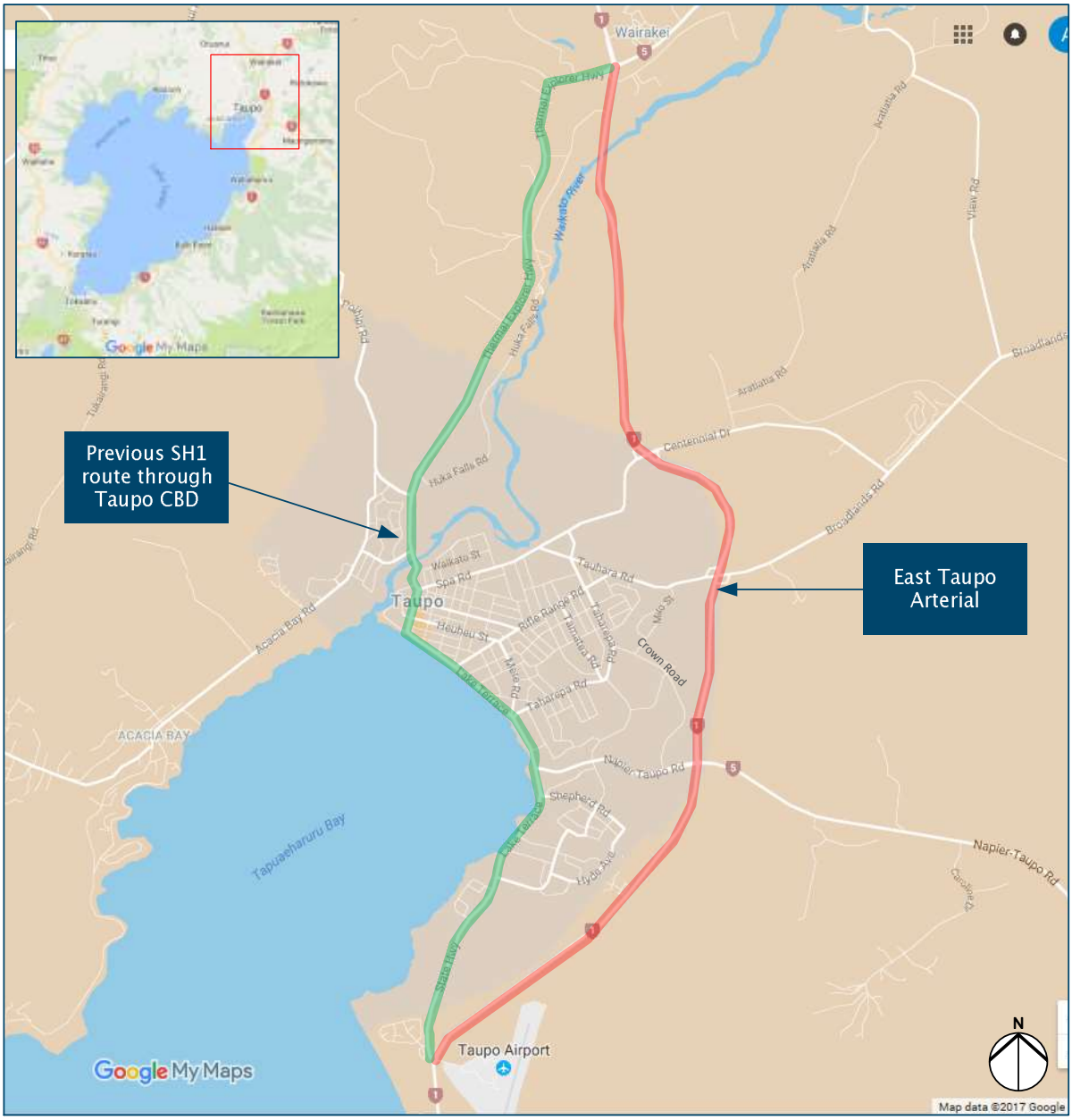
...but scope changes significantly increased project costs

The East Taupo Arterial was completed and opened to traffic nearly half a year ahead of schedule in late 2010. However, this did not reduce its overall cost as a number of major scope changes made during construction substantially increased costs. The final project cost upon completion was $131.5 million, 20% higher than originally budgeted.

Most significant of the scope changes was an extra $10 million required to rebuild three roundabouts on the bypass. The original roundabouts were designed to existing standards by Taupo District Council, but the Transport Agency required their reconstruction to make them larger so that traffic could travel through them at a higher operating speed. Other scope changes included the need to provide an access road between the bypass and Taupo's industrial area, and changes to the pavement type used.

There are lessons learned from these scope and cost increases. These are discussed in Section 4 of this report.

Figure 1: East Taupo Arterial location map



1. Project benefits

Project description

The East Taupo Arterial ('the bypass') is a two lane arterial link bypassing Taupo, east of the township. The bypass' southern start is at a roundabout next to the Taupo Airport. From there it extends 16km north, ending at another roundabout intersecting with SH5 at Wairakei. There are three additional intersections along the bypass: a roundabout connecting with the SH5 Napier-Taupo highway, and two grade separated connections into Taupo at Centennial Drive and Broadlands Road. Figure 1 on page 3 shows a location map of the bypass as well as the previous highway route.

The bypass includes northbound and southbound passing lanes and a shared walking-cycling path alongside the highway. Two bridges at the northern end of the bypass carry the highway over the Waikato River and the Contact Energy Wairakei geothermal field.

