Department of Transport and Main Roads (North Queensland)

Bruce Highway Action Plan – Cattle & Frances Creeks Upgrade Project

Technical Analysis Report

Technical Analysis Report

Final Issue | 14 April 2014

Job number 231518-00

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Document Verification

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Job title	Bruce Highway Action Plan – Cattle & Frances Creeks Upgrade Project	**Job number**	231518-00
Document title	Technical Analysis Report	**File reference**	
Document ref	Technical Analysis Report		

Revision	**Date**	**Filename**	Technical Analysis Report[B]		
Draft 1	12 Nov 2013	**Description**	First draft for initial TMR comment.		
			Prepared by	Checked by	Approved by
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		Signature			
Draft 2	16 Dec 2013	**Filename**	Technical Analysis Report[D]		
		Description	Second draft for TMR review incorporating TMR comments received from Lindel Ryan on 26 Nov 2013 & Tony How Lum on 12 Dec 2013.		
			Prepared by	Checked by	Approved by
		Name	Donald Ewen, Lee Hudson, Aida Bartels, Rachel Brazier	Lee Hudson	Murray Kretschmer
		Signature			
Draft 3	21 Jan 2014	**Filename**	Technical Analysis Report [F]		
		Description	Third draft for final TMR review incorporating TMR comments received from Lindel Ryan on 20/23 Dec 2013 & Tony How Lum 15 Jan 2014.		
			Prepared by	Checked by	Approved by
		Name	Lee Hudson	Lee Hudson	Murray Kretschmer
		Signature			

Final	21 March 2014	**Filename**	Technical Analysis Report [G]		
		Description	Final issue incorporating final TMR review comments received from Lindel Ryan on 12 March 2014.		
			Prepared by	Checked by	Approved by
		Name	Lee Hudson	Lee Hudson	Murray Kretschmer
		Signature			
		Filename	Technical Analysis Report_FINAL[H].docx		
Final Issue	14 Apr 2014	**Description**	Final issue including update to section 2.13.		
			Prepared by	Checked by	Approved by
		Name	Lee Hudson	Lee Hudson	Murray Kretschmer
		Signature			

Issue Document Verification with Document ✓

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Background

The proposed Cattle and Frances Creeks (CFC) project is approximately 4.8km in length and is located some 100 km north of Townsville and 10 km south of Ingham. The project is aimed at specifically improving flood immunity and safety on the Bruce Highway (Townsville to Ingham) section and Bowen to Ingham link of the Brisbane to Cairns corridor. The project section currently has poor reliability and connectivity for at least one-third of each year (December – March), due to its existing poor flood immunity level of approximately Q1 – Q2.

The NB2 submission previously prepared by TMR was based on 2007 flood modelling data, which indicated that this section of critical highway experiences a Time of Closure (TOC) of 72 hours in a Q50 event and an Annual Average Time of Closure (AATOC) of 15 hours. The CFC project aims to address the highway's deficiencies between the existing Pennas Road intersection and the Pomona Road Intersection, just south of the existing township of Toobanna.

Project Outcomes

The project's primary objective is to significantly improve corridor connectivity and reliability between the North Queensland service centre of Townsville and the dependent rural community of Ingham, and on the overall Bowen to Ingham link. Ingham is increasingly dependent on access south to Townsville, to support its key regional industries of sugar and tourism, as are some rural communities further north. As the Bruce Highway has poor flood immunity both south and north of Ingham, the project would also contribute towards improved reliability and connectivity on the Ingham to Cairns section. Overall the poor reliability results in increasing detrimental economic and social impacts.

The project is effectively governed by a set of Bruce Highway Action Plan (BHAP) and other TMR 'Vision Standards' which target a consistent and suitably robust approach aimed at providing significant improvements on the Bruce Highway with regards to flood immunity, connectivity, reliability and safety, without creating significant social and environmental impacts of the project on the surrounding area and communities.

In addition to the 'Vision Standards' the project also has a set of Project Service Requirements which need to be achieved, which are the key outcomes desired for the project by TMR. These primarily relate to the provision of improved levels of flood immunity, accessibility, connectivity, safety whilst minimising social and environmental impacts. The Project Service Requirements identified include:

i. Achieve flood immunity BHAP Vision Standards for the Bruce Highway (Townsville – Cairns) section, to provide a consistent link improvement to the highway's reliability and connectivity for freight and passenger traffic;

ii. Provide an acceptable level of certainty about flood immunity improvements that can be achieved;

iii. Improve accessibility to the Port of Townsville to cater for current export commodities and their inputs (and flexibility to cater for export tasks that may emerge at short notice);

iv. Support economic growth by reducing disruption to key regional industries of sugar, horticulture and tourism, which rely on year-round reliability of access south of Ingham;

v. Improve connectivity and access to services between rural community and regional centre (Ingham and Townsville);

vi. Provide a level of design constructability that reduces Indirect Job Costs;

vii. Improve safety, taking account of the mix of traffic types and fatigue issues;

viii. Contribute to the achievement of link and corridor flood immunity improvements within the medium term, by developing a cost-effective solution;

ix. Minimise social impacts (such as afflux and resumptions) and environmental impacts (including water and habitat quality); and

x. Develop a “fit for purpose” solution which gives due consideration to durability, resilience and safety of ageing bridge assets, in the context of potential future loadings, Vision Standards for width and whole-of-life costs.

Option Descriptions

During the previous stage of the project, two main types of options were identified and assessed, these being infrastructure and non-infrastructure solutions. Although the non-infrastructure solutions (silt removal & removal of waterway weeds) are currently preferred by some local stakeholders, these solutions are only seen as offering ‘short-term’ benefits which may provide a limited temporary reduction in time of inundation and associated length of flooding closures, and do not provide the level of flood immunity certainty which an infrastructure solution would provide in comparison. For that key reason a strong focus has been placed on further assessing infrastructure based options, as highlighted in the TMR Project Brief, which included:

i. Preferred NB2 Option (On line regrade of highway in southern section, utilise existing Frances Creek bridge, move to new off-line highway in northern section and provide new off-line bridge at Cattle Creek);

ii. SASR Sub-option, the same as Preferred Option, but replace existing Frances Creek Bridge with a new wider bridge off-line to the east; and

iii. SASR Sub-option, the same as Preferred Option, but widening the existing Frances Creek Bridge.

In addition to the above, three additional alternative options were also identified and considered briefly, in the early stages of the Business Case development process. These options including the on-line replacement of Frances Creek Bridge and provision of new levee’s to the west of the existing carriageway, had the potential to complement any of the above options, leading to varying degrees of reduced new highway infrastructure works being required. However, none of these options were regarded as viable and as such; all were discarded early in the process.

Given that the project has previously been assessed (at a high level) to suitably inform the NB2 submission, a reasonable amount of existing project data already existed, which was subsequently reviewed to better inform the technical analysis and options assessment phases of the Business Case development stage.

Given the establishment of the Project Service Requirements, the options to be considered and the existing project data already available, the technical analysis and assessment of options could then be further developed with a high degree of certainty in terms of project scope, understanding and number of options to be considered, which will then ultimately best inform the Business Case submission, which is to be prepared to support the potential future delivery of the project.

Technical Analysis

The technical analysis undertaken by the multi-disciplinary project team has remained strongly focused on achieving the desired Project Service Requirements. The key project outcomes of increased flood immunity associated high level of certainty and providing improved levels of safety are understood as the key project drivers. In addition, the technical assessment undertaken has also remained focused on achieving a value for money design solution by investigating numerous design related opportunities without compromising project, safety, stakeholder or budget requirements.

The project team realised earlier in the assessment of each respective key technical discipline that an integrated approach was critical to achieving the desired outcomes, which led to the convening of a Design Integration Workshop and adoption / maintenance of a Design Integration Register and Key Decision Register throughout the Business Case development stage, to help ensure that the project developed in a transparent, focused and collaborative manner.

In particular, the focus was on integrating the four key components of hydraulic, civil, environmental and stakeholder management. The project context included the Cattle Creek Wetlands Rehabilitation Study, which criticised the existing road and rail bridges as having inadequate waterway openings and contributing to changed hydrology due to weed and sedimentation problems. It also included stakeholder concerns (adjacent landowners) regarding potential for increased time of inundation, changed local flow patterns, afflux and resumptions.

Given the sensitive location of the project, within the extents of an existing Wetland Protection Area and the Great Barrier Reef Catchment Area, the comprehensive and rigorous approach to environmental assessment was key to ensuring the Business Case was ultimately suitably informed in terms of likely impacts, appropriate mitigation measures being identified/adopted and associated risks being highlighted and appropriately controlled. The existence of Mahogany Glider habitat (in the vicinity of Frances Creek Bridge) as well as local Cultural Heritage issues on the project site, also further reinforced the aforementioned approach being required to ensure the project was being suitably managed.

To support the reduced impact of the project on the surrounding environment and help lower the capital cost and risk exposure of the project, the project ‘footprint’ was reduced wherever possible. This meant making best use of the existing highway asset, ensuring the proposed geometrical layouts remain within the existing road reserve and achieving the optimal balance of improved flood immunity vs. cost outcome. Given the numerous design iterations undertaken the project team are confident that this fine balance has been successfully achieved. This process was further informed by considering key constructability issues early in the design life cycle to ensure there were no inherent risks associated with the future delivery of the project. This was largely achieved by adopting efficient on-line pavement treatments for the southern section of the project and proposing mainly off-line pavement and bridge works for the northern section so traffic impacts would be kept to a minimal level.

The technical assessment completed has been a combination of reviewing existing project data, undertaking additional field investigation works, efficient application of design standards and ensuring liaison on project critical design with key TMR specialists took place (e.g. independent flood model validation by TMR Director of Hydraulics and seeking early agreement to bridge proposals by TMR Bridge Branch Deputy Chief Engineer).

The level of technical assessment undertaken is commensurate with the requirements necessary to suitably inform a robust concept design proposal for reference in the Business Case submission, to ensure all key technical disciplines have been addressed, to achieve a high degree of certainty with regards scope, risk and costs associated with the options assessed. This means that, ultimately, a well-informed comparative assessment can then be undertaken and a sound and robust recommendation can be proposed.

Options Assessment

With regards to the existing Frances Creek widening option and the Frances Creek Bridge (on-line replacement), these options were discarded early in the Business Case development process due to major associated issues including constructability difficulties, unacceptable level of risk and potential major detrimental impacts on maintaining existing traffic flows during the construction stage.

The two alternative levee options identified were also discarded as they are not a preferred method of achieving the level of desired flood immunity certainty the project requires. These alternative options also have the potential to raise significant opposition in terms of support from public, stakeholders which potentially, may erode political support which the project currently has. Refer to Appendix E Hydraulic Assessment Report, for further details on this matter.

In summary, of all the options identified and considered to varying extents, only the preferred NB2 option and SASR sub-option (New Frances Creek Bridge off-line) were taken forward into the full MCA process for further comparative assessment, due to their full alignment with the Vision Standard and Project Service Requirements criteria.

Design Optimisation/Value for Money

Various different design opportunities have been identified, investigated and assessed to ensure only the most efficient and cost effective design solutions were adopted in the Preferred Option design solution recommended. The assessment undertaken was based on a range of criteria including performance, constructability, environmental, maintenance, risk and cost considerations. As a result, it is deemed that only minimal design refinement will be required to the Recommended Business Case Option during the detailed design phase, and the Business Case, therefore, has a corresponding high level of associated scope, cost and delivery certainty.

Further design refinement at detailed design stage will primarily relate to the optimisation of the exact locations and sizes of all cross-drainage structures. This refinement will further maximise the hydraulic performance, while minimising project risks associated with social (resumptions and afflux issues) and environmental impacts of the project. Further refinement of the proposed Cattle Creek Bridge structure pier and abutment arrangements may also lead to relatively minor additional improvements in hydraulic performance in the northern section of the project.

In addition, as part of the next phase of the project, it is strongly recommended that a detailed topographical survey be undertaken to further 'calibrate' the preferred design solution and to confirm the accuracy of the existing survey data used during the concept design development stage.

Multi-Criteria Assessment

The multi-criteria assessment process adopted by the integrated project team, to govern the comparative assessment of the short-listed options, is clearly demonstrated to fully align with the Project Service Requirements, reduces the subjective scoring of each option, transparently records the associated decision making process and provides suitable justification as to why the recommended option has been chosen in comparison to the other options considered.

The full MCA process was carried out on the Base Case, the NB2 option (with 437m long Cattle Creek Bridge) and the SASR sub-option (with Frances Creek Bridge off-line).

Furthermore, the process also clearly highlights and records several of the key design decisions taken by the project team, the rigour in which these decisions have been reviewed and validated and also demonstrates the areas of the project targeted, where an increased value for money outcome has been successfully achieved.

The preferred option has been shown to achieve the various Project Service Requirements, scores well in comparison to other options considered and can also be delivered within the critically important project budget constraints of $105m (2012 prices, excluding escalation).

Preferred Option Design Refinement

As a result of a minor additional design refinement of the Preferred MCA Option (elongation of Cattle Creek Bridge extents from 437m to 506m), post MCA, an increased level of flood immunity has been achieved (in the order of Q8 - Q17), which is an improvement on the previously identified level of flood immunity of Q5, associated with the preferred option. This increase in the level of flood immunity provided has led to further improved projects benefits being achieved, which include increased flood immunity, further improved section connectivity / reliability and wider associated social and economic benefits. No additional risks have been identified as a consequence of this relatively minimal design change.

Recommendation

Given that the Refined Preferred MCA Option (now known as the Business Case recommended option) meets all Project Service Requirements and is within the agreed budget constraint of $105m (2012 prices), this Report recommends that the refined preferred option should now be considered by the IIC for consideration to approve the project to progress through Major Project Gate 3 (Approval of Business Case) of the PAF governance process. This would provide a sound basis for the project to ultimately progress to construction implementation stage, once funding is made available.

1 Introduction

1.1 Project Background

The Cattle and Frances Creeks section of the Bruce Highway is considered the second worst flooding trouble spot on the Townsville to Cairns section, in terms of frequency of flooding. It is also one of the worst spots for prolonged closures. The root cause is a very poor level of existing flood immunity and the potential for flooding during the wet season makes the section unreliable for approximately 4 months of the year.

Figure 1 - 2013 Flood Photo, Cattle Creek (looking north to Toobanna)

The Cattle and Frances Creeks Upgrade project is one of four candidate projects in the North Queensland Flood Immunity Bridge Package that was submitted for funding consideration in the Federal Government's Nation Building 2 (NB2) Program in October 2012. NB2 runs from 2014-15 to 2018-19. It is also a candidate project under the State Government's Bruce Highway Action Plan (BHAP) "Out of the Crisis" (October 2012).

The basis of the NB2 submission for the Package was to address poor reliability concerns on the Bowen to Ingham link. The link has poor reliability due to flooding that affects the following:

- North Queensland's supply chain;
- Access to two of Queensland's five major ports (Townsville and Abbot Point);
- The self-drive tourism industry;
- Accessibility to essential services for local communities to the north; and
- Disaster relief and/or reconstruction efforts after significant natural events.

Overall, the poor reliability results in increasing detrimental economic and social impacts.

The goal of the North Queensland Flood Immunity Bridge Package for the Bruce Highway is to ensure that the identified sections are built to an acceptable standard which meets the overall flood immunity standard set for the Bruce Highway. The overall outcome of the Package is that it will eliminate four of the worst trouble spots for flooding on the Bruce Highway between Sarina and Cairns.

The BHAP was developed by the State Government in parallel to the NB2 submission and focuses on improvements in three priority areas of safety, flooding and capacity, for delivery over the next 10 years. The plan has recommended the project as a High Priority 1 project under the Flooding Improvement category for the Bowen to Ingham link, for delivery in years 1 to 4. The goal for projects in this category is to improve flood immunity of the nominated sections to a specified minimum standard and to improve connections to cities.

Figure 2 - Existing Cattle Creek Bridge (view looking south)

Figure 3 - Existing Cattle Creek Bridge (eastern side elevation)

Figure 4 - Existing Frances Creek Bridge (eastern side elevation)

Figure 5 - Existing France Creek Bridge (western side elevation)

1.1.1 Vision Standards

The BHAP includes Vision Standards for the Bruce Highway as well as several state wide targets for infrastructure standards/condition, which must be considered when assessing options, and includes:

i. BHAP Vision Standards - Flood immunity for the Townsville – Cairns section: Vision Standard - maximum Time of Closure (TOC) of less than 48 hours in a Q50 event and Annual Average Time of Closure (AATOC) of no more than 10 hours;

ii. BHAP Vision Standards - Installation of Wide Centre Line Treatment (WCLT) on new projects and progressive installation on existing network;

iii. Seal width;
   - Interim standard – 10m (minimum needed to install WCLT)
   - Vision standard – 11m

iv. BHAP Vision Standards - Overtaking lanes – spacing of 5km (>6000 vpd), 10km (>4000 vpd);

v. Bridge width;
   - Interim standard – 8.4m between kerbs
   - Vision standard – 9.2m between kerbs

vi. Bridge (and major culvert) condition (20-year targets);
   - Eliminate 50% of bridges/major culverts with risk scores between 1,500 and 5,000
   - All bridges/major culverts to be serviced in accordance with the requirements of the Bridge/Culvert Servicing Manual

vii. Bridge strength – All current bridge stock has capacity to carry HML B-doubles. While there are loading standards for new bridges, there are no set targets for improving load standards of existing bridges.

In mid-2012, a preliminary study of the Cattle and Frances Creeks' area was completed to confirm the study area for the NB2 submission, develop a cost-effective immunity solution and 'better than strategic' estimate. The study arose from manoeuvring the focus of TMR's initial Link Study on the Bruce Highway (Helens Hill to Rutledge Street). The study also provided the opportunity to focus primarily on flooding improvements.

The study determined a 4.8km section, from 200m south of Pennas Road to 400m south of Ted Row Bridge (Trebonne Creek), Toobanna, as the extent of the project and a strategic estimate of $105 million (2012 prices – excluding escalation). Figure 6 below shows the project site in relation to the surrounding area.

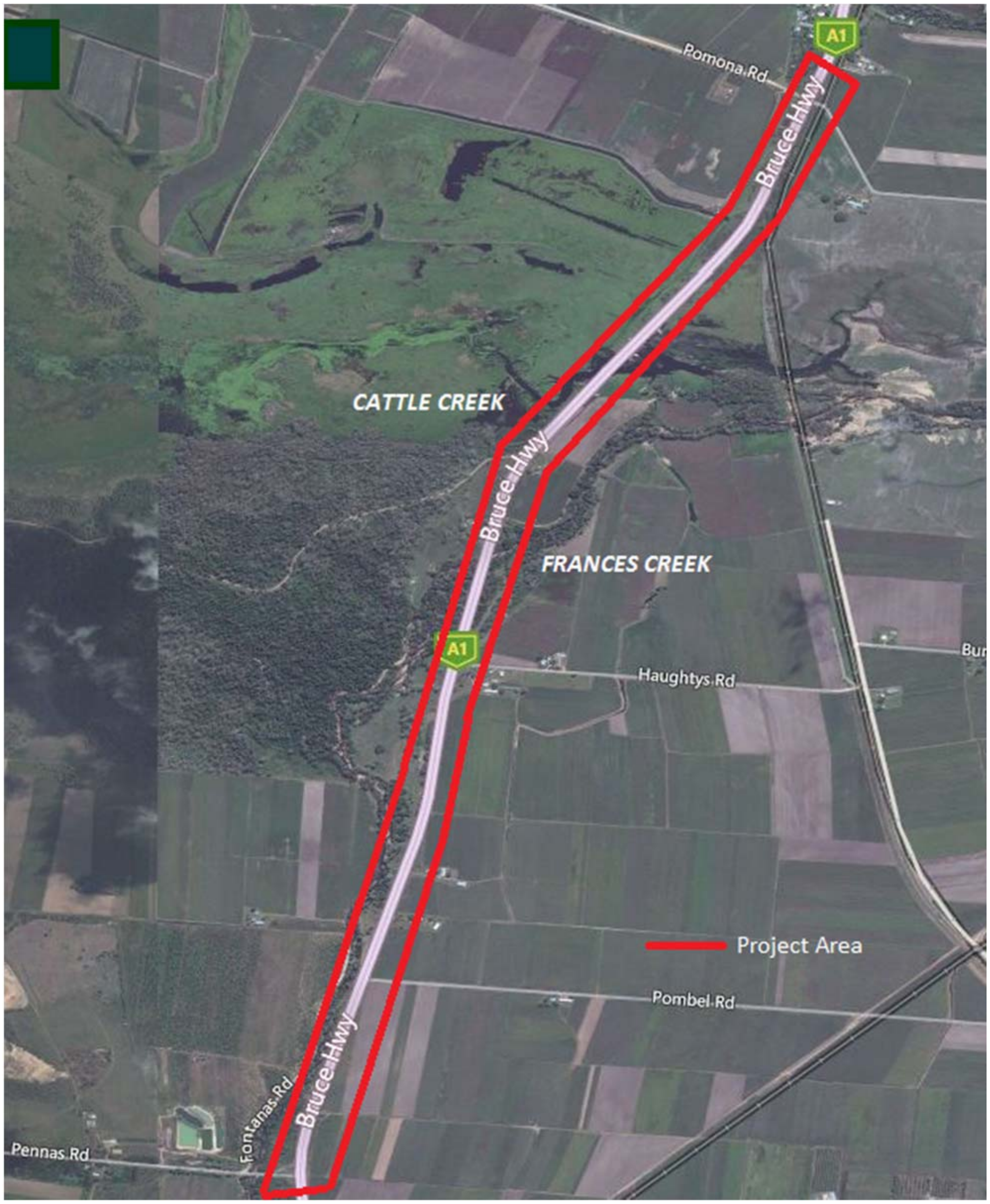

Figure 6 – Project Area Location Plan

1.1.2 Options Development Stage

As part of the Link Study (Helen's Hill to Rutledge Street) a preferred option and associated costing was developed for the NB2 submission, TMR previously appointed SMEC Consultants Pty Ltd in 2012, to complete the options development stage to investigate how the flood immunity for the Bruce Highway (Helen's Hill Road to Toobanna) could be improved to achieve a desired level of Q20 flood immunity for road and Q50 for bridges, and to develop a "better than strategic" cost estimate for the preferred solution.

As a separate commission, TMR appointed BMT WBM Consultants to assess the hydraulic impacts of raising the highway and requested that both Consultants worked together collaboratively to identify and develop feasible options for subsequent assessment.

As part of their commission SMEC investigated the following options:

i. Non-infrastructure Solution - The removal of silt from the Cattle Creek system in an effort to improve the channel profile;
ii. Non-infrastructure Solution - The removal of hymenachne (an invasive weed) from the Cattle Creek system in an effort to improve the efficiency of flow within the Creek; and
iii. Infrastructure Solutions - Raising the highway to above the Q20 ARI level and structures to above Q50 ARI level.

The investigation of non-infrastructure solutions primarily focused on the removal of silt and weeds and showed that:

i. The efficiency of flow in Cattle Creek could not be improved to the point where the highway could remain at its current level and still provide Q20 flood immunity; and
ii. TMR would need to commit to a very onerous on-going and costly maintenance regime.

This maintenance regime would require co-ordination across a number of Government departments. Adopting a solution that is reliant on the support from other government departments with different (and possibly conflicting) priorities could potentially prevent TMR from fulfilling its responsibilities of providing a reasonable level of flood immunity on the highway. Maintenance activities would need to occur not only in the road reserve, but also in environmentally sensitive areas.

The opportunity to increase the flow capacity of Cattle Creek on the downstream side is limited by farming activities that are being undertaken on existing freehold land. For these reasons, the removal of silt and weeds was considered not to be a viable option and was therefore not further assessed or costed.

Raising the highway in order to improve the flood immunity was considered to be the preferred option. This developed solution required the existing highway to be raised ‘on line’ between Pennas Road and Frances Creek and a new ‘off line’ section to be constructed between Frances Creek to Toobanna. The off line section is required as it is extremely difficult to raise the level of the existing Cattle Creek Bridge whilst still keeping the highway fully operational.

As part of their commission, BMT WBM Consultants assessed the upstream impacts associated with raising the highway. This was completed for the 10, 20, 50 and 100 year ARI events. It was noted that TMR set the following requirement relating to afflux:

i. Afflux should not exceed more than 50 mm in areas where there are existing houses and structures; and
ii. Afflux should not exceed 250mm in undeveloped areas (e.g. existing farmland).

The assessment work completed by BMT WBM Consultants showed that afflux was generally acceptable, although there were 18 properties on the southern bank of Toobanna identified where the afflux was assessed to be more than 50 mm for the 10, 20, 50 and 100 year ARI events. At that time, it was considered possible to reduce this afflux through the provision of additional drainage structures in the highway embankment or accepting a slightly lower level of flood immunity in this area. If the afflux could not be reduced to below 50 mm, existing low set housing may potentially need to be resumed. It was acknowledged at that time that further additional hydraulic assessment work would be required to refine the design solution further to meet the desired afflux requirements.

In addition a "better than strategic" cost estimate for the preferred solution was then prepared. The preferred solution consisted of two discreet sections.

- Southern section - Pennas Road to Frances Creek (on line solution) – Ch. 108,890 to Ch. 111,780m ; and
- Northern section - Frances Creek to Toobanna (off line solution) – Ch. 111,780 to Ch. 113,620m

The outturn cost in 2018 for southern section was estimated to be approximately $16.5m and the outturn cost in 2018 for northern section was estimated to be approximately $88.5m. This resulted in a total estimated project cost of $105m (2012 prices, excluding escalation). At this point a decision was then taken by TMR that large scale resumptions in a small rural township would have high social impacts. As such the project scope was then reduced from 5.2km to 4.8km in an effort to mitigate afflux impacts on the township of Toobanna. The decision also involved accepting a Q10-15 level of flood immunity on a 400m section of existing Bruce Highway immediately south of the Trebonne River crossing (Ted Row Bridge) at the northern end of the project.

1.1.3 Current Status of Project

The Cattle and Frances Creeks Upgrade project is being delivered in accordance with the Queensland Government's Project Assurance Framework (PAF) governance process, which is required for major projects >$100m. With regards its current status, the Strategic Assessment of Service Requirements (SASR) was successfully presented to the Department's Infrastructure Investment Committee (IIC) in June 2013 when approval was granted to transition the project directly to Major Project Gate 3 (Approval of Business Case). In addition, consultation has also been undertaken with external stakeholders regarding the Cattle Creek Wetlands rehabilitation and time of inundation on adjacent land.

TMR are currently targeting submission of the Business Case to IIC for consideration in June 2014.

1.2 Project Outcomes

The proposed Cattle and Frances Creeks project is approximately 4.8km in length and is located some 100 km north of Townsville and 10 km south of Ingham. It is aimed at improving flood immunity and safety on the Bruce Highway (Townsville to Ingham) section and Bowen to Ingham link of the Brisbane to Cairns corridor. The project section currently has poor reliability and connectivity for at least one-third of each year (December – March), due to its poor flood immunity of around Q1 – Q2. The NB2 submission was based on 2007 flood modelling, which indicated that this section experiences a maximum Time of Closure (TOC) of 72 hours in a Q50 event and an Annual Average Time of Closure (AATOC) of 15 hours. The project aims to address the highway's deficiencies between the Pennas Road intersection and the small township of Toobanna.

The project's primary objective is to significantly improve corridor connectivity and reliability between the North Queensland service centre of Townsville (including its air and sea ports) and the dependent rural community of Ingham, and on the overall Bowen to Ingham link. Ingham is increasingly dependent on access south to Townsville, to support its key regional industries of sugar and tourism, as are some rural communities further north. This includes the $500m-per-annum banana industry to the north, which relies on year-round access, via road freight, for the time-sensitive outputs. The increasing withdrawal of essential services from rural communities has also increased reliance on access to Townsville. As the Bruce Highway has poor flood immunity both south and north of Ingham, the project would also contribute towards improved reliability and connectivity on the Ingham to Cairns section.

1.2.1 Project Service Requirements

The Project Service Requirements are the desired outcomes which the proposed investment would secure for Government, and include the following:

i. Achieve flood immunity BHAP Vision Standards for the Bruce Highway (Townsville – Cairns) section, to provide a consistent link improvement to the highway's reliability and connectivity for freight and passenger traffic;

ii. Provide an acceptable level of certainty about flood immunity improvements that can be achieved;

iii. Improve accessibility to the Port of Townsville to cater for current export commodities and their inputs (and flexibility to cater for export tasks that may emerge at short notice);

iv. Support economic growth by reducing disruption to key regional industries of sugar, horticulture and tourism, which rely on year-round reliability of access south of Ingham;

v. Improve connectivity and access to services between rural community and regional centre (Ingham and Townsville);

vi. Provide a level of design constructability that reduces Indirect Job Costs;

vii. Improve safety, taking account of the mix of traffic types and fatigue issues;

viii. Contribute to the achievement of link and corridor flood immunity improvements within the medium term, by developing a cost-effective solution;

ix. Minimise social impacts (such as afflux and resumptions) and environmental impacts (including water and habitat quality); and

x. Develop a "fit for purpose" solution which gives due consideration to durability, resilience and safety of ageing bridge assets, in the context of potential future loadings, Vision Standards for width and whole-of-life costs.

The primary benefits to be delivered include improved travel accessibility, flexibility and reliability; increased access of freight transport to and from key economic destinations; improved access to employment centres, health services and social networks via transport; and safety.

From the early stages of the technical analysis and options assessment process, the project team focused attention on the Project Service Requirements and, specifically, on identifying a way of clearly demonstrating to what extent the various requirements were being successfully achieved. As a result, the following table was produced, which is aimed at mapping out specific measurable criteria for each requirement to increase confidence of each of the options specific performance against each key requirement.

Table 1 - Proposed Measurement Criteria associated with Project Service Requirements

#	Project Service Requirements (PSR)	PSR measurement criteria
1	Achieve flood immunity Vision Standards for the Bruce Highway (Townsville – Cairns) section, to provide a consistent link improvement to the highway's reliability and connectivity.	Improvement to flood immunity*: • For the overall 4.8km section to at least meet Vision Standards: Maximum Time of Closure (TOC) =< 48 hours and Annual Average Time of Closure (AATOC) =<10 hours (while achieving afflux targets – refer Social and Environmental impacts criteria). • Q50 immunity for bridges. **Based on trafficability with 200mm water over road, which will be =<300mm head due to low water velocities.*
2	Provide an acceptable level of certainty about flood immunity improvements that a proposed solution could deliver.	There is confidence that the integrated hydraulic/civil solution will at least meet the Vision Standards on the Bruce Highway. This means: • The solution is able to achieve the 48/10 standard as a "stand alone" solution to improving flood immunity on the Bruce Highway (and does not rely on non-infrastructure solutions – clearing of sedimentation and/or elimination of weeds - also being carried out in future). • Regarding potential future blockages at the bridges (due to weed mats/siltation), the recommended option can achieve the 48/10 solution, based on: o Zero blockage at Cattle Creek Bridge (given that weed matting should not occur with a higher-level bridge). o Consideration of the actual recent historical blockage (50% blockage) at Frances Creek Bridge (in recognition that ongoing siltation is likely to occur, due to sediment loads which are most likely associated with upstream land use). • The flood model is appropriately developed and calibrated, such that it receives TMR endorsement. • There is a clear and credible rationale for the way in which the integrated civil/hydraulic solution (road/bridge heights) will achieve the required flood immunity and afflux targets and it can be effectively conveyed to stakeholders and the community through agreed key messages.
3	Improve accessibility to the Port of Townsville to cater for current export commodities and their inputs.	As for the above two PSR (10/48 Vision Standards and certainty about flood immunity improvements). Achieving these PSR will improve the reliability of year-round accessibility, compared to the Base Case.
4	Reduce disruption to key regional industries that rely on year-round reliability of access south of Ingham.	As for the above two PSR (10/48 Vision Standards and certainty about flood immunity improvements). Achieving these PSR will reduce disruption to year-round accessibility for key industries, compared to the Base Case).

#	Project Service Requirements (PSR)	PSR measurement criteria
5	Improve connectivity and access to services between rural community and regional centre (Ingham and Townsville).	As for the above two PSR (10/48 Vision Standards and certainty about flood immunity improvements). Achieving these PSR will improve year-round connectivity, compared to the Base Case).
6	Provide a level of design constructability that reduces Indirect Job Costs.	Concept design solution/s which takes account of practical constructability issues, while balancing the potential to maximise construction productivity. This includes a sound risk-management approach to: • To the extent of risk exposure involved in a compressed vs. a longer construction timeframe. • The extent of disruption to industry and business during construction. • The likely extent of costs in traffic management requirements at the construction stage vs. the proportion of the project budget that is available to be invested in upgraded infrastructure. Any such approach is based on the assumption that safety for both road users and road workers is a primary consideration.
7	Improve safety, taking account of the mix of traffic types and fatigue issues.	Design elements provide a cost-effective, risk-management approach to improving safety. In particular, the emphasis is on: • Providing a more forgiving road environment within an identified fatigue zone. • Providing an appropriate level of rural-intersection safety. • Addressing potential safety issues associated with overtopping. This will include: • Providing an appropriate seal width to accommodate Wide Centre Line Treatment (WCLT) and Audio Tactile Line Marking (ATLM) on edge lines, in line with TMR standards. • Supporting the Frances Creek Rest Area (and Driver Reviver location) as a safe, attractive place for drivers to take rest breaks, by: o Providing safe, well-delineated access to the Rest Area. o Maintaining its amenity, by retaining existing trees in the road corridor in front of the Rest Area. • Developing low-cost, high-benefit solutions to location-specific issues of: o The safety of rural intersections in a 100km/hr speed zone. o The mix of traffic types, including agricultural traffic (this includes identifying priority intersections for treatment based on the extent of heavy vehicles usage, such as cane haulage). Cont….

#	Project Service Requirements (PSR)	PSR measurement criteria
		• Developing flood-immunity solutions which: o Do not increase the risk of flash-flooding. o Reduce the risk of skidding and aquaplaning, given that the area experiences high rainfall and that the road will be overtopped during larger flood events.
8	Develop a cost-effective solution, such that it contributes to the achievement of link and corridor flood immunity improvements within the medium term.	As for the PSR for 10/48 Vision Standards and afflux targets: these are the main project drivers and must be achieved as a minimum. The recommended option should also perform well against the other PSR. The P90 cost estimate remains within the project's P50 estimate of \$105m (\$2012). The recommended option demonstrates that opportunities to achieve savings have been appropriately explored (and a robust rationale is provided for their inclusion or exclusion in the recommended option).
9	Minimise social impacts (such as afflux and resumptions) and environmental impacts (including water/habitat quality).	Social impacts Meet agreed project afflux criteria of: • Afflux on rural land should no more than 250 mm, but preferably less than 200 mm; • Afflux within residential property boundaries should be less than 50 mm; • Where the habitable floor level of a residential or commercial property is lower than the 100 year ARI flood level the afflux should be no more than 10 mm; and • The velocity at the outlet of drainage structures should not increase such that it would cause an increase in scouring on private property. Environmental impacts • Minimise conflict with the aspirations of the whole-of-government Cattle Creek Wetlands Rehabilitation Initiative. These aspirations include restoration of the hydrological regime of the adjacent wetlands (better outflow to provide improved downstream flows), improving water quality and improving fish habitat. • Where possible, in context of the project's primary considerations of cost and hydraulic outcomes), and within constraints of structural considerations, assist in achieving those aspirations by: o Providing waterway openings which assist in reducing potential for trapping of weed mats, increasing water velocities in medium and high-flow events to improve wetland outflows to the downstream catchment (at the Cattle Creek Bridge). o Maintaining existing water quality or contributing to improving it. Cont….

#	Project Service Requirements (PSR)	PSR measurement criteria

		• Minimise environmental impacts on riparian vegetation, particularly impacts on habitat quality of threatened and/or endangered species.
		• Minimise the risk of the project becoming a "controlled action" under the EPBC Act, by adequately assessing and identifying potential triggers.
		• Minimise the risk of decreased political support for the project, by:
		  o Minimising potential for the above social impacts.
		  o Minimising potential for the above environmental impacts.

10	Develop a "fit for purpose" solution that gives due consideration to durability, resilience and safety of ageing bridge assets, in context of potential future loadings, Vision Standards for width and whole-of-life costs.	<u>Flood immunity</u> As for 10/48 Vision Standards and afflux targets: these are the main project drivers and must be achieved as a minimum. The recommended option should also perform well against the other PSR. As above, develop a cost-effective solution such that the project's P90 cost estimate does not exceed the P50 estimate of $105m (2012 prices). <u>Pavement</u> Pavement design takes account of: • The fact that the road will be overtopped at times. • The impacts of the forecast Annual Average Time of Submergence (AATOC), based on the hydraulic model. • Whole-of-life costs. <u>Bridges</u> • Width of new bridge/s allows for incorporation of WCLT. • Bridges could provide safe and sustainable access for heavy-vehicle loadings to the National Network. This includes consideration of whole-of-life costs.

In the context of this project, and for the purposes of developing the Business Case, Arup assumes that the 'fit for purpose' reflects a requirement that the design should comply with all relevant current design standards, including the relevant TMR design guidelines and technical standards. It is ultimately for TMR, to determine if the solution meets their specific project requirements.

1.3 Project Scope

The project aims to improve flood immunity and safety on a 4.8km section to Bruce Highway Action Plan (BHAP) Vision Standards for reducing flooding disruption for the Townsville – Cairns section: TOC of less than 48 hours in a Q50 event and AATOC of no more than 10 hours.

The option included in the NB2 submission included:

Southern Section - Pennas Road to Frances Creek (Ch. 108,890 to Ch. 111,780m)

- Minor on-line re-grading of existing Bruce Highway alignment;
- Minor cross drainage improvements;
- Minor upgrading of intersections with local rural roads (Pennas Road, Pombel Road & Haughty's Road);
- Reinstatement of the entrance and exit to the Frances Creek Rest Area; and
- Fit-for-purpose seal width, in line with BHAP Vision Standards including new wide centre line treatment (WCLT), with audio tactile line marking (ATLM) if feasible.

Northern Section - Frances Creek to Toobanna (Ch. 111,780 to Ch. 113,620m)

- Replacement of existing Cattle Creek bridge with a wider, higher-level bridge to provide Q50 flood immunity;
- Major realignment of existing Bruce Highway off-line, to run adjacent to the existing highway;
- Major cross drainage improvements;
- Minor upgrading of intersections with local rural roads (Pomona Road / Pinnacle Hill Road); and
- Fit-for-purpose seal width, in line with BHAP Vision Standards including new wide centre line treatment (WCLT), with audio tactile line marking (ATLM) if feasible.