Construction of the bypass began in October 2008 and it was opened to traffic in October 2010. Before the opening of the bypass, inter-regional SH1 traffic was required to travel along the Lake Taupo waterfront and through the Taupo town centre.

The bypass was declared a part of State Highway 1 in July 2015. The old state highway was handed over to Taupo District Council at the same time to become a local road.

Expected benefits from the bypass

The main objectives of the bypass project were to:

- reduce travel time and vehicle operating costs by creating a high speed road with limited access points,
- divert heavy vehicle traffic away from the Taupo town centre, residential and accommodation areas, and the lake front, and
- increase amenity values in Taupo

The key expected benefits used in the economic evaluation (benefit cost ratio) to support its funding were dominated by expected travel time savings. These made up 90.2% of the expected benefits, with vehicle operating cost savings contributing 9.1%, and emissions reduction benefits the residual 0.7%.

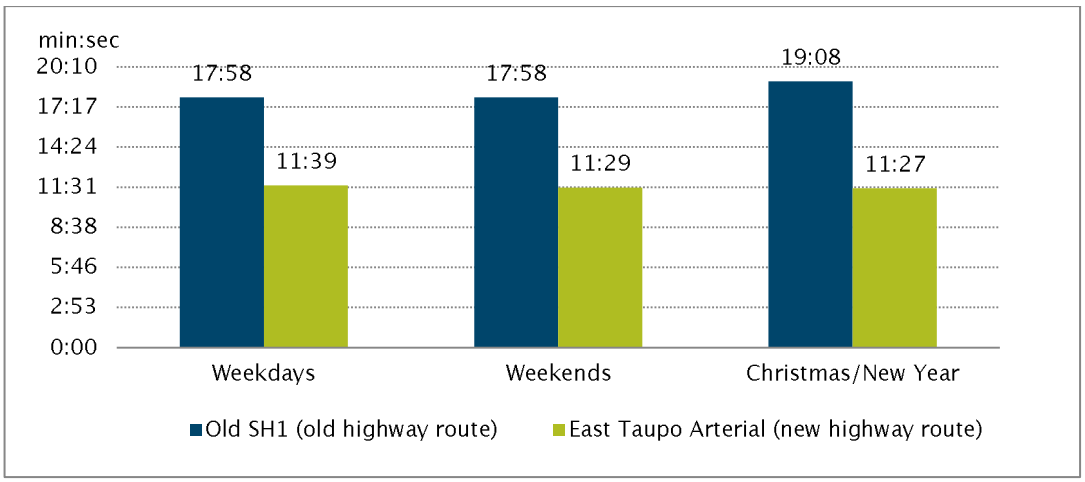
Travel time saving benefits have been achieved

The bypass has substantially improved travel times between south of Taupo to Wairakei.

By bypassing the Taupo township, the East Taupo Arterial has successfully reduced the average travel time it takes to drive the approximately 16km distance from near the Taupo Airport to the SH1/SH5 intersection at Wairakei by more than six minutes. This is evident from figures 2 and 3, which compare average travel times both northbound and southbound on the bypass with the previous highway route along the lake front.[1]

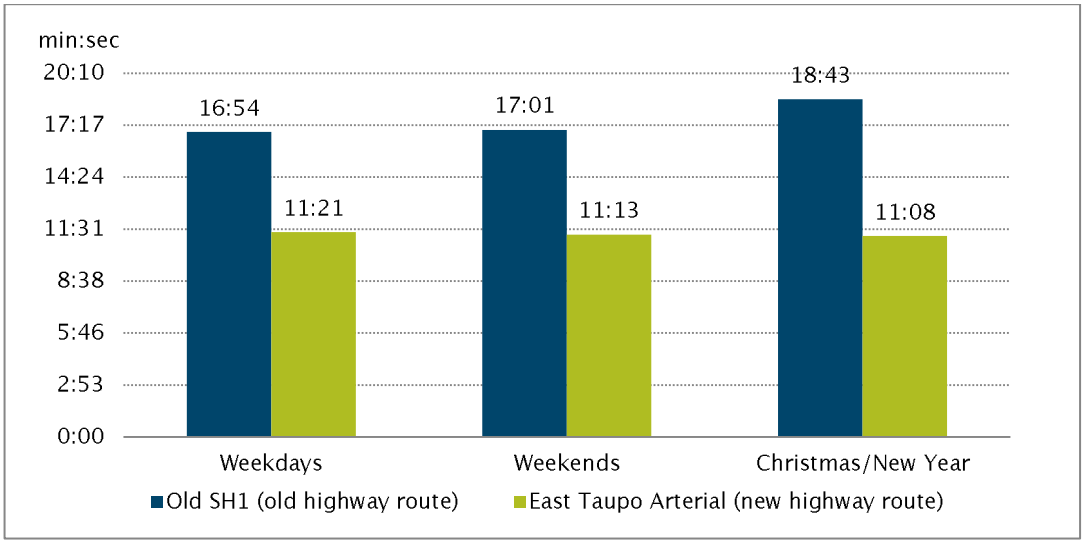
[1] For both routes, the journeys analysed are as shown in figure 1 between the southern roundabout adjacent to Taupo airport and the SH1/SH5 intersection at Wairakei. This review used traffic data from the TomTom Traffic Stats database to evaluate this project's travel time outcomes. This database is a collection of anonymised floating car data taken from TomTom navigation devices, in-dash systems, and apps. Its data goes back to 2008.