The project's scope minimises the need for significant rural/residential resumptions in the township of Toobanna and flow-on social impacts, by accepting a 400m section with flood immunity of Q10 – 15 between Pomona Road and the Ted Row Bridge (Trebonne Creek). In developing the NB2 submission, it was assessed that approximately $4m in resumption costs would be required, which would mean a higher level of investment for the project. However, the main reason for the project scope was to avoid significant social impacts rather than to avoid $4m cost in associated resumptions.

There are potential, differing environmental issues associated with the preferred option (not replacing Frances Creek Bridge) and the two SASR sub-options:

i. Replace existing Frances Creek Bridge with a higher / wider bridge on a new alignment; and

ii. Widen the existing Frances Creek Bridge.

The existing Frances Creek Bridge was thought to have Q50 immunity already, based on broad flood modelling and anecdotal Reports; further investigation was needed to confirm this. The existing bridge is narrow (<9m).

TMR's IIC approved the investigation of sub-options, in addition to the option in the NB2 submission, because there was still uncertainty with regards whether the existing Frances Creek Bridge achieved the full BHAP vision standard requirements. The two sub-options at Frances Creek were also recommended for further investigation, to assess whether they would improve hydraulic performance, safety and environmental outcomes of the project and address the specific Project Service Requirements.

It is noted that both the NB2 submission and BHAP P50 cost estimates were produced based on the preferred option only and therefore did not allow for any costs associated with either the replacement or widening of the existing Frances Creek Bridge.

1.4 Scope of Business Case Development

The scope of the Business Case development stage (PAF Gate 3) involved Arup being commissioned to undertake the following key tasks:

i. Undertake concept design development and a comparative technical analysis of the three potential options in the SASR approved by IIC, as identified during the previous Options Development Stage;

ii. Assess the performance of the options to ensure the various Project Service Requirements can be achieved;

iii. Undertake a multi-criteria assessment to compare options and ultimately recommend a Business Case option, to inform an IIC investment decision. The recommended Business Case option should be approved for development within the 10 year BHAP program, with timing to be based on Federal Funding commitments;

iv. Prepare associated P90 risk adjusted cost estimates for the preferred option and sub-option (New Frances Creek Bridge Off-line); and

v. Document the above work in a multi-disciplinary Technical Analysis Report and prepare specific Chapters 4, 5 & 6 of the PAF Business Case Submission together with corresponding appendices.

Arup were commissioned to undertake the above in July 2013, with an agreed program duration of 28 weeks. All project deliverables, as highlighted in the TMR Business Case Project Brief (May 2013), were to be prepared, reviewed and submitted to TMR in a staged manner on various key dates with the final set of Report deliverables being submitted no later than end of January 2014.

A critical component of the Business Case development involved Arup working alongside BMT WBM Consultants who were directly commissioned by TMR and as such were fully responsible for all associated flood modelling and hydraulic assessment components of the project. Arup worked with BMT WBM Consultants in a fully integrated manner and were supplied with key design related information (e.g. bridge opening areas, RL heights for Creek crossings) which were ultimately used in developing the concept design solutions produced for assessment purposes.

1.4.1 Project Team Responsibilities

Arup were commissioned to work in full collaboration with Department of Transport & Main Roads (TMR) North Queensland Regional Office, TMR Portfolio Investment & Programming Branch (PIP) and BMT WBM Consultants to produce a fully integrated and PAF compliant Business Case submission, which provides a strong and fully justified recommendation to support an investment decision being made with regards the future delivery of the project.

TMR North Queensland Region Office were responsible for the overall management and delivery of the Business Case preparation and are also responsible for producing key chapters of the Business Case associated with project background, project need and priority, project definition, conclusions, recommendations and developing an Implementation Plan.

TMR PIP led and managed the financial, economic analyses, legislative and legal assessment, whole of Government policy issues, public interest assessment and market sounding components of the Business Case submission.

BMT WBM Consultants was separately commissioned by TMR to lead and manage the flood modelling and associated hydraulic assessment components of the Business Case submission. Their flood modelling and associated hydraulic assessment was independently reviewed and verified by TMR Hydraulics Director (Mr B Weeks) for robustness, accuracy and ultimately confidence of the modelling and assessment work undertaken.

1.5 Purpose of the Report

The purpose of this Report is to document the multi-disciplinary detailed technical analysis undertaken on a number of potentially viable options, leading to recommendation being made on a preferred Business Case option, which will then ultimately be documented in a Project Assurance Framework Business Case submission. This Business Case submission will then provide sufficient information for TMR's high level Infrastructure Investment Committee (and Treasury) to decide whether to invest in the development of the proposed project.

The technical analysis undertaken has specific regard to the following key issues:

i. Documenting the findings of a iterative concept design development process, technical evaluation and comparison of the three short listed options (as highlighted in TMR Business Case Project Brief, May 2013) with specific regard to:

   - Identifying the key technical components of each option;
   - Undertaking an iterative and integrated concept design development process for each option, aimed at achieving the desired project outcomes;
   - Identify and evaluate the relative merits of each option and associated impacts including:

- ✓ Engineering and design feasibility (including road design, safety, traffic considerations, pavements, bridges and constructability issues etc.)
- ✓ Hydrology and geotechnical issues, impacts and treatments
- ✓ Safety in design considerations and treatments
- ✓ Public utility plant impacts and treatments
- ✓ Land acquisition requirements
- ✓ Environmental impact assessment (including Cultural Heritage) and identification of treatments
- ✓ Develop P90 cost estimates for each option (including risk assessment)
- ✓ Assess, compare and rank the shortlisted options, leading to the recommendation of a preferred Business Case option

ii. The achievement of all Project Service Requirements;

iii. Developing a fully integrated design solution;

iv. Meeting the project budget constraints of $105m (2012 prices, excluding escalation); and

v. Achieving a value for money design solution.

Additionally, the analysis also focused on better understanding the likely associated risk and constructability issues associated with the delivery of the preferred option. This focus then suitably informs and increases confidence that the preferred Business Case option can be constructed without major detrimental impact on the existing operation of the Bruce Highway, surrounding properties and environment during the planned construction phase.

This Technical Analysis Report supports Section 4 of the PAF Business Case Report of the Cattle & Frances Creeks Upgrade Project. This Technical Analysis Report forms Appendix A of the PAF Business Case submission.

1.6 Options to be Assessed / Considered

In the TMR Business Case Project Brief, the previously identified preferred option (NB2 submission) was highlighted to be assessed along with two potential additional sub-options, which were minor variations to the preferred option. As such TMR confirmed that no further 'optioneering' was to be undertaken. Clarification was confirmed, however, by TMR that if alternative options were identified, which met all Project Service Requirements and offered an improved value for money solution with an acceptable level of associated risk, that these alternative options may then be assessed, subject to prior TMR approval being granted.

With regards the option naming conventions used to describe the various options these were taken directly from the Project Brief. The naming of the alternative options highlighted, were referenced to location of the site they specifically relate too.

The following sections provide a brief description of each of the three previously identified options to be assessed in addition to alternative options, which were also considered briefly early during the Business Case development process and were assessed to varying degrees:

Table 2 - Options Considered

#	NB2/SASR Option Reference	Brief Option Description
1	Preferred NB2 Option	• Minor re-grading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek bridge (southern section); • Maintain existing bridge crossing at Frances Creek; • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section); and • Replace existing Cattle Creek Bridge with a new wider and high level bridge to provide an increased Q50 flood immunity.
2	SASR Sub-option (New Frances Creek Bridge – Off-line)	• Minor re-grading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek bridge (southern section); • Provide new bridge crossing at Frances Creek (Off-line); • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section); and • Replace existing Cattle Creek Bridge with a new wider and high level bridge to provide an increased Q50 flood immunity.
3	SASR Sub-option (Widen Existing Frances Creek Bridge)	• Minor re-grading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek bridge (southern section); • Widen existing bridge crossing at Frances Creek; • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section); and • Replace existing Cattle Creek Bridge with a new wider and high level bridge to provide an increased Q50 flood immunity.
#	**Alternative Option Reference**	**Brief Alternative Option Description**
4	Sub-option (New Frances Creek Bridge – On-line)	• Minor re-grading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek bridge (southern section); • New bridge crossing at Frances Creek (On-line), requiring temporary side track bridge to be built during construction phase; • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section); and • Replace existing Cattle Creek Bridge with a new wider and high level bridge to provide an increased Q50 flood immunity.

#	NB2/SASR Option Reference	Brief Option Description
5	Alternative Levee Option (Southern Section)	• Same as the preferred option, the only difference being the provision of a new earth bund (levee) to the west of the existing Bruce Highway (southern section) between Pennas Road and Frances Creek Rest Area. This alternative sub-option targeted reducing the on-line pavement regrading requirements associated with the existing Bruce Highway alignment.
6	Alternative Levee Option (Toobanna Section)	• Same as the preferred option, the only difference being the provision of a new earth bund (levee) to the west of the existing Bruce Highway (northern section) to surround the existing township of Toobanna south of the Trebonne Creek. This alternative sub-option targeted reducing the off-line pavement regrading requirements to the new proposed Bruce Highway alignment and minimising the associated potential afflux impacts on the existing properties to an acceptable level.

1.6.1 NB2/SASR Sub-options

1.6.1.1 Preferred NB2 Option

The scope of the preferred option included:

Southern Section (Pennas Road to Frances Creek)

- Minor on-line re-grading of existing Bruce Highway alignment;
- Minor cross drainage improvements;
- Minor upgrading of intersections with local rural roads (Pennas Road, Pombel Road & Haughty's Road);
- Reinstatement of the entrance and exit to the Frances Creek Rest Area; and
- Fit-for-purpose seal width, in line with BHAP Vision Standards including new wide centre line treatment (WCLT), with audio tactile line marking (ATLM) if feasible.

Northern Section (Frances Creek to Toobanna)

- Replacement of existing Cattle Creek bridge with a wider, higher-level bridge to provide a Q50 level of flood immunity;
- Major realignment of existing Bruce Highway off-line, to run adjacent to the existing highway;
- Major cross drainage improvements;
- Minor upgrading of intersections with local rural roads (Pomona Road / Pinnacle Hill Road); and
- Fit-for-purpose seal width, in line with BHAP Vision Standards including new wide centre line treatment (WCLT), with audio tactile line marking (ATLM) if feasible.

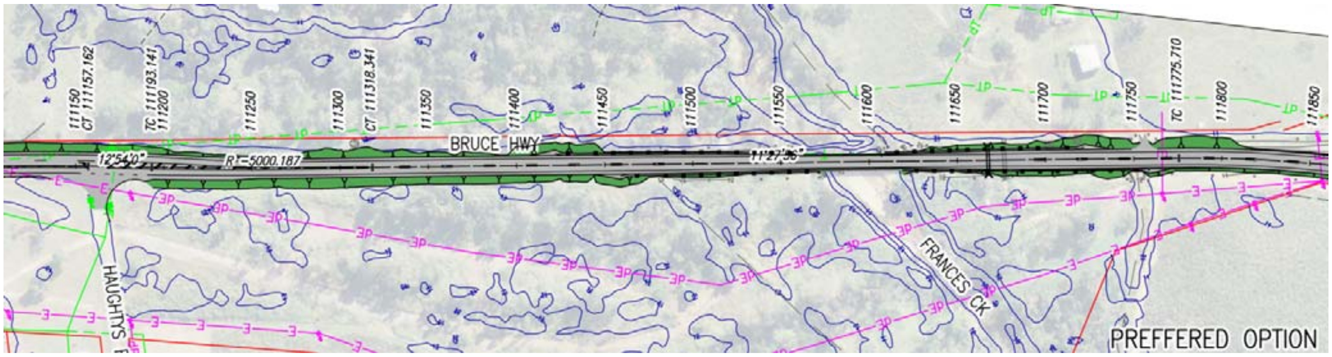

Figure 7 - Preferred Option

1.6.1.2 SASR Sub-option (New Frances Creek Bridge Off-line)

The scope of the sub-option (New Frances Creek Bridge Off-line) included:

- Same as the preferred option, the only difference being allowing for the full replacement of Frances Creek bridge off-line from existing with a new wider and potentially higher level bridge, to the east on a new alignment, which meets TMR standards, i.e. Q50 level of flood immunity.

1.6.1.3 SASR Sub-option (Widen Existing Frances Creek Bridge)

The scope of the sub-option (Widen Existing Frances Creek Bridge) included:

- Same as the preferred option, the only difference being allowing for the widening of the existing Frances Creek Bridge to fully accommodate the proposed wide centre line treatment.

Immediately post commission award TMR confirmed that this proposed sub-option was no longer considered to be a viable option, because the Department had further reviewed and considered the constructability implications and potential impacts associated with widening a bridge of this form of construction. As such TMR confirmed that no assessment of this sub-option would be required.

Figure 8 - Sub-option

1.7 Alternative Options

In addition to the above options, and from a value for money perspective, Arup also identified several alternative options which were briefly considered, early in the Business Case development process, which included:

1.7.1 Alternative Sub-option (New Frances Creek Bridge On-line)

Post commission award TMR confirmed that a new sub-option should also be considered, which included:

- Same as the preferred option, the only difference being allowing for the removal of the existing Frances Creek bridge and replacement with a new bridge, on the existing alignment, which meets the project Vision Standards.

1.7.2 Alternative Levee Option (Southern Section)

The scope of the alternative levee option (southern section) included:

- Same as the preferred option, the only difference being the provision of a new earth bund (levee) to the west of the existing Bruce Highway (southern section) between Pennas Road and Frances Creek Rest Area. This alternative sub-option targeted reducing the on-line pavement regrading requirements associated with the existing Bruce Highway alignment (southern section only). However, this sub-option was discarded from further consideration, early in the Business Case development process, due to stakeholder concerns about impacts from the existing levee (refer to Section 4.7 for further information).

1.7.3 Alternative Levee Option (Toobanna)

The scope of the alternative levee option (Toobanna) included:

- Same as the preferred option, the only difference being the provision of a new earth bund (levee) to the west of the existing Bruce Highway (northern section) to surround the existing township of Toobanna south of the Trebonne Creek. This alternative sub-option targeted reducing the off-line pavement regrading requirements to the new proposed Bruce Highway alignment and minimising the associated potential afflux impacts on the existing properties to an acceptable level. This sub-option was discarded from serious consideration early in the Business Case development process, due to the level of uncertainty involved, the extent of consultation required (which would delay the Business Case development work) and the potential for community and political disquiet regarding this type of option.

In addition to the above options, various design opportunities were also identified, assessed and subsequently agreed. These opportunities were primarily focused on achieving a better value for money and commercially robust design solution, which would ultimately be recommended in the Business Case submission. These issues are described in more detail in Section 4 of this Report.

1.8 Approach to Technical Analysis and Options Assessment

The approach taken to undertaking this technical analysis and options assessment was a relatively simple four-stage process which involved:

- Stage 1 – Project understanding
- Stage 2 – Technical investigation / options analysis (including iterative design development)
- Stage 3 – Concept design development/refinement
- Stage 4 – Final documentation / Reporting

1.8.1 Stage 1 – Project Understanding

The first stage commenced upon commission award and was focused on fully aligning the project team with TMR's Project Service Requirements and associated project outcomes. In summary the stage involved:

- Formal provision / handover of all existing project data;
- Clarification of all Project Service Requirements and desired outcomes and discussion around potential conflicting requirements;
- Clarification on roles and responsibilities, develop and understanding of TMR PIP/BMT WBM Consultants role on the project and agree communication protocols and key inputs/deliverables;
- Discussion surrounding the initial project review findings to develop a sound understanding of all project constraints / opportunities;
- Final confirmation of design criteria to be used on the project;
- Agree on the early commissioning of traffic, environmental / cultural heritage surveys and ground investigations; and
- Agree and confirm the project delivery programme, specifically key milestone dates.

1.8.2 Stage 2 - Technical Investigation / Options Analysis

Stage 2 of the project delivery process primarily involved the key investigation and assessment works where key decisions were taken to ultimately decide on the preferred solution to be recommended in the Business Case submission. The work undertaken during this stage included:

- Detailed review of all existing documentation and gaps in information were highlighted, assumptions / assessments were challenged and keys areas to be further investigated were identified;
- Holding a Design Integration workshop to identify key inter-disciplinary design issues, associated interfaces and highlight key considerations to be developed in a fully collaborative manner to ensure all Project Service Requirements remain central to the design development decision making process. In particular, the focus was on integrating the four key components of hydraulic, civil, environmental and stakeholder management;

- Findings from early traffic, environmental and ground investigations were assessed and Reported;
- Environmental, cultural heritage and native title issues/risks were identified, discussed to consider whether or not there were any insurmountable issues/associated risks;
- Flood and hydraulic modelling and assessments were progressed on an iterative basis in parallel with other key design activities (geometry, structures, environmental and geotechnical disciplines), and collaboratively challenged, developed and further refined as appropriate. This process remained focused on achieving the desired Project Service Requirements in a cost effective and logical manner;
- Identification of associated PUP impacts and potential resumption requirements;
- The safety in design process was commenced, carefully considered in the options assessment and documented accordingly;
- Risks, opportunities and issues were identified, discussed, documented and initial mitigation strategies developed (including time-saving related initiatives);
- All discipline-specific technical analysis was undertaken to inform the comparison of options and documented accordingly;
- Preparation of initial cost estimates for comparison purposes; and
- MCA criteria were developed, in partnership with TMR, and the associated assessment was undertaken of all options to identify and jointly agree the preferred option. Key decisions and views expressed at the MCA workshop were recorded to fully inform the final documentation of the project.

Throughout this stage, design refinements to the preferred NB2 option were proposed and innovative ideas flagged aimed at driving increased value for money.

1.8.3 Stage 3 – Concept Design Development / Refinement

Stage 3 involved developing and refining the preferred NB2 option into a concept design. This involved all key design disciplines driving safety, value, certainty and innovation to ensure the final design solution proposed had been sufficiently optimised and represented a real value for money proposition which could be strongly recommended in the Business Case Report. This stage included:

- Planned and methodical development of the design to maximise the ‘knowns’ and minimise the ‘unknowns’ (Planned and unplanned risk quantification);
- Focused the design effort to the key cost / risk areas where largest certainty can be obtained and incorporation of all appropriate opportunities into the finalised concept design; and
- Developing further detail around the P90 cost estimate by refining quantity take-offs, clarifying key assumptions and ensuring a robust risk management process was developed.

As part of this stage, the team prepared all necessary draft design drawings and Reports to clearly document and communicate the complete scope of the preferred option. This then allowed a sufficiently robust internal and external review process to be completed. This review process drove increased refinement and certainty in the design solution and associated costs being reported, so that they were fully representative of all costs associated with the future delivery of the project, through latter stages.

1.8.4 Stage 4 - Final Documentation / Reporting

In stage 4 the final documentation and Reporting of all technical investigation and options assessment work was undertaken, which is of critical importance to the ultimate success of the Business Case.

In summary, the thorough understanding of the project, the suitably informed assessment work, the sound technical analysis and the risk / project service requirement focused concept design development were all progressed in a staged, controlled and integrated manner, to fully support a strong and robust Business Case Report being developed.

The Report was then further challenged by independent, experienced and specialist reviewers to test the strength of work undertaken. This provided additional confidence that the analysis and subsequent recommendation are suitably robust.

1.9 Existing Project Data

The following existing project data was supplied by TMR on the dates highlighted to suitably inform the technical investigation and options assessment process:

Table 3 - Existing Project Data Supplied by TMR

Date Issued	Project Data
3 July 2013	Cost Report for Upgrading Bruce Highway (Section 10M) from Helen's Hill Road to Toobanna – Concept Design, prepared by SMEC (January 2013) Options Report for Upgrading Bruce Highway (Section 10M) from Helen's Hill Road to Toobanna – Concept Design, prepared by SMEC (January 2013) Bruce Highway Helens Hill to Rutledge Street Link Study – Hydraulic Assessment Final Report, prepared by BMT WBM Consultants (August 2012) Cattle Creek Wetlands Rehabilitation Project – Broad scale Environmental Appraisal, prepared by C&R Consulting (May 2011)
9 July 2013	Bridge Inspection Reports for Cattle Creek and Frances Creek bridges
10 July 2013	Strategic Assessment of Service Requirements IIC Presentation (12 June 2013) Townsville Outer Ring Road Business Case Report
11 July 2013	SMEC 12D model files of previously developed preferred option
16 July 2013	DBYD Job No: 6518672, information received from individual assets' owners.
18 July 2013	Historic aerial photography of the project site Revised LIDAR

Date Issued	Project Data
22 July 2013	Existing Road Crash Data Report Infrastructure Australia – Project Submission NBP2 Project Proposal Report (June 2012) Road Evaluation Reports (July 2012)
23 July 2013	Cattle Creek Strategic Management Plan
24 July 2013	Cattle Creek Bridge Site Foundation Investigation Report (August 1979) Cattle Creek – Frances Creek Materials Survey Report (November 1972)
29 July 2013	Existing Traffic Count Data 2012 SMEC AutoCAD files of previously developed preferred option
31 July 2013	Historic Cattle Creek & Frances Creek bridge general arrangement plans, prepared by TMR (1974)
2 August 2013	Cattle Creek Catchment – Strategic Management Plan 2009-2014, prepared by Caroline Coppo (July 2009) BHAP P90 Cost Estimate Report (Pennas Road to Toobanna – Flood Mitigation Project), prepared by Aquenta (August 2012) Flood velocity maps (Figures 1-4), prepared by BMT WBM (August 2013) Pavement Data
6 August 2013	TMR Digital Video Recording of Project Site
7 August 2013	List of Key Project Stakeholders, prepared by TMR
8 August 2013	Collection of historic photographs taken by TMR during 2012 flood event at Cattle Creek and Frances Creek bridge location
14 August 2013	Frances Creek Bridge Site Foundation Investigation Report (August 1973)
16 August 2013	Northern Highway (Townsville to Ingham Section) historic working plan and sections (February 1945)
23 August 2013	TMR Risk Management Requirements
29 August 2013	TMR Design Development Report Template
5 September 2013	Existing Pennas Road Levee Details (July 2007)
17 September 2013	Ergon Assets GIS base
19 September 2013	Aerial Photo of Project site
23 September 2013	Revised Cadastral information of Constrained Section of Corridor
10 October 2013	Ground Investigation Results
17 October 2013	Existing Pavement History
18 October 2013	Ground Investigation Laboratory Test Results
24 October 2013	Plan showing Existing Cane Tramlines
31 October 2013	Extracts from SASR – Section 2.2 - Strategic Context, Section 3.3 - Existing Transport Network Issues, Section 3.5 - Future State, Section 4.0 - Service Requirements and Section 7.0 – Conclusions & Recommendations

1.9.1 Arup Desktop Research

The following information from Arup previous projects database has been retrieved and considered for the purpose of the study;

- 7458 - Frances Creek Bridge Assessment, Arup Report prepared for TMR Bridge Asset Management, Dated: June 2010
- TMR Structure Condition Inspection Report, B2/1, Dated: June 2005
- TMR Defective Components Report, B2/3, Dated: June 2005
- TMR Standard Procedure Exceptions Report, B2/4, Dated: June 2005
- TMR Level 2 Inspection Report - Photos & Sketches Record, B2/6, Dated: June 2005
- TMR Structure Scour Soundings Report, B2/7, Dated: June 2005
- TMR Structure Maintenance Schedule, M1, Dated: June 2005

1.10 Project Constraints

The following project constraints and key decisions were agreed with TMR Project Manager to ensure the commission remained focused on successfully achieving the various requirements of the project brief, developed in an agreed and transparent manner where uncertainties existed and that the level of investigation / assessment to be undertaken was sufficient to best inform the associated Business Case submission.

1.10.1 Commission Scope Constraints

The following list of issues provided additional confirmation with regards the scope limitations the technical analysis and options assessment activities were to strictly comply with:

i. No relaxations to the Project Service Requirements are allowed, as identified in the TMR Business Case Project Brief;

ii. The preferred Business Case option recommended must be affordable and within the project budget constraints of $105m (2012 prices, excluding escalation);

iii. No assessment of alternative options will be undertaken without prior approval from TMR;

iv. With regards design development, concept design layouts for the preferred NB2 option and SASR sub-option (replace Frances Creek Bridge off-line) only, will be developed to suitably inform the options assessment and P90 cost estimate preparation;

v. Ideally no additional land requirements (beyond those previously identified) will be accepted to facilitate any revised design alignment;

vi. Any revised design alignments suggested must be feasible, constructible and adhere to TMR and AustRoads design standards; and

vii. No assessment of future land use and planning issues will be undertaken, as TMR has assessed there are no significant land use changes or growth issues in the general vicinity of the site, (except for the 2016 commencement of the NQ Bioenergy operations of which the project has taken account).

1.10.2 Key Decisions

Throughout the technical analysis and options assessment process a Key Decisions Register was produced and maintained. The purpose of this register was to formally record all key decisions taken by the team and then share this information to ensure all respective project team members were kept fully informed, to ensure a fully integrated analysis and assessment process was being achieved. The register includes justification to support the decisions made and allowed the options assessment to develop in a reduced risk and transparent manner.

Several key decisions recorded on this register worthy of particular note are:

A fine balance has to be struck between the proposed road height, flood immunity, afflux, number and type of structures and cost. The proposed alignment has to be sufficiently high enough to meet the Project Service Requirements, whilst also being low enough to allow overtopping of the highway in major events and not introduce associated afflux impacts on land and properties upstream and west of the Bruce Highway.

i. Agreement to allow proposed highway alignment to over top to a maximum depth of 200mm (over road crown) in times of flood. This requirement was as per the regional guidance provided by TMR, aimed at ensuring driver safety (= <300mm head because of the low velocities at project locations, equates to approximately 200mm);

ii. Agreement of acceptable levels of afflux to be achieved (Less than 10mm net impact on existing habitable floor space, less than 50mm on existing properties in residential areas and less than 250mm on existing rural land);

iii. Agreement to adopt lengthened bridge structure (437m) at Cattle Creek instead of shorter bridge length (250m) with significant total lengths of culverts on bridge approaches (600m);

iv. Agreement on pavement treatment solutions to be proposed in the preferred concept design solution;

v. Agreement to increase proposed level of flood immunity (for proposed bridges) from Q50 to Q100, to address the flooding impacts on the nearby township of Toobanna): and

vi. Agreement on form of bridge construction to be proposed in the preferred concept design solution.

Although key design decisions were justified at the time, several of the key design decisions were also run through a ‘mini-MCA’ process to double-check alignment with the Project Service Requirements. This process is further discussed in Section 5 of this Report.

For further details associated with the Key Decision Register please refer to Appendix C of this Report.

1.11 Summary

In summary, the proposed Cattle and Frances Creeks project is approximately 4.8km in length and is located some 100 km north of Townsville and 10 km south of Ingham. It is aimed at improving flood immunity and safety on the Bruce Highway (Townsville to Ingham) section and Bowen to Ingham link of the Brisbane to Cairns corridor. The project section currently has poor reliability and connectivity for at least one-third of each year (December – March), due to its poor flood immunity of around Q1 – Q2.

The NB2 submission prepared was based on 2007 flood modelling, which indicated that this section experiences a maximum Time of Closure (TOC) of 72 hours in a Q50 event and an Annual Average Time of Closure (AATOC) of 15 hours. The project aims to address the highway's deficiencies between the existing Pennas Road intersection and south of the small township of Toobanna (Pomona Road Intersection).

The project's primary objective is to significantly improve corridor connectivity and reliability between the North Queensland service centre of Townsville and the dependent rural community of Ingham, and on the overall Bowen to Ingham link. Ingham is increasingly dependent on access south to Townsville, to support its key regional industries of sugar and tourism, as are some rural communities further north. As the Bruce Highway has poor flood immunity both south and north of Ingham, the project would also contribute towards improved reliability and connectivity on the Ingham to Cairns section. Overall the poor reliability results in increasing detrimental economic and social impacts.

The project is effectively governed by a set of 'Vision Standards' which target a consistent and suitably robust approach aimed at providing significant improvements on the Bruce Highway with regards to flood immunity, connectivity, reliability and safety, without creating significant social and environmental impacts of the project on the surrounding area and communities.

In addition to the 'Vision Standards' the project also has a set of Project Service Requirements which need to be achieved which are the outcomes desired for the project by TMR. These primarily relate to the provision of improved levels of flood immunity, accessibility, connectivity, safety whilst minimising social and environmental impacts.

During the previous Options Development stage of the project, two main types of options were identified and assessed, these being infrastructure and non-infrastructure solutions. Although the non-infrastructure solutions (silt removal & removal of waterway weeds) are currently preferred by some stakeholders, these solutions are only seen as offering 'short-term' temporary benefits which may provide a limited reduction in time of inundation and associated length of flooding closures, but do not provide the level of flood immunity certainty which an infrastructure solution would provide. For that reason a focus has been placed on further assessing infrastructure based options. Those which were highlighted in the Project Brief included:

i. Preferred NB2 Option (On line regrade of highway in southern section, utilise existing Frances Creek bridge, move to new off-line highway in northern section and provide new off-line bridge at Cattle Creek);

ii. SASR Sub-option same as Preferred Option, but replace existing Frances Creek Bridge with a new wider bridge off-line; and

iii. SASR Sub-option same as Preferred Option, but widen existing Frances Creek Bridge.

In addition to the above, three additional alternative options were identified which in part, would complement any of the above options, leading to varying degrees of reduced new highway infrastructure works.

Given that the project has previously been assessed (at a high level) to suitably inform the NB2 submission a reasonable amount of existing project data already existed, which was subsequently reviewed to better inform the technical analysis and options assessment phases of the Business Case development stage.

Given the establishment of the Project Service Requirements, the options to be considered and the existing project data already available, the technical analysis and assessment of options could then be further developed, which will ultimately inform the PAF Business Case submission which is to be prepared to support the potential future delivery of the project.

2 Technical Analysis

2.1 Introduction

The primary aim of the technical analysis component of the Business Case development stage is to develop a robust and affordable concept design solution, which achieves the identified Project Service Requirements and appropriately identifies, mitigates and costs corresponding risks to provide a P90 risk-adjusted project cost estimate. The technical analysis for the Business Case development stage not only documents the investigations carried out to achieve this, it also demonstrates that a rigorous process was followed and that there is a robust and transparent rationale behind the decision-making for the Business Case's recommendation.

Prior to the commencement of the technical analysis stage of the project, the key challenge highlighted to the project team involved each respective design discipline working collaboratively to achieve all the desired Project Service Requirements, which ultimately involved developing a fully PSR compliant, robust and cost effective concept design solution. The preferred solution had to be designed to the required 'Vision Standards' to ensure the project service, function and safety requirements were all met, and all within the capped budget of $105m (2012 prices, excluding escalation). The budget for the project was set following the completion of an NB2 submission and the preferred NB2 option was subsequently approved by TMR IIC, for further investigation in the Business Case development phase, along with the two SASR sub-options. As part of the NB2 process a 'better than strategic' cost estimate was prepared in a rapid timeframe, which resulted in a budget of $105m (2012 prices) being agreed for the project. Please refer to Appendix S of this Report for further details of this cost review undertaken during the early stages of the project.

Consistent with the outcomes of SASR and NB2 Submission, the technical analysis and options assessment primarily focus on developing the NB2 preferred option and two sub-options previously identified in the SASR for further investigation. However, prior to commencement of this analysis and assessment stage there was a key change to the way in which the desired level flood immunity of the project would be measured. In previous stages, the project specifically targeted achieving a Q20 level of flood immunity for roads and Q50 for bridges. This requirement was superseded and replaced by the flood related Project Service Requirements consistent with the BHAP. This placed greater emphasis on the time of closure of the highway, rather than the level of flood immunity to be achieved. This change in requirement was driven by TMR North Queensland bridge package, which was granted a relaxation to drive greater cost efficiencies in individual circumstances, in recognition of the extent in project scope that might be required to achieve these immunity levels on individual projects.

The Project Service Requirements which were required to be achieved were as follows:

i. Time of Closure (TOC) of less than 48 hours in a Q50 event; and

ii. Annual Average Time of Closure (AATOC) of no more than 10 hours.

This key change subsequently led to a change in design strategy as to how the specific flooding-related Project Service Requirements could be satisfied. In the earlier concept design solution developed, the highway was elevated above the desired flood immunity level. The change in requirement then allowed the highway to be 'overtopped' for limited depth and durations during times of flood, which allowed the proposed highway level to be lowered accordingly, without compromising the achievement of the flooding and afflux-related Project Service Requirements.

The following sub sections of the Report, describe on a discipline-specific basis, the various issues, constraints, risks and opportunities which all needed to be effectively managed, in a fully integrated manner, to ensure the preferred Business Case option recommended fully achieved all the various Project Service Requirements and associated desired project outcomes.

2.2 TMR Design Development Report

A TMR Design Development Report (DDR) has been prepared for the project to provide a record of the design development process as well as documenting key design parameters, standards and the decision making process involved in developing the preferred design solution. Key points included in this Report are:

- Project requirements;
- Existing conditions;
- Developing scope and identifying design inputs;
- Design parameters;
- Design details;
- Record of design issues arising from process activities;
- Road project development attachments; and
- Key design actions

The DDR plays an instrumental role in safeguarding against potential future changes to the project in the detailed design or construction phases, which could increase project risks and / or cost, or which could jeopardise the delivery of the projects intended outcomes and benefits. The DDR does so by clearly documenting the rationale behind the concept design decisions, regarding risk, cost and project outcomes.

For further details associated with the TMR Design Development Report please refer to Appendix A of this Report.

2.3 Design Integration

Given the multi-disciplinary nature of the project and the various key design disciplines involved, effective design integration was a critical success factor which was identified in the very early stages of the technical analysis process. As a result of this issue a Design Integration Workshop was held in week 5 (attended by TMR NQ, TMR PIP, BMT WBM Consultants and Arup) to ensure:

i. All key project interfaces between respective disciplines were identified;

ii. All respective disciplines involved could appreciate and actively support each other in the achievement of the various Project Service Requirements; and

iii. All key design integration considerations and associated actions were recorded on the Design Integration Register (then used as a live management tool).

This focused on achieving an integrated approach to completing the Business Case development stage. Project risks were effectively reduced by developing an integrated technical solution which took account of all potential impacts and required associated mitigation strategies to be developed. This ultimately gave rise to increased surety that the desired project outcomes would all be successfully achieved.

For further details associated with the Design Integration Register please refer to Appendix B of this Report.

2.4 Safety in Design

A key consideration during the Business Case development stage was the incorporation of safety in design thinking into the options development and assessment process. This involved ensuring safe design principles were embedded in the project right from the very outset of the design process. Effective safety in design is focused on identifying issues / potential hazards associated with the project design, and provides the opportunity to eliminate or reduce hazards to an acceptable level. The safety in design review undertaken helped effectively de-risk the project to a certain extent, which then gives rise to the achievement of early safety, financial and project delivery related benefits.

The following key safety and design issues were identified and considered during the Business Case development stage:

i. Aquaplaning has been identified as key problem in several crashes highlighted in the Crash Reports for this section of road. Due to the flat nature of this road, superelevation development has been heavily scrutinised to address aquaplaning problems;

ii. A typical 11m seal width with Wide Centre Line Treatment (WCLT) has been adopted for the entire project;

iii. Existing narrow bridges are not sufficient to accommodate minimum width (10.4m) required for WCLT installation;

iv. Bridge vs. culverts options, a single large spanning bridge design with no culverts has been investigated and found to be marginally cheaper and more beneficial than a smaller bridge with culverts solution. Installing culverts under a live road has constructability issues, along with providing suitable safety barrier protection to these hazards in low lying sections of the road where it is designed to overtop, to meet Vision Standards and Project Service Requirements;

v. Cane haul-out vehicles do not appear to be linked to accidents in the historic crash data records;

vi. A high percentage of freight vehicles use this key regional transport link, and volumes are expected to increase;

vii. Increase in expected traffic levels associated with the Northern Queensland Biofuels development which will utilise the Pomona Road Intersection;

viii. Ergon power poles located within the clear zone have been considered hazards and will be relocated outside of the clear zones; and

ix. Turning traffic volumes are minimal at all intersections. The analysis of each intersection on the basis of the traffic volumes alone warrants basic treatments to be provided. The existing channelized right turn treatments at the following intersections have been maintained:

- Bruce Highway (southbound) turning right into the Frances Creek Rest Area; and
- Bruce Highway (northbound) turning right into Haughty's Road.

For further details associated with the Safety in Design Register please refer to Appendix D of this Report.

2.5 Survey

As part of the existing project data supplied by TMR, a number of different surveys for the Cattle and Frances Creek section of the Bruce Highway were provided. These include two aerial LIDAR surveys that covered the entire project site area and three separate feature string surveys, which located road crown/formation and hydraulic information, relating to specific sections of the existing highway corridor. During the review of this survey data various anomalies were discovered, which were primarily related to discrepancies in the reduced levels of the feature string survey, which were outside the normal accuracies associated with such data.

The discrepancies identified were discussed with BMT WBM Consultants and TMR and it was agreed that the LIDAR survey would be used for the geometrical highway design. This LIDAR data was captured using Airborne Laser Scanning from 27th July to 15th August 2009. BMT WBM Consultants completed a sensitivity analysis on the levels to establish what impacts the differences would have, if any, on the achievement of the Project Service Requirements. BMT WBM Consultants confirmed that the associated impacts were minimal and within the afflux and vision standard acceptable level of tolerance. Detailed outcomes are discussed in the Hydraulics Assessment Report, included in Appendix E of this Report.

During the next phase of the project it is recommended that a full feature survey be undertaken to check the accuracy of this survey data, which in turn may allow the preferred option design to be further optimised.

For further related details, please refer to the Survey Technical Note included in Appendix N of this Report.

2.5.1 Cadastral

During design development, it was observed that there was an error in the accuracy of the digital cadastral boundaries at lot 4/SP130991. TMR's Surveyor confirmed there was an error and supplied revised cadastral information for this location. This is a constrained location for the new alignment and the revised cadastral information was used to set out partial resumptions and PUP relocations required as part of the Business Case design.

2.6 Hydraulic Analysis

2.6.1 Background

Approximately 100 km north of Townsville in North Queensland the Bruce Highway traverses the Frances Creek and Herbert River floodplains, which includes Cattle Creek. There is a history of severe flooding on these floodplains with frequent road closures. These frequent closures impact on the connectivity of the Bruce Highway between Townsville and Cairns. Therefore the Department of Transport and Main Roads (DTMR) is seeking to improve the flood immunity and transport efficiency of the highway across this floodplain.

The Report Bruce Highway Upgrade Frances Creek to Cardwell Range Preliminary Hydraulic Assessment (BMT WBM Consultants, 2007) found that the most flood prone locations on the Bruce Highway in the vicinity of Ingham /Hinchinbrook Shire were at the Gairloch Washaway and the Seymour River, both north of the Herbert River. Other flooding 'hotspots' included Arnot Creek, Kingsbury Creek, Palm Creek, between Macrossan and Cooper Streets (in Ingham), Cattle Creek, and Frances Creek. This focus of the Business Case Report is the highway crossings of Frances Creek and Cattle Creek.