Figure 2: Average northbound travel times for East Taupo Arterial bypass and old SH1 for northbound traffic, 2015



Source: TomTom Traffic Stats

Figure 3: Average southbound travel times for East Taupo Arterial bypass and old SH1



Source: TomTom Traffic Stats

The average travel times on the bypass compared to the old SH1 route are around 6–6.5 and 5.5 minutes less for northbound and southbound traffic respectively on weekdays and weekends.

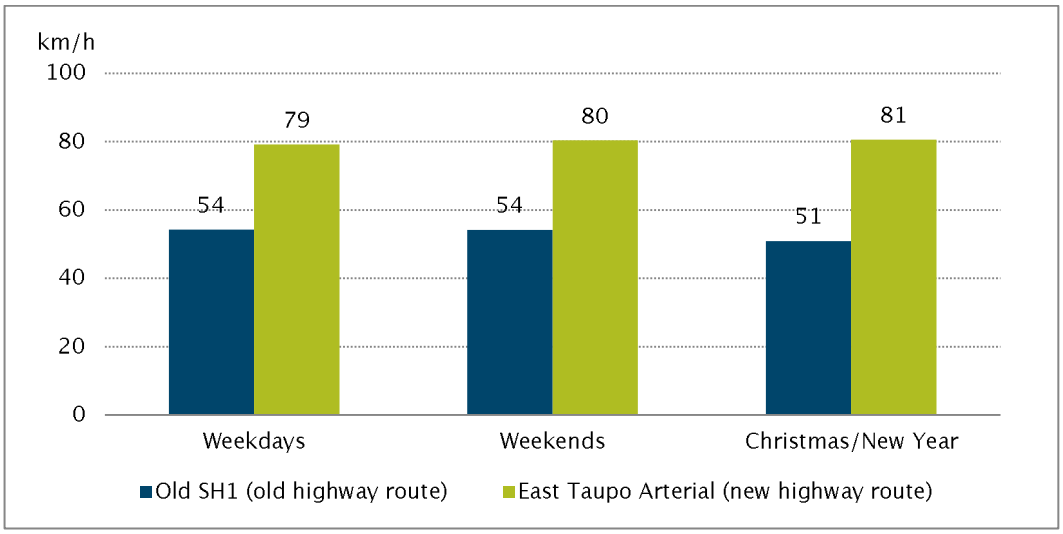
Since Taupo is a major holiday destination, travel times over the busy Christmas/New Year period when the township experiences large increases in traffic were also analysed (see figures 2 and 3). Increased traffic around Taupo over the holiday period appears to have had no material impact on travel times along the bypass. But, as might be expected, it increases average travel times on the old highway route along the lakefront and through the township by 1–2 minutes.

The bypass and the previous highway route are nearly the same length of 15–16km. The significant travel time savings for traffic using the bypass are therefore the result of its higher (100km/h) speed environment. In contrast, the previous state highway route has a mix of speed limits, ranging from 50km/h through Taupo to 80–100km/h north of the

township. There is also periodic congestion and signalised intersections within the township which slows through-traffic. The effect of these factors are apparent in figure 4, which compares average speeds on the alternate routes.[2]

Speeds on the old SH1 route tend to average out at between 51-54 km/h overall, while bypass traffic averages speeds of around 80 km/hr.

Figure 4: Average speed comparison – East Taupo Arterial bypass and old SH1 for northbound traffic, 2015



Source: TomTom Traffic Stats

The bypass has helped reduce traffic volumes on the old SH1 route...

Traffic count data from two sites was analysed to help assess the effect of the bypass on local traffic volumes. The first site was near the control gate bridge on the old SH1 route immediately north of the Taupo town centre. The second site is towards the southern end of the bypass, between its southern two roundabouts. Figure 5 summarises available traffic volume data from these sites used in the commentary below.

The opening of the bypass in October 2010 has resulted in a significant and sustained reduction in traffic heading in and out of Taupo township from the north on the old SH1 route. On average around 28,000 vehicles used this route each day in the five years before the bypass opened. Since opening, the average daily traffic has fallen to around 24,000 vehicles (2011-14). That this remains a busy high volume route in and out of Taupo is partly explained by strong residential housing growth north-west of the township (including in Acacia Bay and Kinloch). Tourist traffic also uses the old route since it forms part of the "Thermal Explorer Highway" that accesses local tourist attractions such as the Huka Falls.

Traffic volume data is not available on the bypass itself for the early years after it opened (2011-12). But more recent counts show traffic using the bypass has grown steadily, from nearly 5,500 vehicles per day in 2013 to more than 6,000 in 2015.

...and it has successfully diverted heavy vehicles away from the town centre

Available traffic counts for heavy vehicles show the bypass project successfully met its objective to divert trucks away from Taupo's town centre.

[2] The average speeds shown in figure 4 are for northbound traffic. However, the results for southbound traffic were almost identical.

The proportion of heavy vehicles to total traffic using the old SH1 route has generally decreased since the bypass opened (down from 7.7% in 2010 to 5.0% in 2014). Comparing estimated heavy vehicle numbers in 2009, the year before the bypass opened, with 2011, the first year after opening, indicates that the bypass helped remove around 800 trucks a day from travelling through the town centre.

The bypass itself is heavily used by trucks, as evident in figure 6. Around 1,400 heavy vehicles used the bypass on a daily basis in 2015. More than one in five vehicles (22%) on the bypass are trucks or other heavy vehicles. This proportion is at the high end observed for state highways (where typically the proportion of heavy traffic to total traffic is around 4–11%).