DTMR historical road closure data shows that over the last 40 years the highway has been closed on average about every 2 to 3 years, on the Cattle & Frances Creek section. Since 2010 the highway has been closed more frequently than the long term average. The duration of the closure can range from a few hours to many days.

In 2012 DTMR undertook a Link Study for the highway from Helens Hill to Rutledge Street, which focussed on the Frances Creek and Cattle Creek crossings. As part of the Link Study BMT WBM completed a hydraulic assessment, Bruce Highway Helens Hill to Rutledge Street Link Study Hydraulic Assessment Final Report (BMT WBM Consultants, 2012).

Flooding at these crossings is complex, with runoff from local catchments as well as significant overflow, in the case of Cattle Creek, from major river systems including the Stone River and Herbert River. Because of these complexities BMT WBM Consultants used for the Link Study analysis a fully two-dimensional (2D) model of the floodplains that represents these complex interactions. Some uncertainties in the Link Study modelling were identified and recommendations were made for further upgrades and validation during Business Case development and later stages.

2.6.2 Flood Model Development

As part of the current Business Case the model was further upgraded and additional validation was undertaken, including validating against the 2009 flood and seeking feedback on model outputs from local residents. Following this process it was determined that the model was fit-for-purpose for the Business Case. When the project moves to detailed design it is recommended that the model be further upgraded to include detailed survey along the study corridor and validation against another flood, should one occur prior to detailed design. To allow this validation DTMR should survey extensive flood height data along the road corridor and from farms adjacent to the corridor, should a flood occur.

The 2D flood model was used to set road level and drainage structure requirements to achieve the flood serviceability and flood impact requirements. The flood serviceability requirements were the DTMR Vision Standards of an average annual time of closure (AATOC) of no more than 10 hours/year, and a time of closure (TOC) of no more than 48 hours in the 50 year average recurrence interval (ARI) event. The flood impact criteria related to acceptable increases in flood level, velocity and afflux.

The Link Study serviceability criteria of providing 20 year flood immunity is a higher standard than that adopted in the current Business Case. However it was identified in the Link Study (BMT WBM Consultants, 2012) that although the serviceability criterion was achieved, the flood impact criterion was not achieved at the residential properties at the southern end of Toobanna (immediately to the north of Pomona Road), and hence further investigation was required. The flood level impact at these properties was a controlling factor in the hydraulic design during the Business Case, and to achieve the flood impact criteria at these properties it was necessary to reduce the serviceability criteria from Q20 immunity to satisfy the Vision Standard requirements for highway closures for the Business Case.

2.6.3 Options Assessment

Three design options were investigated (Preferred NB2 Option, SASR Sub-option and Base Case), and after a process of iteration, the preferred NB2 option and the SASR sub-option achieved the flood serviceability requirements. The study team selected a preferred option from the three options and further iterations of this design were done to improve the flood immunity of the approaches to the Cattle Creek Bridge. Further optimisation of the design could be undertaken, and so there may be an opportunity at detailed design stage to develop a more cost effective solution.

Each design option provides a similar level of serviceability, although the Preferred Option (Refined) provided the highest level of serviceability. At Cattle Creek, currently the more frequently closed crossing, the level of serviceability is significantly improved with the 50 year ARI TOC reduced from 75 hours to 38 hours, and the AATOC from 28 hours/year to 4.0 hours/year. The flood immunity of the Cattle Creek crossing has increased from about 2 to 3 years ARI to approximately 10 years ARI, where immunity is defined as the flood level that cause closure, i.e. 200 mm depth of water over road; in each design option the Cattle Creek bridge is above the 100 year ARI flood level and so this refers to the approaches.

At Frances Creek it is the bridge’s southern approach that is cut by flooding rather than the bridge itself, which has a deck level above the 50 year ARI event. On the southern approach the 50 year ARI TOC is reduced from 40 hours to 4.5 hours and the AATOC from 11 hours/year to 0.5 hour/year.

Further improvement on the serviceability criteria would require consideration of the AATOC and 50 year ARI TOC of the highway immediately to the north and south of the Business Case study area. For example, to the south in the vicinity of the Pappins Road intersection the existing 50 year ARI TOC is 37 hours and the AATOC is 3.9 hours/year. Immediately to the north near the Pomona Road intersection the 50 year ARI TOC is 37 hours and the AATOC is 4.1 hours/year. However, these sections are still within the Vision Standard requirements and were upgraded within the last 20 years.

For further details associated with the Hydraulic Assessment Report please refer to Appendix E of this Report.

2.7 Environmental Assessment

A Review of Environmental Factors (REF) has been prepared, to identify and evaluate constraints and potential environmental impacts associated with the Project. The REF also identifies means to avoid, minimise or sufficiently mitigate impacts. The Project Service Requirements have informed design development and this REF, including:

- Minimising social impacts (such as afflux and resumptions) and environmental impacts (including water/ habitat quality); and
- Developing a cost-effective solution, such that it contributes to the achievement of link and corridor flood immunity improvements within the medium term.

Research and investigation undertaken to support the REF included:

- Flora and fauna surveys to characterise the vegetation communities present, and identify habitat values;
- Review of previous plans and strategies for the Cattle Creek Wetlands Area; and
- Review of relevant environmental and land use planning statutory frameworks. It is noted that at the time of writing, the Queensland planning process is undergoing significant review and revision, and the statutory requirements identified in the REF will require review in future stages of design and project implementation.

The following key issues were identified during this assessment, as listed below:

- Replacement of the Frances Creek Bridge (sub-option), will require the removal of existing riparian vegetation, which has been assessed as currently providing marginal foraging habitat for the Mahogany Glider;
- The raising of the highway levels will result in higher embankments, which will require clearing of roadside vegetation so as to meet safety standards;
- The Cattle Creek Wetland is defined as a wetland protection area. The design of proposed waterway crossing structures (particularly at Cattle Creek) presently allow for significant areas under the bridge above the low flow channel of the Creeks. This may facilitate better opportunities for fauna passage from east to west under the highway. The preferred longer bridge structure allows for minimum disturbance of vegetation and the protection of the existing ecological corridor. The State Development Assessment Provisions require development in a wetland protection area to ensure that any existing ecological corridors are enhanced or protected, and have dimensions and characteristics that will: (1) effectively link habitats on or adjacent to the

development (2) facilitate the effective movement of terrestrial and aquatic fauna accessing or using a wetland as habitat;

- Where temporary side-tracking may be required, vegetation clearance should be minimised through future design and construction footprint minimisation, and quickly remediated on completion of construction works;
- The greatest risk to water quality is during construction, particularly for bridge installation, excavation, filling, and remediation or removal of redundant structures. Water quality risks during operation have been assessed as negligible. The project is currently obliged to meet existing water quality objectives, therefore no additional stormwater treatment devices (beyond those normally deployed to meet water quality objectives) are proposed for the operational phase (e.g. grassed swales/ embankments);
- The downstream environs of the Cattle and Palm Creek Fish Habitat Area and the Great Barrier Reef mean that stringent water quality, excavation and stockpile controls will need to be applied during construction. As limiting the construction period to outside the wet season is understood to not be practical, consideration of limiting high risk activities (such as placement of piers and bridge elements) to outside the wet season should be factored into project programming and future environmental management procedures;
- The current bridge allows stormwater to runoff to the wetland. This is considered acceptable based on current standards, therefore no additional treatment is proposed on the bridge, given the limited volume and type of pollutants generated by operational activities that will remain identical to the existing situation. Whilst the design does not provide for an improvement in water quality, the existing quality will be maintained;
- The existing hydrological function and ecological condition of the wetlands is likely to be improved by replacement of the existing Cattle Creek Bridge with a higher, longer bridge, with wider pier spacing's;
- The larger openings under the Cattle Creek Bridge are intended to minimise the potential for weed mats to be tangled or caught in the bridge piers. This means however that there is a potential for these 'weed mats' to be transported further downstream. Ongoing partnerships between land owners and land managers should be encouraged to address this issue upstream of the project area; and
- The Cattle Creek Bridge has been designed to meet the Vision Standards for flood road closures in this region. This will result in a significant improvement to access and mobility during and immediately after severe weather events, benefiting local and regional communities, businesses, defence services and emergency services.

The project has the potential to impact Matters of National Environmental Significance (MNES), as specified under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), including:

- Listed threatened species and communities (Sections 18 and 18A);
- Listed migratory species (Sections 20 and 20A); and
- Great Barrier Reef Marine Park (Sections 24B and 24C).

These MNES would require documentation as part of an EPBC Act referral. The presence of marginal Mahogany Glider habitat is most likely to require further detailed consideration and mitigation. Core and marginal habitat for the for the Mahogany Glider species should be protected and retained, due to the highly fragmented nature of remaining habitat within the very small distributional range of the species. The two other MNES, water quality impacts to Great Barrier Reef Marine Park and construction impacts to listed migratory species occasionally utilising the Cattle Creek Wetlands, are likely to be managed through TMR environmental management processes.

An EPBC Act referral is recommended, regardless of which option is chosen (i.e. Frances Creek Bridge replacement or not). This recommendation has been based on field studies, desktop based research and commissioned assessments of specific elements. Despite the reduction in impacts through design considerations it is still considered prudent and best practice to refer the project to the Commonwealth Department of Environment for determination of 'controlled action' status. As well as minor impacts to Mahogany Glider, the project is within the Great Barrier Reef catchment and Cattle Creek Wetlands provides habitat for Saltwater Crocodiles and migratory birds. Impacts to water quality and the wetlands will be temporary and managed through a Construction Environmental Management Plan. Impacts associated with a reduction of habitat connectivity will be mitigated and reduced through design considerations, including limiting vegetation clearing, revegetation works and installation of glider poles.

The design and construction mitigation measures are considered sufficient to reduce the risk of obtaining a controlled action determination for the project. With the installation of glider poles and revegetation works, the impacts to Mahogany Gliders will not be significant. The sub-option has a greater impact to habitat connectivity for gliders as it will result in the clearing of more movement habitat and result in a greater width between habitat patches. For this reason the sub-option involves a greater risk of receiving a controlled action determination, which will require detailed assessment and approval from the Department of Environment.

Given that the project is anticipated to be several years from construction, and there are potential future changes to statutory requirements for environmental assessments, it is recommended that an EPBC Act referral is progressed in future stages of design. This will also ensure that any field investigations are completed as close to the point of construction as possible in order to maximise their accuracy for what species are utilising the area.

Part 10 of the EPBC Act provides the framework for Strategic Assessments. Given the Project Area is partially within the bounds of the Great Barrier Reef Strategic Assessment - Coastal Zone, the *Strategic Assessments: Policy Statement for EPBC Act Referrals* would be taken into consideration for assessment purposes.

The Queensland and Australian Governments recently signed a memorandum of understanding regarding environmental assessment. At the time of writing, the implications of this on EPBC Act assessment processes was yet to be defined.

An Environmental Management Plan – Planning (EMP) incorporates the mitigation and management recommendations for future stages of design and construction. This document should be reviewed during future stages of design and prior to construction, so that issues and management requirements identified in this REF can be implemented in future stages. The EMP is appended to the REF Report.

For further details associated with the Review of Environmental Factors Report (including the Environmental Management Plan) please refer to Appendix F of this Report.

2.8 Cultural Heritage Assessment

A cultural heritage assessment, including both desktop research and site inspections was undertaken for this project. The desktop component comprising register and database searches, review of contextual background research and surveys and historical background. The site inspection of the study area was also carried out in order to apply the Aboriginal Cultural Heritage Duty of Care Guidelines and assess the non-Indigenous cultural heritage potential of the road corridor. Site inspections of the corridor were also undertaken with representatives of the Nywaigi and Warrgamay aboriginal groups.

2.8.1 Indigenous Cultural Heritage

Key findings include:

- The project area is not located within the external boundaries of a registered Native Title Determination Application (NTDA) and is not located within the external boundaries of a registered Cultural Heritage Body.
- The search result of the Department of Aboriginal Torres Strait Islander and Multi-Cultural Affairs (DATSIMA) register and database did not locate any Aboriginal cultural heritage sites and places as being located within the study area.
- The review of secondary source material suggests that the DATSIMA results are likely to reflect that little cultural heritage research or consultancies have been undertaken in this specific area.
- Preliminary consultation identifies two aboriginal groups for the area: the Nywaigi aboriginal group and the Warrgamay aboriginal group.
- Given the nature of modifications to the landscape since the beginning of the historic period (e.g. vegetation clearance, road construction, levee and drain construction, services installations and farming), it was considered that Category 3 of the Aboriginal Cultural Heritage Act (ACHA) 2003 Duty of Care Guidelines best described the status of the study area (that is the road corridor).
- It was considered that Category 4 of the ACHA 2003 Duty of Care Guidelines best described the status of the lands surrounding the road corridor.
- An area of wetlands (the Cattle Creek Wetlands) and the Frances Creek corridor, identified as conjoining the project area, possesses the potential to represent a residual Aboriginal cultural heritage area of bio geographical significance as described in paragraph 6.2 of the Duty of Care Guidelines. There is also low potential for cultural heritage objects to remain in elevated areas adjacent to the waterways. As a result, this study finds that the undertaking of a proposed road upgrade has some risk of impacting on Aboriginal cultural heritage, both identified and as yet unidentified.

- No sites of places of non-Indigenous cultural heritage significance were identified on the relevant statutory or non-statutory databases and registers.
- The study area demonstrated evidence of a variety of historic activities, most associated with earlier road alignments, installation of services and earlier flood mitigation measures. A previous road alignment is apparent on the eastern side of the current highway between the north side of Cattle Creek and intermittently to the south of Haughty's Road. An earlier crossing of Cattle Creek and associated features was considered to have potential cultural heritage significance at a local level.

The potential for the presence of significant Non-Indigenous cultural heritage was considered to be low, with any as yet unrecorded sites expected to most likely relate to the history of road construction in the study area.

Accordingly, TMR should continue consultation with the identified Aboriginal Parties to advise them of the project, including final design, and to seek their advice and agreement on how best to avoid or minimise harm to Aboriginal cultural heritage, both identified and unidentified, within the project area.

2.8.2 Non- Indigenous Cultural Heritage

The results of the searches of various statutory and non-statutory registers and databases and the review of the historic background for the region allow the following comments to be made:

- No sites or places of Non-Indigenous cultural heritage significance were identified as being located within the study area; and
- The historic background for the area suggests that relevant historic themes for the study area are: Moving goods, people and information and exploiting, utilising and transforming the land.

The site inspection identified a previous road alignment on the eastern side of the current alignment between the north side of Cattle Creek and intermittently to just south of Haughty's Road. The most significant section of this previous alignment was assessed as being in the vicinity of Cattle Creek and included planted exotic trees, evidence of road construction techniques, two culverts, remnant boundary fencing and a permanent survey marker. This location was assessed as being of potential local heritage significance, which would warrant additional research and recording prior to its removal.

The potential for as yet unidentified Non-Indigenous cultural heritage of a significant nature is considered to be low.

For further details associated with the Cultural Heritage Assessment Report please refer to Appendix F of this Report.

2.9 Traffic and Transport Assessment

2.9.1 Transport Task

The transport task for the project location is summarised in Table 4 below. A range of demographic and economic factors affect the transport task and associated mode share. There is a heavy reliance on road transport for most functions.

This dependence on road is most pronounced for connectivity between the regional service centre of Townsville (its airport, seaport and essential services) and Ingham. Other smaller rural townships in Hinchinbrook Shire also depend on this access. The continuing trend of gradual withdrawal of some essential services from rural communities and associated increasing dependence on access to regional cites for these services has also increased reliance on road access.

Table 4 - Transport Task Summary

Transport Task	Primary mode/s
Long-distance (inter-state and inter-regional): Brisbane to Cairns corridor and Mackay to Cairns link	
Time-sensitive, non-bulk freight	Air
Tourism – inter-state	Air
Tourism – inter-regional	Air/road (for drive tourism)
Export of agricultural commodities (raw sugar and sugar products, including molasses and biofuels)	Sea (Port of Lucinda and/or Port of Townsville)
Transport of bananas to southern markets (inter-state and inter-regional freight – time-sensitive, bulk freight)	Road
General freight – bulk supplies of foodstuffs and goods	Road/rail
Disaster relief - emergency	Air/road/rail
Disaster re-construction	Road
Short-distance (intra-regional and local): Townsville to Ingham section	
Access to essential services - intra-regional	Road
Tourism - intra-regional	Road
Transport of agricultural commodities and agricultural inputs to and from the Port of Townsville - intra-regional freight	Road
General passenger transport - intra-regional	Road
Access to Townsville airport – intra-regional (to access intra-state and inter-state flights)	Road
Local freight & passenger transport from southern side of Hinchinbrook Shire to main centre of Ingham/Port of Lucinda	Road

2.9.1.1 Mode Share

Mode share is not expected to change significantly in the medium to long term. Some minor forecast or potential changes to mode share are outlined below.

2.9.1.2 Decreased Dependence on Road

Increased use of sea transport for a component of the general freight task (inter-regional/inter-state) has been flagged by the Port of Townsville, to bring domestic goods directly to the Port of Townsville (rather than by road or rail). However, road is expected to remain the dominant mode for general freight, particularly for foodstuff.

2.9.1.3 Increased Dependence on Road

There is potential for more of the general freight task (intra-regional) to shift from rail to road. Currently, Ingham Railway Station still has a freight depot; however, recent closures of freight depots at other rural towns (Ayr and Tully) have raised the prospect of further closures of rail-freight depots in rural, coastal townships on the North Coast Line (Brisbane – Cairns corridor).

There is potential for increased tourism traffic on road, due to the state government's push to increase drive tourism numbers, through its overall tourism strategy (Destination Q) and Drive Tourism Strategy. Regional tourism strategies also have a strong emphasis on road for intra-regional access.

There is potential for increased volumes of inter-regional and inter-state road freight associated with increased horticultural production, given the state government's push to double agricultural production (Queensland's agriculture strategy). Both sugar and horticulture predicted to increase production.

In extraordinary circumstances, there is potential for temporarily increased road freight for sugar exports, should significant cyclone damage occur to the Port of Lucinda again (as happened during 2011-2012, due to Cyclone Yasi, when raw sugar was transported by road to the Port of Townsville, along with timber from Cardwell).

The draft NQ2031 Economic and Infrastructure Framework (EIF) and key local government documents (Hinchinbrook Economic Development Strategy and Hinchinbrook Community Plan) emphasise the need for economic diversification in Ingham/Hinchinbrook Shire, to provide increased employment opportunities and mitigate the social issues arising from its ageing demographic.

2.9.1.4 Road Traffic Demand – Current and Forecast

The project location carries 4,700 vpd, with an annual forecast 3-5% growth rate. The current traffic volume includes a relatively high 20% of heavy vehicles (some 940 vehicles) in comparison with 15% average, for the overall 110km Townsville to Ingham section.

2.9.2 Traffic Modelling / Analysis

Traffic modelling was not undertaken for the Business Case, because of the straightforward nature of traffic patterns at the project location. The assumption is that there will not be a significant change in traffic volumes from current traffic growth forecasts, based on the above analysis of the traffic transport task and modal share.