While the bypass has substantially reduced heavy vehicle traffic through Taupo's town centre, trucks are obviously still needed and used within the town to support its local commercial and industrial activities. Taupo's relatively central position within the North Island means it is also a stopover or driver-swap location for some trucking and freight companies. Many trucks on inter-regional journeys therefore still enter Taupo rather than simply bypass the township on the East Taupo Arterial.

Figure 5: Comparison of traffic volumes – bypass and old SH1 route [a]

	Old SH1 Route				East Taupo Arterial Route			
	AADT[b]	YoY % Change	% Heavy	Heavy Volume[c]	AADT[b]	YoY % Change	% Heavy	Heavy Volume[c]
2005	28,195	-1.3%						
2006	28,879	2.4%						
2007	29,255	1.3%	7.4%	2,165				
2008	27,829	-4.9%	6.0%	1,670				
2009	28,465	2.3%	6.6%	1,879				
2010	24,881	-12.6%	7.7%	1,916	*Bypass opened October 2010*			
2011	24,021	-3.5%	4.3%	1,033				
2012	23,695	-1.4%	3.4%	806				
2013	24,494	3.4%	4.6%	1,127	5,475		22.3%	1,221
2014	23,887	-2.5%	5.0%	1,194	5,905	7.9%	22.0%	1,299
2015					6,113	3.5%	22.8%	1,394

[a] Traffic counts for the old SH1 route are taken from 20m north of the Control Gate bridge located immediately north of the Taupo township. Traffic count data for the bypass route is taken between the Broadlands Road roundabout and the SH1/SH5 Napier–Taupo highway roundabout.

[b] Annual Average Daily Traffic

[c] Estimated from percentage of AADT which classified as Heavy vehicles.

Source: NZ Transport Agency, *State Highway Traffic Data Booklets*

Figure 6: Trucks heavily use the bypass, diverting them from Taupo township

Source: Site visit observation, February 2017.

Crashes have reduced on the previous SH1 route through Taupo

Improved safety through predicted crash cost savings was not an identified objective in the bypass project's benefit cost ratio (BCR) used to support its funding approval. This is unusual for an project of its size and nature.

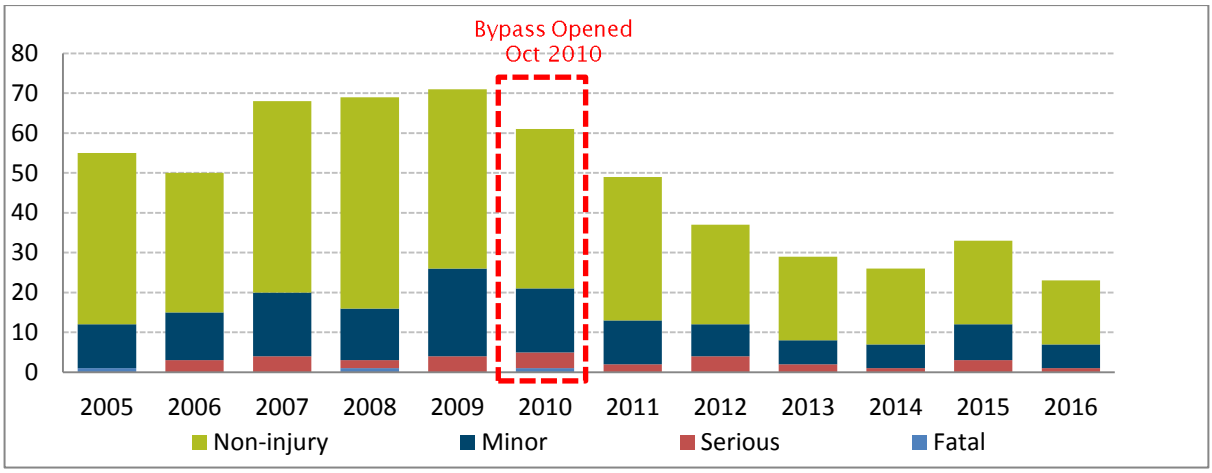
Nonetheless, this post implementation review still examined safety outcomes resulting from the bypass; for two reasons:

- It is reasonable to expect that the reduction of traffic volumes and trucks on the old SH1 route as result of the bypass might have helped improve safety on the route, and
- Concern about a high crash rate on the bypass since it opened has prompted the NZ Transport Agency to actively investigate intervention options for improving safety.

Safety has improved on the old SH1 route via the lake front and through the Taupo township. The crash rate on the old SH1 route has nearly halved from 62 crashes per year over the period January 2005 to October 2010 to 35 crashes per year recorded in the six years since the opening of the bypass in early October 2010. Figure 7 shows the trend of total crashes on the old SH1 route and how it has declined since the bypass was opened.

The reduction in crashes on the old SH1 route since the bypass opened is statistically significant. This means it can be concluded with sufficient confidence that the observed decline in crash incidence is a trend of improved safety and not merely the result of random fluctuations with crashes. It is difficult to 'go the next step' and explicitly attribute this safety improvement specifically to the effects of the bypass' introduction. Nevertheless, it is reasonable to conclude that the significant reduction in traffic volumes observed on the old SH1 route since the bypass opened will have helped contribute to the reduction in crashes.