The estimated future transport task is based on TMR's Traffic Analysis and Reporting System (TARS), 2012 data. As the nearest TMR traffic counter is on the southern outskirts of Ingham, a 24-hour traffic count also was taken at the project location on 15 August 2013, to provide an individualised snapshot of traffic demand at this location and to capture traffic volumes and types at the Bruce Highway's intersections with local roads. The count reflects the peak annual volumes for this section, as it occurred during the peak drive-tourism season and cane-harvesting season. The count captured approximately 4,700 vehicles (two-way), including 20% heavy vehicles. This showed a higher percentage of heavy vehicles at this location than the assumptions that were based on the nearest TMR traffic counters (42km north of Townsville and 2km south of Ingham), where heavy vehicles made up 15% of total volumes.

The traffic analysis has also taken account of the increased future freight demand generated by the proposed North Queensland Bio-energy (NQBE) plant on this section of the Bruce Highway. The NQBE venture is forecast to generate an additional 0.5 million tonnes per annum (Mtpa) of freight from Ingham to the Port of Townsville.

2.9.2.1 Intersection Treatments

An assessment of the traffic volumes turning from the Bruce Highway found that with regards the majority of intersections, the level of turning traffic was minimal, (one or two turning vehicles during the peak hour). At these locations, on the basis of the above, minimal turning treatments would be required under AustRoads, and a Basic Left Turn/Basic Right Turn (BAL/BAR) treatment would suffice.

TMR have since advised that the National Road Safety Strategy (NRSS) emphasises safer intersection treatments as a key area of intervention for regional areas, to assist in reducing serious casualty clashes. Similarly the Queensland Road Safety Action Plan 2013-2015 notes that expenditure on safety focused improvements such as intersection treatments creates infrastructure which is more forgiving to human error. As such, channelised right turn treatments CHR (S) with additional turn provision for left turns (AUL(S)) have been adopted as a higher standard for all intersections within the study area, as a low cost high safety benefit treatment. Costs associated with these intersection upgrades, are therefore included in the P90 cost estimate.

The assessment also considered the Pomona Road / Pinnacle Hill Road intersection, which is located within the project area. It was noted that this intersection is to be upgraded, to be provide a channelised right turn treatment, as a condition of the nearby North Queensland Bio-Energy development (which is expected to be operational by 2016). The future detailed design stage of the project will need to consider the associated tie-in points with the upgraded intersection layout, once these works have been completed.

2.9.3 Comparative Analysis

The main transport/traffic outcomes sought from the project are improved reliability, connectivity and accessibility for freight and passenger traffic, to provide social and economic benefits. These benefits would include:

2.9.3.1 Social and Economic Benefits (Section Improvements)

- Improved access to essential services via the Townsville – Ingham section (particularly more equitable access to health services, including birthing services, specialist services and other services for an ageing population);
- Support for the shire’s key industries (sugar/biofuels), by improving year-round access to the Port of Townsville; and

- Support for economic diversification in Ingham/Hinchinbrook Shire, to provide increased employment opportunities and mitigate the social issues arising from its ageing demographic.

2.9.3.2 Economic Benefits (Link and Corridor Improvements)

- Support for key regional industries (drive tourism and bananas) by improving access on the Mackay – Cairns link and to southern markets via Brisbane – Cairns corridor.

2.9.3.3 Transport-related Outcomes reflected in Project Service Requirements

The relevant Project Service Requirements capture these outcomes, which are required to support the transport task outlined above. The relevant service requirements are:

- Improve accessibility to the Port of Townsville to cater for current export commodities and their inputs (and flexibility to cater for export tasks that may emerge at short notice)
- Support economic growth by reducing disruption to key regional industries of sugar, horticulture and tourism, that rely on year-round reliability of access south of Ingham
- Improve connectivity and access to services between rural community and regional centre (Ingham and Townsville)
- Contribute to the achievement of link and corridor flood immunity improvements within the medium term.

The service requirements reflect both the economic and social benefits that would accrue from these outcomes. These include the potential for increased economic development for the shire and North and Far North Queensland and quality of life and equity considerations for rural residents.

Service requirements relating to safety are covered above under Section 2.19 of this Report.

2.9.3.4 Assessment of Base Case against Transport-related Outcomes

The Base Case option (a continuing maintenance and rehabilitation regime but no capital expenditure) would not be able to provide the above outcomes, regarding support for economic growth, better accessibility to key freight destinations (the Port or southern markets) and improved transport equity through better access to essential services. It follows that the Base Case could not deliver the identified economic and social benefits derived from these outcomes.

This is because significant flooding disruption would continue, affecting various aspects of the transport task on the Townsville to Ingham section, the Mackay to Cairns link and Brisbane to Cairns corridor.

2.9.3.5 Assessment of Options against Transport-related Outcomes

Both the preferred option and sub-option would provide increased flood immunity (achieve desired 10/48 TOC/AATOC requirements) and improved safety, given that their scope includes a higher alignment, wider seals and wider / higher bridge crossings (for preferred option includes Cattle Creek only and for Sub-option includes both Frances & Cattle Creek structures).

Both options would deliver the above outcomes resulting in the same level of improvement in reliability, connectivity and accessibility for the section, link and corridor.

2.9.4 Transport Summary

The transport outcomes sought from the project do not provide a point of differentiation between the preferred option and the sub-option. Both would provide equivalent TOC/AATOC and flood immunity, resulting in the same level of improvement in reliability, connectivity and accessibility for the section, link and corridor.

2.10 Alignment Geometry

The 4.8km section of Bruce Highway under review runs across relatively flat terrain in a northerly direction parallel to Frances Creek, from the southern project extents (Pennas Road un-signalised T-intersection) up to the existing 45m long Frances Creek Bridge. This southern section also includes three other existing un-signalised T-intersections (at Pombel Road, Haughty's Road and Frances Creek Rest Area). From this point the highway then reduces in level (by approximately 3m) over a distance of approximately 2km and crosses the existing flat and low-lying Cattle Creek wetland area, on a low embankment and existing 150m long Cattle Creek Bridge, which spans the creek channel. The project extents terminate at the existing Pomona Road/Pinnacle Hill Road intersection (4 leg un-signalised intersection), located approximately 250m south of the existing township of Toobanna.

The concept design comprises of a raised on-line alignment for the southern section to provide the desired level of flood immunity. The northern section includes an off-line alignment to the east of the existing alignment across the Cattle Creek floodplain and an on-line alignment at the northern tie-in (prior to Pomona Road intersection). Initially a new 253m long bridge was proposed with banks of culverts either side (totalling 670m) to alleviate upstream afflux, which was further refined as a consequence of the iterative multi-disciplinary design process adopted.

Where possible, the proposed road alignment was to remain within the existing road reserve to minimise associated property resumptions and environmental and cultural heritage impact issues. The following sections outline the design parameters used and the alignment adopted for the Business Case concept design development process.

For further details associated with the alignment and geometry design please reference the Geometry Checklist included in Appendix Q of this Report.

2.10.1 Design Standards

The following design standards were utilised as a guide throughout the Business Case design. Design standards are listed in order of precedence.

- TMR RPDM - Road Planning and Design Manual (2nd Edition);
- AustRoads Guide to Road Design;
- TMR MUTCD - Manual of Uniform Traffic Control Devices (2003 Edition) ;and
- TMR Standard Drawings and Specifications.

The RPDM - Interim Guide to Road Planning & Design Practice provides clarification for designers of which road design criteria are applicable within this interim period from the AustRoads guidance documentation.

2.10.2 Design Software

The following design and drafting software has been used in the preparation of the geometric road design;

- 12D Model 10 (by 12D Solutions);
- AutoCAD 2011 (by Autodesk); and
- AutoTrack 9.01 (by Savoy Computing).

2.10.3 Speed Parameters

The following design speeds were adopted.

Table 5 - Speed Parameters

Road	Posted Speed	Min. Design Speed
Bruce Highway 10M	100km/h	110km/h
Local side roads	60km/h	70km/h

2.10.4 Sight Distance Criteria

The following sight distance criteria were adopted.

Table 6 - Sight Distance Criteria

Criteria	Distance
Eye Height	1.1m car & 2.4m truck
Object Height	0.2m or pavement surface as appropriate
Reaction Time	2.5 seconds
SISD at Intersections	Calculated from driver's eye height at a point no closer than 3m from the edge of the traffic lane on the side road.

2.10.5 Design Vehicles

The following vehicles were used as design vehicles to check turn movements:

Table 7 - Design Vehicles

Element	Requirement
Highway mainline	For the through alignment a 25m B-double vehicle will be used as the design vehicle (Class 10).
Major Intersections	19.0m prime mover and semi-trailer (AustRoads' 19m single articulated vehicle) & check Vehicle 25m B-double. (Class 9).

Vehicle tracking through intersections was undertaken using an envelope offset of 0.6m and a vehicle speed of;

- 10km/h for vehicles entering from the side roads; and
- 20km/h for vehicles turning into the side roads.

2.10.6 Horizontal Alignment

The existing horizontal alignment has generous sweeping curves in line with the road environment to the north and south. The proposed alignment has been split into southern and northern sections and includes a sub-option of a new Frances Creek Bridge. Each of the two sections are discussed in detail below and can be referenced in the concept design layout plans included in Appendix V of this Report.

2.10.6.1 Southern Section (Pennas Road – Frances Creek Bridge)

To meet the Project Service Requirements it is proposed that the southern section of the project will remain on the existing horizontal alignment and where necessary the formation width will be widened to 11m. The alignment has been applied with the intention of one sided widening to the eastern side of the existing carriageway where possible. This will help streamline construction and reduce costs.

The corridor in this section is constrained by overhead power lines on each side, an existing rest area, environmentally sensitive habitat to the west and farmland to the east.

2.10.6.2 Northern Section (North of Frances Creek Bridge – Pomona Road)

The northern section of the project will be built off-line to accommodate the construction of a new off-line carriageway and new Cattle Creek bridge, which will ease traffic impacts during the construction stage. The original preferred option alignment (NB2 submission) has been moved closer to the existing alignment to reduce the size of the scheme footprint, and as such, reduce the environmental impact of the project and provide further clearance from the existing overhead power lines, currently located to the east. This new section of the highway ties back into the existing carriageway at the adjacent horizontal curves and will be constructed on-line for a short section to the northern tie-in.

2.10.6.3 Sub-option (New Frances Creek Bridge)

A short section at the interface of the southern and northern sections would be built off-line to allow construction of a new Frances Creek Bridge. The proposed corridor passes through an environmentally sensitive habitat, and as such, has the potential to affect the successful achievement of all the desired Project Service Requirements.

2.10.7 Vertical Alignment

The existing vertical alignment of the Bruce Highway within the project area is generally very flat with the lowest section of the road in the vicinity of Cattle Creek Bridge (southern section). In order to meet the Project Service Requirements, the existing vertical alignment of the carriageway has to be raised in order to achieve the increased level of flood immunity required. The new road levels were determined through an integrated and iterative multi-disciplinary design process which primarily centred on the hydraulic analysis undertaken by BMT WBM Consultants, aimed at achieving the 10/48 TOC and AATOC Project Service Requirements. The design of the vertical geometry also took due consideration of the following key elements:

i. Compliance with AustRoads design standards;

ii. Previous safety issues relating to aquaplaning concerns;

iii. Alignment of the proposed bridge structures (reduce skew angle of bridge to ease constructability);

iv. Making best use of existing pavement asset;

v. Proposed intersection upgrades required;

vi. Minimising scheme footprint – reduce environmental impacts and ensure proposed land acquisitions were kept to a minimum;

vii. Constructability of the proposed design in relation to minimising impact to existing traffic during construction; and

viii. Maintaining existing property access.

2.10.7.1 Southern Section (Pennas Road – Frances Creek Bridge)

The vertical geometry from Pennas Road to Pombel Road has been raised and culverts introduced to meet the afflux requirements of the project and to ensure the existing drainage flow paths remain largely unchanged. North of Pennas Road the alignment currently meets the desired flood immunity requirements, however this section does historically overtop in times of increased storm intensity (frequent short duration occurrence, which does not appear in modelling). TMR have therefore requested that these localised flooding areas be raised by approximately 100-200mm, primarily to provide an increased level of flood immunity, but also to allow the existing pavement to be widened and additional pavement thickness added, to meet Project Service Requirements (20 year design life and minimum width). It is considered that the existing asphalt wearing surface will be fatigued by the proposed opening year and would therefore require replacement regardless. This offers TMR a more cost effective solution in the longer term and reduces associated future maintenance costs. The alignment then ties back into existing levels at the Frances Creek Bridge.

2.10.7.2 Northern Section (North of Frances Creek Bridge – Pomona Road)

The northern section will be on a new raised alignment to the east side of the existing highway and will generally overlay the original highway alignment, as recommended in the pre-concept planning stage. Increasing the height of the road has the potential to cause a 'damming' effect in time of flood, resulting in an increase in afflux levels upstream, thus affecting the achievement of the Project Service Requirements. In order to reduce this effect, water can be allowed to flow over or under the road. When over-road flow depths reach 200mm, the road will be closed and TOC and AATOC are affected. For water to flow under the road, bridge or culvert structures are required which are high cost components of the project.

As such, a fine balance has to be struck between the proposed road height, flood immunity, afflux, number and type of structures and cost. The proposed alignment has to be sufficiently high enough to meet the Project Service Requirements, whilst also being low enough to allow overtopping of the highway in major events and not introduce associated afflux impacts on land and properties upstream and west of the Bruce Highway.

There was a comprehensive investigation of a range of iterations and options investigated during the Business Case, which aimed to achieve the optimal balance between reduced road closure times and the effective mitigation of associated afflux, as further discussed in Section 2.6 and the Bridge v Culvert Technical Note attached in Appendix P of this Report.

The proposed solution includes a new 437m Cattle Creek Bridge with a reduced level (RL) of 13.7m. The increase in level of nearly 3m from the existing is to locate the bridge soffit above the Q100 level to reduce afflux impacts upstream. The approach embankments have an RL of 11.4m. This is an approximate reduction of 0.7m from that proposed in the original preferred NB2 option. These changes were due to the change in focus of the project, from emphasis being placed solely on flood immunity to now achieving Vision Standard requirements to limit the extents of potential associated future flood disruption.

2.10.7.3 Sub-option (New Frances Creek Bridge)

The proposed RL of the new Frances Creek Bridge is 13.515m. The vertical alignment of the approaches has been designed to seamlessly tie into this level.

2.10.8 Cross Section

The average existing seal width for this section of the Bruce Highway is currently 10.6m. The highway upgrade is to achieve a new seal width of 11m minimum and include a 1m Wide Centre Line Treatment (WCLT). The typical cross sections are illustrated in Appendix V of this Report. Key elements of the formation are shown in Table 8 below. Lane widths will be amended slightly to allow for the additional width required for the shoulders and WCLT provisions.

Table 8 - Cross Section Parameters

Element	Measurement	New Bridges	Existing Frances Creek Bridge
No. of Lanes	2 (one in each direction) - Undivided		
Lane width	3.25m	3.25m	3.5m
Shoulder width	1.75m	1.45m	0.7m
Median Width	1.0m	1.0m	N/A
Cross fall	3%	3%	3%
Verge Batter	1 in 4 max	N/A	N/A
Cut Batter	1 in 2 max	N/A	N/A

The carriageway width is reduced to 10.4m on new bridges. The reduction in width is applied to the shoulder. The existing Frances Creek Bridge will remain in the recommended Business Case option and it has a sealed width of 8.4m, the existing elements will remain. The transition from the WCLT to the existing structure occurs over 35m, providing a gradual and safe change in the road environment.

2.10.9 Batter Slopes

As noted in Table 9, minimum verge batter slopes of 1 in 4 have been adopted across the project. For the forecasted traffic volumes, a clear zone width of 13m has been adopted. Ergon assets located within the clear zone have been identified to be relocated. A revised clear zone width of 10m can be adopted when batter slopes of 1:6 or flatter are used. Table 9 below, identifies where batter slopes of 1:6 could be locally introduced to reduce the required width of clear zone and possibly mitigate against the requirement for Ergon relocations.

Table 9 - Batter Slope Variations

Item	Lane	Chainage	Description
1	LHS	109250	115m of Ergon relocation mitigated with 1:6 slopes
2	LHS	110100	150m of Ergon relocation mitigated with 1:6 slopes
3	LHS	111455 – 111560	Existing Frances creek bridge approach with 1:2 slopes protected with guard rail
4	LHS	111610 – 111690	Existing Frances creek bridge approach with 1:2 slopes protected with guard rail
5	LHS	112235 - 112345	Cattle creek bridge approach with 1:2 slopes protected with guard rail
6	LHS	112785 - 112865	Cattle creek bridge approach with 1:2 slopes protected with guard rail
7	RHS	110550 - 110900	1:6 slopes mitigate requirement for Ergon relocation and associated resumption
8	RHS	111490 – 111570	Existing Frances creek bridge approach with 1:2 slopes protected with guard rail
9	RHS	111620 – 111725	Existing Frances creek bridge approach with 1:2 slopes protected with guard rail
10	RHS	111960	1:6 slopes mitigate requirement for Ergon relocation and associated resumption

Item	Lane	Chainage	Description
11	RHS	112215 - 112345	Cattle creek bridge approach with 1:2 slopes protected with guard rail
12	RHS	112785 - 112895	Cattle creek bridge approach with 1:2 slopes protected with guard rail
13	RHS	113100	300m of Ergon relocation mitigated with 1:6 slopes
14	RHS	113640 – 113740	130m of Ergon relocation mitigated with 1:6 slopes

Item 6 and 7 are outside the extents of the preferred option, however, are considered here due to close proximity to the works. As the location of PUP is yet to be accurately located in greater detail, any likely impact as identified above will be considered as an unplanned risk. An estimate of approximately $1.1M has been included in the P90 cost estimate for the associated potential relocation works.

2.10.10 Signage and Line Marking

2.10.10.1 Line Marking

Line marking and overtaking restrictions have been detailed as per the existing conditions. The Road Safety Audit recommendations to update the line marking requirements at driveways, should be considered and implemented as required, at detailed design stage. The off-line northern section of the project will require analysis during the detailed design stage to determine overtaking sight distances and associated line marking requirements.

2.10.10.2 Signage

Allowance has been made in the P90 cost estimate to replace all the existing road signage for the chainage extents in both considered options. WCLT treatment signs will be required North and South of the project to identify the change in treatment.

It is noted that there are a number of large advertising boards, both within the road reserve and adjacent fields. Some of these may require relocation out-with the clear zone and if the sub-option is adopted some signs will become obsolete. Appropriate stakeholder engagement will be required during the detailed design stage to inform owner/advertiser of the changes and relocations required.

2.10.11 Aquaplaning

Aquaplaning has been identified as a key problem in two of the fifteen crashes reported for this section of road. The flat nature of the road and superelevated curves lead to long flow paths and associated ponding. The superelevation development has been reviewed and revised to address the aquaplaning problems within the project extents.

In the southern section around Pennas Road, the road grade has been lifted to accommodate new culverts to meet the Project Service Requirements and Vision Standards. The position of the culverts and the inclusion of additional vertical grade have been coordinated, where possible, to match the locations of super development and generate extra longitudinal fall to assist in mitigating aquaplaning problems. In other areas, standard super development lengths result in adequate flow depths.

There are two locations that are not compliant however, and as such, will need to be further reviewed and assessed during the detailed design phase. One location is at Ch. 108,900m where the super development occurs partly outside the extents of project limits and corresponds with an existing aquaplaning prone area that has a history of crashes resulting from water across the road.

The other is at Ch. 110,430m where super development is applied to correct the substandard adverse cross fall. Both sites are very flat with minimal longitudinal fall. Previous designs highlight that at least 0.3% longitudinal fall is required for a single lane rotation with possible methods to reduce film depths including:

i. Revise super development location. Vertical elements are quite large and would need a significant shift to be located over an area with sufficient grade;

ii. Revise project extents to move ramping out of super development location and or revise vertical grade by raising pavement;

iii. Possible inlay to generate extra grade if existing pavement/subgrade permits;

iv. Turn down road shoulder and rotate separately;

v. Revise rate of rotation further, current design has a 0.03 rate of rotation;

vi. Install a diagonal crown; and

vii. TMR departure from design guidelines.

With regards the points above, the first four points (i – iv) could be further investigated during the detailed design phase to assess whether the potential associated benefits would justify the increased investment required. This would include assessing the extent of that investment and whether a scope change to include the Ch.108,900m section was considered affordable and a priority for investment. The last three points (v – vii) are not preferred and do not provide a desirable design solution.

For further details and calculations associated with Aquaplaning please refer to Geometry Checklist included in Appendix Q of this Report.

2.10.12 Intersections

There are five existing intersections with local roads, along the length of the project including;

- Pennas Road;
- Pombel Road;
- Rest Area;
- Haughty's Road; and
- Pomona Road / Pinnacle Hill.

These existing intersections are all basic un-signalised T intersections, except for the Pomona Road/Pinnacle Hill Road intersection, which is a four leg un-signalised intersection. It is noted that this intersection is to be upgraded and provided with a channelised right turn treatment as a condition of the nearby

North Queensland Bio-Energy development. The detailed design will need to consider tie in points with the upgraded intersection layout.

Turning traffic volumes are minimal at all intersections. The analysis of each intersection, based on traffic volumes, warrants basic treatments to be provided at each, based on traffic volumes alone. The existing channelized right turn treatments at the following intersections have been maintained:

- Bruce Highway - Southbound turning right into the France Creek Rest Area; and
- Bruce Highway - Northbound turning right into Haughty's Road.

Additionally, there is an existing Rest Area at Frances Creek which comprises of two accesses with the northern access incorporating a CHR for southbound traffic. This arrangement will be maintained in the proposed layout for both the preferred option and sub-option. There are also four existing private property accesses which front on to the Bruce Highway, these are all maintained in the proposed layout for both the preferred option and sub-option.

2.10.13 Clear Zone and Road Furniture

The road design is to consider the guidance provided in Chapter 8 of the RPDM. The clear zone width was calculated from Figure 8.4 (of RPDM) and is defined as the area of works 13m from the formation edge on both sides of the road.

Safety considerations were made in zones where roadside obstacles were present. The requirements for clear zone protection were been analysed using TMR's Roadside Impact Severity Calculator V4.0.1.1 (RISC). RISC software weighs the probability of an incident/accident, which has a predetermined severity based on the nature of the hazard (i.e. batter grade or obstacle offset from the edge line), against the combined cost of installation and maintenance, and loss of human life. For the purpose of this assessment the cost of installation of safety barriers has been approximated at $160/m with a repair cost of $1,846 per crash.

A benefit cost ratio (BCR) cut-off of 1.5 for rural roads was adopted (i.e. safety barriers need to be installed to ensure an incident between vehicle and an off-road obstacle is avoided when the BCR exceeds 1.5).

Other than on the bridge approaches, based on this analysis, it was determined that only one area requires the installation of new safety barriers; the trees within the clear zone at the existing Frances Creek rest area. Test level 3 barrier and end terminals shall be provided. For all of the other identified hazards, installation of guardrail and end terminals would not be cost effective. For hazards not prescribed guardrail, it is recommended that guide posts be located at closer spacing's to alert drivers of the approaching hazard.

For further details associated with the Safety Barrier Assessment please refer to the Technical Note included in Appendix O of this Report.

Two existing TMR roadside cameras and a weather station are located along the alignment at chainages 109900, 111090 and 112090 respectively, as shown in Figure 9, Figure 10 and Figure 11 below.

Figure 9 - TMR Camera Pole (at Chainage 109,900m)

Figure 10 - TMR Camera Pole (at Chainage 111,090m)

Figure 11 - TMR Weather Station (at Chainage 112,090m - to be relocated)

The existing weather station is to be relocated to suit the new alignment. The existing camera at Ch. 111090 is 12.5m from the edge line and we will look to adopt 1:6 slopes or greater to keep this within the clear zone. A1:6 slope with less than 6000 ADT requires a 9m clear zone, and 10m for 6000+. The existing camera at Ch. 109900 is 9.4m from the edge line ADT and will remain so in the new alignment. Detailed survey may locate the pole out with the clear zone and therefore no works would be required. Further analysis may show that the cost benefit ratio is not sufficient to move the pole, especially considering that it is close to overhead electricity, or that there is not another suitable location. As such relocation of the pole will be costed as a planned risk.

2.10.14 Property Impacts

Given that one of the key design considerations for the project was to minimise property resumptions, the alignment design proposed has achieved this and only requires a single partial land resumption. For further details associated with the Property Impacts please refer to Section 2.17 of this Report.

2.11 Geotechnical Assessment

Geotechnical site investigation works were completed during August and September 2013 as part of the Business Case development stage, to confirm desk study findings and inform evaluation of the three concept design options. A total of four boreholes (with associated in-situ testing), Falling Weight Deflectometer testing (FWD) and five trial pits were completed. The ground profile across the site typically encountered comprises of pavement fill underlain by thick alluvial soils with indurated layers.

The proposed Cattle Creek Bridge foundations require five piles per pier with pile toe levels at -10.5 m AHD and -15 m AHD (pile lengths of approximately 20.5m and 25m respectively). Presence of indurated/cemented strata may impact pile foundation driveability and a reduction in pile length may be considered by using more piles at each pier location. Embankment raising through the existing alignment overlay and new alignment embankments were assessed to be feasible, with limited restrictions in geometry and require associated ground treatments, such as excavate and replace.

Technical analysis of the three options considered has identified that there are limited geotechnical risks; therefore the ground conditions present an overall low risk to the project. The limited identified risks include isolated soft soils and the potential for presence of Acid Sulphate Soils (ASS); both of which were not encountered during the geotechnical site investigation work undertaken. However, these two items should be further considered / assessed during the detailed design stage of the project and corresponding mitigation adopted if required.

The maximum settlement of embankment is 120mm over 40 years. With the structural zone (within 25m of the bridge structures) this would cause differential settlement that would exceed the allowance of 25mm post construction settlement over 40 years. It is therefore recommended that surcharging is undertaken within this zone which should comprise of 2m of suitable fill for a period of 9 months.

Imported fill has been assumed for the proposed earthworks, given that the project largely involves the construction of new higher road embankments. The use of in-situ (or site sourced) material is not considered viable because of the limited availability; associated environmental constraints which would need to be resolved. Quarry-sourced imported fill material has therefore been assumed for use of the project and is reflected in the P90 cost estimate prepared.

Detailed assessment and analysis regarding the ground conditions, site investigation works and geotechnical concept design options can be found in the Geotechnical Desk Study and Geotechnical Report, both included in Appendix H of this Report.

2.12 Pavement Analysis

The proposed highway alignment largely follows the existing alignment for approximately 60% of the total length of the project, with the exception of the northern section (Cattle Creek Bridge to Pomona Road intersection). The existing pavement will therefore be utilised over a significant length and will be overlaid with a fully compliant new plant mix cement modified base pavement overlay. Across the project the proposed road alignment is to be raised in level to meet both Project Service Requirements and Vision Standards and as such a variety of pavement options were duly considered. All options considered cater for the future forecast design traffic flows, in addition to providing a suitable level of flood durability. The options considered included concrete, asphaltic and granular type pavements. A plant mix cement modified granular pavement was chosen as the preferred pavement treatment as it provides satisfactory resilience to flooding, has moderate construction costs compared with other options, and ties in with adjacent existing pavement and typical local road construction.

The proposed new full depth pavement treatment is a 300mm plant mix cement modified base, overlaying a CBR 15 sub-base for the length of the project (excluding bridge decks which have an asphaltic concrete surfacing). The sub-base material depth will be as required to match existing levels. All existing seals, asphaltic concrete surfacing and asphaltic concrete base courses are to be removed prior to placing any new granular pavement layer to prevent water from being trapped in the overlay and resulting in premature pavement failure.

This proposed pavement solution is suitably robust, will provide a 20 year design life and is consistent with the pavement designs that are typically preferred by TMR in this region, to cater for the regional climatic conditions.

The Pavement Design Report included in Appendix I, details all associated traffic calculations, design methodology, and pavement specification information. Supporting information was obtained by carrying out geotechnical site investigations, laboratory testing of existing pavement material, falling weight deflectometer (FWD) testing, and back analysis of FWD results.

2.13 Structures

The two structures which are included in the CFC project are of critical importance, as they will ultimately help to achieve the desired Project Service Requirements and are a major cost and risk component, which as such, must be both efficiently and robustly designed and constructed. Of the two structures, Cattle Creek is the larger structure and is more prone to flooding impacts and closure given that it is located in the lowest section of the project area. Given the design life for the new structures needs to be 120 years, a decision was taken at the very early stages of the project, to locate the soffit of proposed new Cattle Creek Bridge and the proposed deck level of Frances Creek Bridge above the existing Q100 flood level, to help reduce the associated afflux impacts on surrounding properties. This would ensure that both bridges would remain sufficiently high in terms of reducing the impact on the structure in times of flood.

The design of the structures, as well as being closely integrated with the hydraulic analysis process, was also linked to the geometrical design, environmental assessment and geotechnical assessment elements of the project. All key disciplines had to work in a collaborative and integrated manner to ensure the optimal bridge locations, configurations and span arrangements were identified, suitably informed and efficiently designed. In addition, stakeholder issues were also taken into account as was the consideration of whole life costs to ensure capital costs were not being reduced at the potential expense of higher future maintenance costs. The age and general condition of the existing structures were carefully considered and partly helped to inform the options assessment process as to whether the proposed sub-option (new Frances Creek bridge) could offer significant benefits in comparison to the preferred option (leaving existing Frances Creek bridge in-situ). These issues and the general approach to the structures design development are further discussed in the following sub-sections.

Both new bridge structures were designed to meet relevant standards and as required by the Project Brief, including;

- TMR Design Criteria for Bridges and Other Structures (June 2013); and
- AS 5100 Bridge Design Standards; Assuming SM1600 and HLP400 loading.

The following functional requirements are assumed to be common for both new bridge structures:

- Flood load velocities as per hydraulic modelling;
- Clear kerb-to-kerb width of 10.4m;
- The bridges will carry two lanes, one in each direction, with the central median and wide shoulder on each side;
- No provision for pedestrians or cyclists is required;
- Provision for safe access for maintenance will be detailed at each abutment in accordance with standard TMR details;
- Jacking shelves at the pier headstocks need to be detailed as the bridge deck units will be supported on elastomeric bearings in accordance with TMR Design Criteria for Bridges and Other Structures;
- Steel traffic barrier regular containment fixed on top of the reinforced concrete kerb;
- There will be no provision for lighting on the bridge, given its location on a rural section of the highway;
- Existing Telstra services will be carried within a kerb by a single 100mm conduit; and
- An additional 100mm diameter conduit for future PUP services provisions has also been designed and included in the P90 cost estimate.

2.13.1 Existing Cattle Creek Bridge

Table 10 – Cattle Creek Bridge

TMR Bridge ID No:	7459
Structure Name:	Cattle Creek Bridge
Design Year:	1974

The existing Cattle Creek Bridge was considered for inclusion into the upgrade scheme, however this bridge has been recommended to be replaced in its entirety in order to allow the overall scheme to meet the flood immunity and Vision Standards requirements.

This recommendation is based on the bridge general arrangement (deck level and bridge piers) and principal recommendations from the hydraulic modelling related to the key project objectives. Therefore all options considered during the study exclude the existing structure and assume the new structure will be constructed with the deck level above Q100.

The summary of the key determining factors include:

- **Current flood immunity and Vision Standards:** the hydraulic modelling, which was undertaken by BMT WBM Consultants and completed during this study, confirms that the existing bridge deck is well below the minimum flood immunity requirements, and its general arrangement and the opening do not satisfy the project objectives including the Vision Standards. Both these fall short from the project requirements by a significant margin, and from the hydraulic perspective it would contradict the project objectives if this general arrangement was to be retained.
- **Suitability for re-use:** the bridge was constructed in 1974 which predates current design standards, and as such was designed for the loading and durability requirements which would not be satisfactory to current standards. Therefore all elements have been excluded from the proposed upgrade, and the bridge has been assumed to be demolished and removed, with all of its piles cut to the ground level once the new bridge is constructed.

  A condition of the bridge elements were not taken into account in this assessment, however observations from the bridge inspection reports have been taken into consideration for the design of the bridge replacement. This particularly relates to ongoing maintenance issues to control the vegetation which informed optioneering of the new bridge opening and the span lengths.

2.13.1.1 Existing Bridge General Arrangement

The existing bridge structure comprises 11 simply supported spans which carry two traffic lanes of the flood plain. The end spans are 13.8m and the mid spans are all 14m in length. Three central spans appear to be spaning over the creek, which flows at approximately 45° skew to the bridge horizontal alignment. The bridge drawings indicated that this bridge replaced an old timber bridge that appears to have been 30m long and spanning over the main creek channel.

The existing bridge deck consists of transversely stressed prestressed deck units (14 no) and two prestressed kerb units. The deck wearing surface (DWS) forms two way cross-fall at 1½ %. The clear width between kerbs is 8.644m and carries two traffic lanes. The decks span between reinforced concrete headstocks which are supported on precast concrete piles. There is no horizontal or vertical curvature of significance and the bridge alignment is set on a 0° skew to its piers and abutments. The bridge deck is at RL 10.82.

2.13.1.2 Existing Bridge Condition Assessments

The following maintenance information has been included in the review of the existing Cattle Creek Bridge:

Table 11 - Cattle Creek Bridge Maintenance

	24-JAN-2013	09-APR-2009
Structure Condition Inspection Report	Level I	Level II
Defective Components Report		Yes
Level I Inspection Report – Photos and Sketches Record	Exceptional	
Level II Inspection Report – Photos and Sketches Record		Yes
Structural Maintenance Schedule		Yes
Structure Scour Sounding Report	Yes	
Standard Procedure Exception Report		Yes
Routine Maintenance Inspection Report	Yes	

Inspection Report 24 January 2013

This was an exception inspection after a flood event. No detailed observations were made in regards to the structure, only scour sounding report suggesting several locations with the condition state 3, meaning change in depth of 0.5 to 1m, or local scour depth between 2 and 4m. The worst spans appear to be spans 1, 8 and 9. Condition state 2 was further recorded for spans 5, 6, and 11. This condition state means change in depth of 0.2 to 0.49m, or local scour depth between 0.5 to 1.99m. All other locations are noted as condition sate 1, with change in depth <0.2, and local scour depth <0.5.

Inspection Report 9 April 2009

This was a scheduled Level II condition inspection as part of the regular bridge maintenance regime.

Structure was reported to be in fair condition, condition state 2. Miscellaneous defects including localised spalling and ASR (Alkali Silica Reaction) along the sides of the kerb units were observed. Total maintenance budget of $45,000 was recommended, with $10,000 allocated for the repairs to deteriorated and damaged DWS, and $5,000 for the vegetation control. Significant siltation and vegetation growth were observed upstream and shown on the photographic record.

2.13.1 Proposed Cattle Creek Bridge

Following a rigorous comparative analysis exercise (as detailed in Section 4.2 and Section 6 of this Report) the proposed concept design layout arrangement for the preferred bridge option at Cattle Creek comprises of:

- **Bridge Length:** 437m long with 19 No, 23m long, simply supported spans.
- **Bridge Skew:** 0^{o}
- **Crossing:** Cattle Creek.
- **Bridge Piers and Abutments:** reinforced concrete headstocks supported on 5 No 550mm Dia Octagonal Precast Prestressed Driven Piles.
- The precast piles are assumed to be approximately 22.5m long and founded on founded in competent dense/stiff alluvium.
- **Bridge Deck:** 18 No Transversely stressed Precast Prestressed Deck Units per span with high performance Type C waterproofing membrane in accordance with TMR technical specifications. This solution provides a cost effective and sufficiently resilient solution for this specific bridge location.
- **Deck Units:** 950mm deep precast prestressed deck units.
- **Deck Wearing Course:** 80mm deck wearing surface.
- **Bridge Levels:** bridge soffit is assumed to be at or above RL12.4m AHD, which is equivalent to Q100 recommended by BMT WBM Consultants hydraulic modelling results. Soffit at this level is required to minimise afflux and hydraulic performance which meets project objectives and Vision Standards. Bridge road level at the centreline of each abutment is therefore set at RL13.7m AHD.
- **Horizontal Alignment:** bridge control line is set on a straight alignment.
- **Bridge Drainage:** assumed via drainage scuppers discharged directly into the waterway. Bridge Deck will have two-way cross-fall at 3%, and 0% longitudinal fall.
- **Traffic Barriers:** standard TMR steel bridge barrier for regular containment.

2.13.1.1 Flood Loads

Water velocity at Cattle Creek Bridge is very low, vertically averaged peak velocity through the bridge is estimated at 0.5 m/s for Q100, as per BMT WBM Consultants recommendations. This is less than the minimum design requirements by TMR bridge design requirements based on a 1.5m/s. Therefore square bridge piers are proposed similar to existing bridge. This geometry will enable ease of and repetition in detail and as such have cost advantages during construction.

2.13.1.2 Bridge Drainage

Surface water will be discharged directly into the waterway via scuppers. This is standard practice in North Queensland. This is due to the lower traffic volumes compared to urban areas and associated lower levels of pollutants, combined with high rainfall levels which make it more costly to retain and filter the ‘first flush’ of surface water. It is generally considered to be a reliable solution in a long term.

The scuppers will require regular maintenance and will be detailed to minimise risks of blockage.

Confirmation that this proposal is fully compliant with the evolving Environmental Management Plan in regards to waterway management strategy for Cattle Creek, will be required in the next stage of the work.

2.13.1.3 Bridge Articulation

Bridge expansion joints are proposed at every third pier with necessary adjustments to fit within 19 spans.

TMR requires bearings at each end of a 23m long deck unit. Allowance for this has been included in the cost estimate.

2.13.1.4 Approvals and Communication with Authorities

- Kerb to kerb clear width 10.4m has been confirmed by TMR NQ at the onset of the project;
- The project brief requires minimum bridge immunity of Q50, however soffit above Q100 has been provided to meet the hydraulic performance requirements and has been recommended by BMT WBM Consultants as a minimum bridge soffit level;
- Transversely stressed deck units have been recommended with confirmation of TMR Bridge Branch, provided that Type C Waterproofing Barrier is used in conjunction and in accordance with TMR Technical Specifications for Deck Wearing Surface October 2013;
- Drainage discharge from bridges will comply with the water quality objectives identified in the Environmental Management Plan, including the Queensland Environmental Protection (Water) Policy. These guidelines establish the objective of maintain/achieve existing water quality objectives for the waterways assessed within the project area, and therefore no additional stormwater quality treatments are proposed on the bridge structures. There is the potential for changes in legislative requirements to influence water quality aims and objectives in this region, therefore it is recommended that legislative requirements are reviewed in future stages of design development. Section 2.7 provides commentary on stormwater management requirements during construction; and
- Services requirements have been confirmed with relative authorities (Telstra & Ergon) as described in Section 2.16 of this Report.

2.13.1.5 Departure from Standards

There are no known departures from the relevant, current standards.

2.13.2 Existing Frances Creek Bridge

Table 12 – Frances Creek Bridge

TMR Bridge ID No:	7458
Structure Name:	Frances Creek Bridge
Design Year:	1977

The existing Frances Creek Bridge has been considered and recommended as suitable for inclusion into the upgrade schemes, more specifically for the inclusion in Preferred Business Case Option.