Figure 7: Crashes on old SH1 route by severity 2005-16



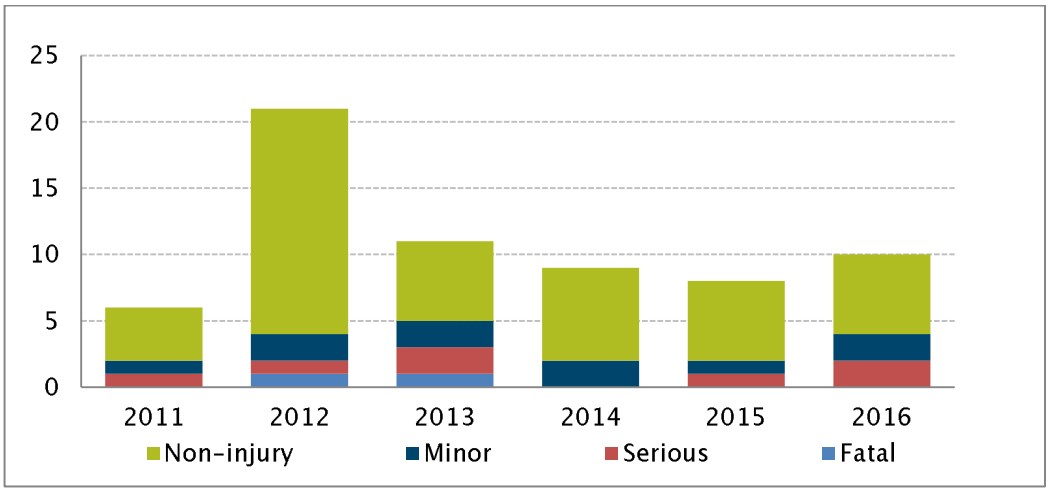
Source: NZ Transport Agency, Crash Analysis System (CAS)

Crashes on the Eastern Taupo Arterial have generated concern...

There has been a relatively high crash rate on the Eastern Taupo Arterial since it opened. Figure 8 shows the trend in crashes by severity between 2011 and 2016. There were 65 crashes reported on the bypass over this period, including two fatal crashes and seven serious injury crashes.

It is apparent from figure 8 that there was an upward spike in non-injury crashes in 2012 which has not been repeated since. Analysis of the specifics for these non-injury crashes identified that driver-related factors dominated over environmental factors with their cause. Poor observation was identified as a crash factor in nearly two-thirds of the crashes. It should be noted, however, that it is problematic to draw clear conclusions from the incidence of non-injury crashes as their reporting is highly variable. The observed spike may also have been the result in the random fluctuation that tends to occur with crashes.

Figure 8: Crashes on ETA Bypass by severity 2011-16



Source: Source: NZ Transport Agency, Crash Analysis System (CAS)

…prompting plans for bypass safety improvements

Planning was underway by the Transport Agency (as at March 2017) to address the bypass' high crash rate with a project of safety improvements. The bypass had been identified as requiring action in the short term as part of the Agency's *'National Programme Business Case – Safer Journeys – Delivering Safer Roads and Roadsides.'*[3]

Business case planning to support the project of safety improvements identified that the main problem needing to be addressed with the bypass was:

> *"poor driver behaviour and an unforgiving environment has resulted in a poor safety record along the corridor."*[4]

In particular, these factors had resulted in many of the crashes involving loss of control, centreline crossing, and overtaking.

The majority of crashes have occurred on the northern section of the bypass between the Broadlands Road Intersection and the Wairakei roundabout.[5] This is apparent from figure 9, which maps the location of bypass crashes recorded between 2011 and 2016. Also evident from figure 9 is:

- the concentration of crashes at the bypass' intersections and interchanges, especially the Wairakei and Napier–Taupo Highway roundabouts,
- a concentration of the fatal and serious injury crashes around the Centennial Drive interchange, and
- an absence of any crashes recorded on the southern section of the bypass between the southern Memorial Drive roundabout and the Napier–Taupo highway roundabout.

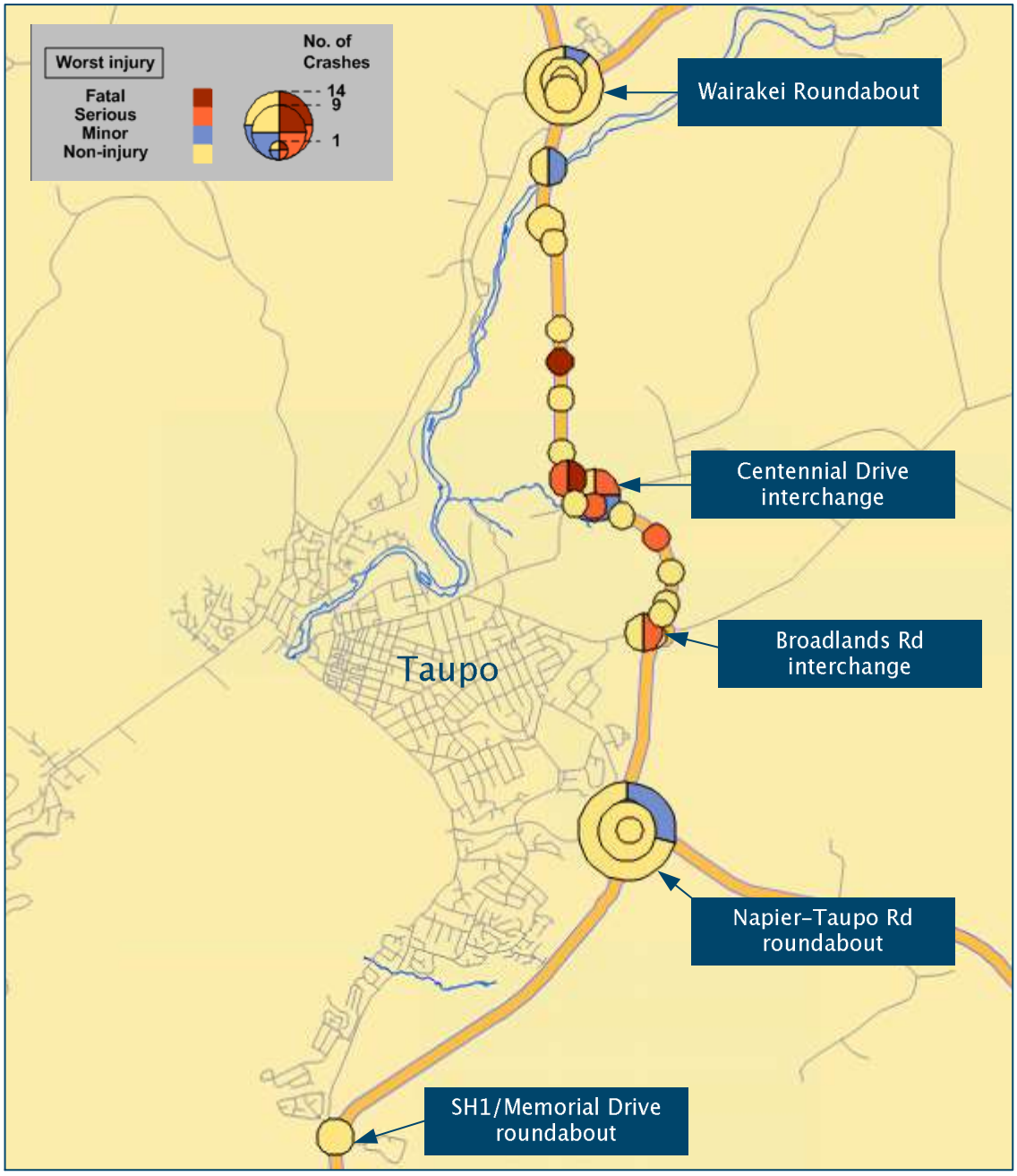
At the time of this review, the preferred safety improvements being proposed for the bypass included:

- the construction of a 1.5m centreline with wire rope barrier along its full length,
- audio tactile pavement marking on edge and centre lines over its northern bridges,
- roadside barriers at highest risk sites, and
- improvements to signs, markings and landscaping at each roundabout[6].

It should be noted in conclusion for this review's safety outcomes section that the bypass was designed and constructed in 2008–10 to the safety standards used at the time. Subsequent advancements with design standards and guidelines under the *Safe System* approach mean equivalent highway projects built today would include such features as wire rope median barriers.

[3] NZ Transport Agency, Highways and Network Operations (2015) *Business Case for pre-implementation – Detailed Business Case to proceed from Initiation to pre-Implementation – SH1 East Taupo Arterial Corridor Improvements.*
[4] Ibid, Executive Summary.
[5] Ibid, pp15-19.
[6] Ibid, pXXX1

Figure 9: Map of reported crashes by severity on East Taupo Arterial, 2011-16



Source: Source: NZ Transport Agency, Crash Analysis System (CAS)

Amenity values are likely to have improved but difficult to objectively evaluate

One of the predicted benefits of the East Taupo Arterial was to increase amenity values in Taupo township. Amenity values can be broadly described as a location's features which make it pleasant and appealing to people.[7]

More detailed explanation of how the bypass project would increase amenity values was not available for this post implementation review. It is reasonable to assume, however, that increased amenity values were likely viewed as an expected by-product of moving state highway traffic (especially trucks) away from the township.

Evaluation of the outcomes with this project objective is limited to subjective observations from the site visit and anecdotal evidence. This is because suitable before and after performance measures for amenity value were not defined and monitored for the bypass project.[8] Setting up such measures is an identified lesson learned for other future projects aiming to increase amenity values – see *Section 4 Lessons learned* below.

Observational and anecdotal examples of increased amenity values include:

- The many motels and hotels along the lakefront have quieter accommodation for visitors with the reduction in trucks using the route (especially overnight).
- Reduced traffic along Tongariro Street in the CBD (the former SH1 route) has created a more pleasant environment for pedestrians and shoppers.
- Concerns by township businesses that the bypass would adversely affect their business do not appear to have eventuated. There were some reports of reduced business turnover when the bypass opened in late 2010. But it also opened during the height of the global financial crisis, which depressed Taupo tourist visitor numbers and local holiday home construction. Business conditions subsequently improved with wider economic recovery.

2. Project implementation (construction cost and timeframe)

Construction of the bypass was completed earlier than planned…

Construction of the bypass started in October 2008. It was completed and opened to traffic five months ahead of schedule in October 2010.

In an unusual arrangement for the time, Taupo District Council constructed the bypass as a local road, but on the assumption it would later be handed over to the Transport Agency (then Transit) to manage as a state highway. A Heads of Agreement signed between the Council and Transit acknowledged this arrangement. It set the Council as the 'Principal' with the Transport Agency a key stakeholder able to request scope variations if needed. Under this arrangement the Council was required to build the bypass to suitable standards to become a state highway.

The Transport Agency funded 76% of the project's cost, with Taupo District Council contributing the remaining 24%.

[7] More specifically, the Resource Management Act 1991 defines amenity values as *"those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes."*

[8] Examples of performance measures which might have been considered include: pedestrian counts in affected areas of township, visitor numbers/satisfaction ratings from lakefront motels and hotels, indicators of local business turnover, noise ratings/monitoring.

...but rebuilding of roundabouts significantly increased the project's cost

The cost of building the bypass was 20% higher than budgeted.

The original estimated total cost for the bypass project was $109.8 million. This was made up of the following components:

- Construction costs: $98.22 million
- Property acquisition costs: $6.56 million, and
- Investigation and design costs: $4.99 million.

The final project cost upon completion was $131.5 million, 20% ($21.8 million) higher than budgeted. This cost increase was driven by four significant construction cost scope adjustments (figure 10).

Figure 10: Construction cost escalations

	Cost additions	Total cost
Project construction costs at approval		**$98.22m**
Subsequent scope adjustments:		
1. Crown Road realignment and link to SH5	$3.07m	
2. Roundabouts reconstruction	$9.85m	
3. Foamed Bitumen pavement	$3.77m	
4. Unforeseen additional costs	$5.10m	
Project construction on completion		**$120.02m**
Construction cost variation	**+$21.79m (+22.2%)**	

Crown Road realignment and link to SH5

Crown Road and adjoining streets form a light industrial area immediately west of the middle section of the bypass (figure 1). Before the bypass was constructed Crown Road connected directly to the SH5 Napier–Taupo highway. This enabled trucks servicing the industrial area direct access to the stage highway.

Early project designs originally proposed a replacement connection with Crown Road on the bypass 400m north of the SH5 Napier–Taupo highway roundabout. But this was removed from the designs after concerns were raised in an early road safety audit.

Issues with severance of the southern end of Crown Road from SH5 as a result of the bypass were not fully recognised until after construction had begun. Concerns raised centred on the impact lack of direct access between the industrial area and SH5 would have on heavy traffic having to go through local residential areas. A decision in late 2009 to add to the bypass project the realignment of Crown Road to directly link it to SH5 added $3.07 million to the project's costs.

Roundabouts redesign and reconstruction

The demolition and rebuilding of the three roundabouts on the bypass in 2010 before it had opened added $9.85 million to the project's cost. This was the largest single contributor to the project being completed over budget.

The Transport Agency got the Council to halt work on the roundabouts after members of the heavy transport sector raised concerns about the adequacy of their design. They were concerned that the roundabouts were too small for large trucks to get round. A Transport Agency investigation found the Council was meeting 'Principal's Requirements' under their Heads of Agreement, and the contractor was building the roundabouts to approved standards. However, the design adopted by the Council was for an operating speed of 15km/h through the roundabouts to reduce crash risk. The Transport Agency did not consider this would deliver a sufficient operating speed to meet service levels appropriate for a state highway. It subsequently funded 100% of the costs to rebuild the roundabouts to wider dimensions with a higher operating speed.

Foamed Bitumen Pavement

A decision in mid-2010 to use a Foamed Bitumen Pavement on the bypass added $3.77 million to project costs. The contractor and the Transport Agency supported this scope change because it offered the best Net Present Value (NPV), lower maintenance costs, and the least risk of premature failure compared with other options (Taupo District Council was not involved in this decision). Unfortunately, some of these benefits were partly eroded by the pavement being applied in autumn, a less-than-desirable time of year for this pavement type. This was done to accelerate completion of the bypass, but has resulted in some remedial work being subsequently required to address premature pavement rutting.

Unforeseen additional costs

A range of unforeseen additional costs involved with construction added $5.10 million to the total project construction costs. These additional costs included such items as additional culvert and underpass work relating to numerous Contact Energy steam pipe crossings, relocation of services, and bridge widening.

3. Good practice identified

The East Taupo Arterial has been designed and constructed so that there is provision along a lot of its length (although with pinch points) for widening to four lanes in the future traffic demand warrants it. This is good future proofing which was built into the project.

4. Lessons learned

There are lessons with relevance for other future projects stemming from the East Taupo Arterial project. A couple of these have previously been identified and acted upon, but are worthwhile repeating here.

Transport Agency control of project delivery for roads to become state highways

The nearly $10 million increase in project cost for the rebuild of the roundabouts required Transport Agency Board committee approval. A lesson learnt from this cost blow-out was a committee decision that if a road is to become a state highway after completion then the project should be delivered by the Transport Agency. In the case of the East Taupo Arterial, Taupo District Council built the original roundabouts to acceptable existing standards but at a lower operating speed design than wanted by the Transport Agency.

State Highway revocations and declarations need to be appropriately signalled for financial accounting

The East Taupo Arterial was transferred from Taupo District Council to the Transport Agency to become a state highway in mid-2015. Although this revocation/declaration was long planned, its financial implications for the Transport Agency's financial accounting (along with another state highway section) were not appropriately declared. This resulted in a "high risk" priority audit finding by the Agency's external auditors in 2016 because nearly $300 million of unbudgeted additional expense and just under $100 million unbudgeted revenue appeared in the financial statements. The auditors recommended the Transport Agency consider and budget for the financial impact of any expected revocation/declaration of state highway sections as part of submitting project business cases for approval. In response, the Transport Agency has implemented, as an interim measure, a manual process to value declarations and revocations each year.

Oversight with bypass planning overlooking key road connection

The $3 million cost to rectify omission of a connection between Taupo's Crown Road industrial area and the bypass (see Section 2 above) should have been avoidable. It was unclear from this post implementation review how this oversight occurred. A lesson from this for other bypass projects is to ensure that all changes to access to adjoining sites are clearly considered and built into construction design where necessary.

5. Taupo District Council's response to findings

The Taupo District Council's feedback and comments on this review's findings were sought before this report was finalised. Some minor amendments to the report were made as a result. Additionally, a council representative confirmed that:

- the facts disclosed have been stated correctly
- no facts material to an issue have been omitted, and
- no unfair inference has been made, either generally or specifically.

Appendix 1: Detailed crash analysis

This appendix discusses in more detail the crash analysis and its findings summarised in Section 1 which was used to assess how well the East Taupo Arterial bypass project affected crash numbers.

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, there were too few of these along both the old SH1 route and the bypass to enable significant conclusions to be made. Therefore, all crashes were analysed.

As the bypass was a completely new road and did not affect traffic during construction, only two periods were used for the crash analysis:

- A pre-project opening '*before*' period from January 2005 until 8 October 2010
- A post project opening '*after*' period from 9 October 2010 to 9 October 2016.

Three crash datasets were used:

- Crashes along the old SH1 route from the just after the turnoff near the Taupo Airport along the lake front through town to just before the intersection of SH1/SH2 at Wairakei.
- Crashes along the bypass from the just after the turnoff near the Taupo Airport to just before the intersection of SH1/SH2 at Wairakei.
- Crashes recorded as occurring on all roads in the Taupo District were used as a control group to assess the potential effect of wider regional crash or reporting trends on the observer number of crashes on the studied sections of road.

Crashes on old SH1 route

Figure A1 summarises the analysis of *all crashes* on the old SH1 route covered by the crash analysis.

On the basis of the crash history in the nearly 6 years before the ETA was opened, it was estimated that 373 crashes could have been expected after the ETA opened in the period between October 2010 and October 2016. The actual result of 213 crashes is therefore a substantial reduction on the expected number, which is statistically significant at 90% confidence using the Poisson distribution. This means that it can be concluded that the reduction in crashes since the ETA Bypass was opened were very likely an outcome of vehicles using the safer alternative route, and not merely the result of chance variation in the underlying crash rate.

Figure A1: All crashes analysis table

	Before period (Jan 2005 - 8 Oct 2010)	After period (Oct 2010 - Oct 2016)	Crashes expected in after period
	5.8 years	6 years	
Old SH1 Route	361	213	373
Crash rate (crashes per year)	62.24	35.50	
old SH1 route - all crashes trend corrected using control group of all road crashes in Taupo District			287

To test whether the observed reduction in crashes at the site area have been affected by wider trends in crash rates, the results were also trend adjusted using a control of all road

crashes reported in the Taupo District. On this basis, it would have been expected that less crashes – 287 – might have been expected than without trend adjustment. This is also a statistically significant reduction in crashes, and strengthens the conclusion that the ETA Bypass has diverted some traffic from the old SH1 route and improved safety along this stretch of road.

Overall crashes on combined route

Figure A2 summarises the analysis of *all crashes* on the old SH1 route and the new ETA Bypass covered by the crash analysis. It also shows all crashes for the old SH1/SH5 intersection on the Napier Taupo road for the before period compared with the new SH1/SH5 roundabout on the ETA Bypass.

On the basis of the crash history in the nearly 6 years before the ETA was opened, it was estimated that 374 crashes could have been expected after the ETA opened in the period between October 2010 and October 2016. The actual result of 258 crashes is therefore a substantial reduction on the expected number, which is statistically significant at 90% confidence using the Poisson distribution. This means that it can be concluded that the reduction in crashes since the ETA Bypass was opened were very likely an outcome of vehicles using the safer alternative route, and not merely the result of chance variation in the underlying crash rate.

Figure A2: All crashes analysis table

	Before period (Jan 2005 - 8 Oct 2010)	After period (Oct 2010 - Oct 2016)	Crashes expected in after period
	5 years	3 years	
Combined site crashes	362	258	374
Crash rate (crashes per year)	62.41	43.00	
Combined route - all crashes trend corrected using control group of all road crashes in Taupo District			287
SH1/SH5 Napier/Taupo Intersection	9	12	9
Crash rate (crashes per year)	1.55	2.00	

To test whether the observed reduction in crashes at the site area have been affected by wider trends in crash rates, the results were also trend adjusted using a control of all road crashes reported in the Taupo District. On this basis, it would have been expected that less crashes – 287 – might have been expected than without trend adjustment. This is also a statistically significant reduction in crashes, and strengthens the conclusion that the ETA Bypass has improved safety for vehicles travelling via Taupo.

Crashes at SH1/SH2 Napier–Taupo Intersection

In addition to the combined old and new SH1 roads being assessed, the number of crashes on the old SH1/SH5 Napier–Taupo intersection on the lake front was compared to the new intersection which is part of the ETA bypass. On the basis of the 5.8 years of crash history it was estimated that 9 crashes could have been expected after the ETA opened in October 2010 and October 2016. The actual result of 12 crashes is an increase in the expected number, but it is not deemed to be statistically significant at 90% confidence level using the Poisson distribution. This means that the increase in crashes may be due to chance variation in the crash rate and not necessarily attributable to the new ETA bypass. The subsequent SH1 East Taupo Arterial Corridor Improvements project plans to make improvements to all roundabouts along the ETA.