This recommendation is based on the investigations that were carried out within the scope of this study, limited to a desk top review of the available information including the condition of the existing bridge.

The bridge will require an ongoing regular maintenance as per standard TMR Asset Management requirements and as expected for any road bridge structure. A detailed Level III condition inspection and assessment, in accordance with TMR Bridge Inspection Manual (BIM) and requirements of TMR Bridge Asset Management (BAM), is recommended in near future in order to confirm the assumed level of required maintenance for the next 20-25 years. Based on the available information the previous scheduled Level II Condition Inspection was undertaken in 2010, therefore Level III condition inspection in 2014 would suit the timeframes for this project.

The summary of the key factors considered during the study include:

- **Current flood immunity and Vision Standards:** the hydraulic modelling, which was undertaken by BMT WBM Consultants and completed during this study, confirms that the existing bridge achieves necessary flood immunity, and its general arrangement and the opening adequately satisfy the project objectives including the Vision Standards. Therefore from the hydraulic perspective there are no specific obstacles from retaining the bridge in as is condition.
- **Condition of the existing bridge and structural reliability:** the latest condition inspection of the 36 year old bridge indicates it to be in fair to good condition, and the bridge has been servicing the Bruce Highway traffic with no known concerns in regards to its structural or functional performance.

The existing bridge will require regular maintenance over its design in order to reach the intended 100 years design life as is typical of any bridge structure. Regular inspection and maintenance requirements, however, increase with the age of structure, therefore as the bridge approaches the 50% of its intended design life it is prudent to proactively check the base line in regards to its current condition. In return this will provide increased certainty with respect to its maintenance requirements, thus detailed Level III condition inspection by an RPEQ Engineer (including necessary testing, preparation of the maintenance plan, and the whole life costing) is recommended.

To offset any risks of unknowns in regards to its current condition, it is recommended to proportion a risk contingency which would allow an exceptional maintenance (e.g. rehabilitation outside the current maintenance plan) that may arise in the next 30 years as part of this study. A nominal provision of $350k has been allocated in the P90 cost estimate to allow for this, including the Level III condition inspection ($50k) being undertaken at detailed design stage and potential associated repair works ($300k). Please refer to Table 15 for scope details of the proposed works required.

- **Load rating and functional requirements:** the functional capacity of the Bridge in terms of the vehicle loading and the bridge width is typical of a TMR bridge for this age. The bridge appears to have enough robustness in its design, and has passed the TMR load rating assessment which was carried out in 2010 and for the vehicle recommended by TMR Bridge Asset Management at the time of the assessment. The outcome of the assessment confirmed the bridge satisfies the load rating for all TMR specified vehicles with no travel restrictions.

It should be noted that the current TMR recommendations for Tier 1 bridge assessments (load rating) includes for vehicles loads that were not considered for this Bridge. Current records for Frances Creek Bridge within the Bridge Asset Management database do not indicate that any further management strategies are needed for this bridge and therefore it is reasonable to assume that the impact of the change may not be significant at this point in time. If during its design life, the bridge is required to carry heavier loads, consequently to change in traffic conditions, further assessment will be needed. It is expected that if this should occur within next 20 years, an assessment would determine an appropriate Structural Management Plan (SMP) to be developed in line with standard TMR practice and Tier 2 assessment, and which is likely to be a value for money solution. The SMP could comprise of specific vehicle and/or lane restrictions, strengthening of specific elements, or a combination of both.

2.13.2.1 Existing Bridge General Arrangement

The existing bridge structure comprises 3 simply supported spans; the end spans are 15m and the mid span 15.25m in length. The deck consists of 6 pre-cast pre-stressed concrete I beam girders which span between reinforced concrete headstocks. The headstocks are supported on precast concrete piles. In-situ concrete cross girders are cast between the girders and act as diaphragms at the ends of the girders and at mid span. The girders act compositely with a 150mm deep slab which spans across the girders and cantilevers over the edge girders. In-situ concrete kerbs are cast integral with the slab and run along the edges. The deck is placed such that the slab forms a 2% cross-fall either side of the bridge centreline. There is no horizontal or vertical curvature of significance; however the bridge alignment is set on a very high 50° skew to its piers and abutments. The clear width between kerbs is 8.4m and carries two traffic lanes.

2.13.2.2 Existing Bridge Load Rating

This bridge was originally designed for HS20 loading as noted on the supplied design drawings. Department of Transport and Main Roads, Bridge Assets Management (BAM) Team, has assessed the load rating for this structure in 2010, the work which was carried out by Arup in this instance.

The assessment was based on Equivalence Ratings for the Bridge, the results of which was summarised in a detailed Report including the assumptions and theory applied in the analysis and calculations. The assessment also included a review of the TMR Condition Inspection Reports available to that point in time, and their subsequent impact on the assessment of element capacities. The condition Report in this instance was dated June 2005.

All of the loading applications, combinations and restrictions adopted in the assessment were in line with the requirements from TMR Project Brief and Guidelines at that point in time. The Standard Vehicles and travel restrictions are detailed in Arup Report dated July 2010.

The outcome of the assessment confirmed the bridge satisfies the load rating for all TMR specified vehicles with no travel restrictions.

Arup has recently followed up with BAM team to confirm if there is any further information available for this bridge, and to confirm if any specific bridge management plan has been considered as needed now or in future (a telephone conversation between Aida Bartels (Arup) and Robert Heywood (TMR), dated 9/9/13). Based on the verbal confirmation, BAM current records do not indicate that any further work has been undertaken subsequent to Arup assessment in 2010. Furthermore, there are no other specific requirements noted for this structure.

Further to above advice from BAM we have reviewed the draft Design Criteria for Widening/Strengthening Existing Bridges (Version 2.2), which includes the minimum design load requirements for the new bridges on National Highways, B-double routes and Type 1 Road train; as applicable to Frances Creek Bridge. When compared to design vehicles assumed in the load assessment of the Bridge, the discrepancies which have not been considered to date are;

- HML AB-triples T1 road train, or HML AAB quad T2 road train. Neither of which have been assumed for the assessment;
- The wheel spacing for AB-triple is very similar to the ‘road train’ for which the bridge was assessed, however the total load of the assessed ‘road train’ vehicle is 95.5 tonnes whereas the HML AB-triples T1 road train has a total load of 113 tonnes; and
- HML AAB quad vehicle is included in the latest brief for the TMR Bridge Load Assessments; however it was not included in the Project Brief when Frances Creek Bridge was assessed. This vehicle has a total axle load of 158 tonnes with axle groups 1/2/3/3/3/3/3/3, compared to axle groups for ‘road train’ of 1/2/2/3/2/3 and a total axle load of 95.5 tonnes.

T44 was assessed but with no trailing vehicles. However, with a span of 15 m and a vehicle length of 11m and headway of 3m or 6m, the effects of this are expected to be minimal.

Table 13 below is a high level summary of the comparison between the draft design criteria for widening and the loading assumed for the Frances Creek Assessment.

Table 13 – Summary of Comparisons

<table>
<tr><th>Vehicle</th><th>Draft TMR Design Criteria</th><th>2010 Load Assessment Assumptions</th><th>Comparison</th><th>Comment</th></tr>
<tr><td>T44</td><td>Multiple vehicles in one lane</td><td>Only one per lane</td><td>Vehicle length 11m, bridge span 15m</td><td>Possibly very minor impact, further check to confirm this may be prudent</td></tr>
<tr><td>HML AB triples</td><td>Total Load 113 tonne</td><td>similar to assessed road train (total load 95.5 tonne)</td><td>Has not been assessed for this load</td><td rowspan="2">If required to be used on the bridge a further assessment would be required to investigate the impact</td></tr>
<tr><td>HML AAB quad</td><td>158t HLP AAB Quad</td><td>similar to assessed road train (total load 95.5 tonne)</td><td>Has not been assessed for this load</td></tr>
<tr><td>48t crane</td><td></td><td>Assessed for 48t crane</td><td>Ok</td><td rowspan="2">No further assessment required</td></tr>
<tr><td>HLP280</td><td>HLP axle weight proportioned down from HLP320</td><td>Assessed for HLP320</td><td>Ok</td></tr>
<tr><td rowspan="2">Co-existing vehicles</td><td>HML AB-triples</td><td rowspan="2">T44 is the same as first 6 axles of AAB Quad, however the critical loading is likely to be the length beyond the first 6 axles</td><td rowspan="2">Likely to have less impact for the smaller span bridges, e.g. 11m T44 + 4.4 axle spacing = 15.4m therefore greater than the existing spans on the Bridge</td><td rowspan="2">If required to be used on the bridge a further assessment would be required to investigate the impact and necessary management strategy</td></tr>
<tr><td>HML AAB Quad</td></tr>
</table>

2.13.2.3 Existing Bridge Condition Assessments

The following maintenance information has been included in the review of the existing Frances Creek Bridge:

Table 14 - Frances Creek Bridge Maintenance

	20 June 2005	16 March 2010	13 Jan 2013
Structure Condition Inspection Report	Yes	Yes	
Defective Components Report	Yes	Yes	
Level II Inspection Report – Photos and Sketches Record	Yes	Yes	
Structural Maintenance Schedule	Yes	Yes	
Structure Scour Sounding Report	Yes	Yes	Yes
Standard Procedure Exception Report	Yes	Yes	
Routine Maintenance Inspection Report			Yes

Inspection Report 13 January 2013

This was an exception inspection after a flood event. No detailed observations were made in regards to the structure, comments generally relate to debris and the level of scour which was observed up to 1.3m at spans S1 to S3.

Inspection Report 16 March 2010

This was a scheduled Level II condition inspection as part of the regular bridge maintenance regime.

Structure was reported to be in fair to good condition although it was noted that restraint angles at Pier 2 and Abutment 2 require urgent repairs. Repairs to Joints and the Approach 2 were also recommended.

Inspection Report 20 June 2005

This was a scheduled Level II condition inspection as part of the regular bridge maintenance regime.

Structure was Reported to be in fair condition, with the majority of the structural elements rated as Condition State 1, free of defects. This includes the deck slab, girders, cross girders and 7 out of 12 pier supports. The piles supporting the abutments were not visible and are therefore not rated.

Structural elements that were rated as Condition State 2 – free of defects affecting structural performance, integrity and durability, include all headstocks for a number of reasons; cracks appear to have formed along the cold joint between concrete pours approximately 450mm from the tops of the headstocks. The pier headstocks have apparent epoxy repairs to the bearing pedestals and vertical cracks are visible. Five out of 12 piles appear to have areas where surface water-washed old epoxy repairs exposed the cracks which are becoming visible.

Changes in Reported condition from June 2005 to March 2010

Below is a summary from the condition inspection in 2005 and 2010 including observations of any changes in this period:

Table 15 - Condition Inspection

20 Jun 2005 Observations	March 2010 Observations	Arup Comments	Maintenance Required
Structure Maintenance Schedule			
The guardrail height was measured to be below expected (current) standards and therefore not compliant. It was noted as a 'safety issue' however no further clarifications were made.	No further comments were made.	This is typical for the bridges of this age and needs to be investigated on case by case basis. Generally safety audit and a risk assessment are required in order to determine the need for an upgrade at any given point in time.	To be assessed by TMR

20 Jun 2005 Observations	March 2010 Observations	Arup Comments	Maintenance Required
35-38mm gap at nosing was observed. Rubber seal was noted as missing and requires replacement.	No further comments in regards to the gap, however the rubber seal was noted as still missing and requires replacement.	The rubber seals need to be replaced as part of the regular maintenance. Refer discussion for further comments.	Yes
Debris build up and material falling through joint was observed, and noted to have sped up corrosion of steel.	Note that flood debris on top of headstocks and abutments requires cleaning.	Refer comment above regarding the replacement of the rubber seal. Refer discussion for further comments.	Yes
Waterways require clearing from debris.	A large amount of flood debris was observed in waterway, requires cleaning.	This will continue to be a part of regular maintenance particularly after the significant storm events.	Yes
Pavement failure in the northbound lane observed requiring major repairs.	Sign of settlement and depression at the approaches were observed. Patches were noted to require redoing.	It is unclear if there are changes from the previous condition (e.g. were the repairs undertaken in first place), however further work appears to be required. Refer discussion for further details	Yes
No comments	Guardrail bolts require tightening; some bolts require replacement/installation.	This will continue to be a part of regular maintenance, particularly after the significant storm events.	Yes
No comments	Spalls in concrete deck require rust treatment and patching.	There appears to be localized spalling to underside of the concrete deck, at Span 3 with exposed rusty reinforcement. This will need to be further investigated and rehabilitated to prevent further deterioration. Refer discussion and recommendation section for further comments re further investigation.	Yes

20 Jun 2005 Observations	March 2010 Observations	Arup Comments	Maintenance Required
Restraint system was observed to be severely rusting, bolt and bracket, indicating a replacement is needed.	No Comments	It is not clear if this defect has been rectified or not observed during the subsequent inspection.	TMR to check if restrain system rehabilitated or still require action.
Minor localized mechanical damage to bridge rail was observed which may require repairs in future.	No Comments	This may not be of significance in terms of the structural integrity, however should be included in the maintenance schedule as appropriate.	Yes
Minor spot rusting and typical deterioration of the protective coating was observed along the guardrail, which will need regular maintenance and patch ups.	No Comments	This will continue to be a part of regular maintenance particularly after the significant storm events and incidents.	Yes
Summary from Condition Inspection and Photographic Records			
'Structure in fair condition – restrain angles at Pier 2 and Abutment 2 require urgent repairs. Repairs to Joints and Approach 2 as listed. Bridge water blasted.'	*'Structure is in a Fair to Good Condition. Some repairs are required (as listed above)'.*	The structure appears to be in fair to good condition, however will require regular inspection and maintenance to prevent further onsets of deterioration.	

Discussion

i. Substandard guard-railing is typical for bridges of this age. The safety issues associated with the guardrail height are usually investigated on a 'case by case' basis. A safety audit and a risk assessment are typically undertaken in order to determine the need for an upgrade. The safety audit may be based on bridge and road approaches general arrangement, traffic count in the area, predicted traffic, accident history, and other relevant available information.

ii. The rubber seals should be replaced as part of the regular maintenance. This is important to minimize the water leaking through the deck onto the bearing shelf and to prevent exacerbation of durability problems currently found with restraint system. Soil, rubbish, and other contaminants can also be trapped in the joint impacting on the performance of the joint and hence bridge in general.

iii. Bearing shelves should be kept clean and free of debris, water ponding, and rubbish in general. Therefore regular inspection and maintenance after significant storm/flood events will continue to be required.

iv. There appear to be some issues with the approaches which show signs of settlement, causing damage to pavement which requires patching. It is unclear if there have been actual changes from the previous observations (e.g. it is unclear if the repairs undertaken or condition worsened). Further investigation to understand the deterioration mechanisms would be prudent in a detailed Level III condition inspection.

v. A detailed condition inspection should also be considered to set the base line for the movement of the expansion joints. Regular observations of the movement at different times of the year will provide a sound base minimizing risk of overlooking anomalies that may occur in the future.

vi. The spalling to underside of the concrete deck, at Span 3, where rusty reinforcement appears to be exposed seems to be occurring only along the edge of the bridge at the joint with the reinforced concrete kerb (above). Although these appear to be only localized the defect should be repaired as soon as practically possible to prevent further durability issues, deterioration, and potential impact on structural integrity of the deck.

A detailed Level III condition assessment would be prudent to investigate the cause of the spalling. As a minimum concrete cover to reinforcement survey and defects mapping are recommended and found necessary further (destructive) testing such as concrete core sampling and in-situ carbonation testing may be needed. This will inform if there are more wide spread durability concerns, and inform the residual life expectancy of the deck slab. This information can then be used to identify preventative measures to avoid further onset of deterioration.

As a minimum all of the defects currently noted in the Condition Inspection Report should be reviewed, prioritised for necessary repairs as found appropriate, and/or further investigation where noted or required. Follow investigation to confirm if noted defects have been rectified is recommended. It is noted that current available funding is limited state-wide, therefore a risk based approach using TMR Bridge Inspection System (BIS) to manage the deterioration of existing bridge assets is adopted. This has implications for the durability of the existing Frances Creek Bridge.

2.13.3 Proposed Frances Creek Bridge

Following a rigorous comparative analysis exercise (as detailed in section 4.3 of this Report) the proposed concept design layout arrangement for the preferred bridge option at Frances Creek comprises of:

- **Bridge Length:** 40m long with 2 No, 20m long, simply supported spans.
- **Bridge Skew:** 40 ^{o}
- **Crossing:** Frances Creek.
- **Bridge Piers and Abutments:** reinforced concrete headstocks supported on 5 No 550mm Dia. Octagonal Precast Prestressed Driven Piles**.** The precast piles are assumed to be 17m long and founded on founded in competent dense/stiff alluvium.
- **Bridge Deck**: 18 No Precast Prestressed Deck Units per span composite with 210mm in-situ concrete topping slab.
- **Deck Units:** 825mm deep precast prestressed deck units.

- **Deck wearing surface:** 50mm deck wearing surface.
- **Bridge levels:** bridge soffit is assumed at or above RL12.1m AHD as recommended by BMT WBM Consultants. This is equivalent to bridge soffit at the existing Frances Creek bridge, both of which satisfy project requirements in regards to hydraulic performance. Bridge road level at the centreline of each abutment is set at RL13.515m AHD. Assumed flood levels are RL 13.2m AHD for Q100, RL 13.1m AHD for Q50, and RL 13m for Q20. Therefore the bridge deck is above assumed Q100 level.
- **Horizontal alignment:** bridge control line is set on a straight alignment.
- **Bridge drainage:** assumed via drainage scuppers discharged directly into the waterway. Bridge Deck will have two way cross-fall at 3% and 0% long fall.
- **Traffic barrier:** standard TMR steel bridge barrier .

2.13.3.1 Functional Requirements

Provision for safe access for maintenance will be provided at each abutment in accordance with standard TMR details. However, the clearance under the bridge is low and it is expected that minimum 1200mm headroom will need to be provided. Access for inspection to piers and abutment through water is likely.

2.13.3.2 Flood Loads

Vertically averaged peak velocity through the bridge is estimated at 3.4 m/s for Q100, as per BMT WBM Consultants recommendations assuming 50% blockage. Immediately upstream of the bridge the vertically averaged peak velocity is 2.1 m/s.

The new bridge will be constructed over a section of the Creek where its width gradually decreases from the upstream end to downstream end. Observed at the soffit of the bridge structure, RL 12.1mAHD, the width of the Creek on the upstream end is approximately 8m wider than that at the downstream end. The length of the proposed bridge has been reviewed from both structural and hydraulic perspective concluding that the optimum bridge opening at this location approximately corresponds to that along the bridge control line (centreline of the bridge). Thus a 40m long two span bridge was adopted and recommended.

Subsequently, the upstream end will require extended abutment / embankment protection where Creek is locally constricted. Abutment headstock is expected to be built above the existing ground at this end.

2.13.3.3 Bridge Drainage

Surface water is proposed to be discharged directly into the waterway via scuppers, as outlined in Section 2.13.1.2. This is a commonly adopted solution for new bridges in North Queensland and is generally considered to be a reliable solution in long term. The scuppers will require regular maintenance, and need to be detailed to minimise the risks of blockage.

Confirmation that this option is fully compliant with evolving Environmental Management Plan in regards to waterway management strategy for Cattle Creek, will be required in the next stage of the work.

2.13.3.4 Bridge Articulation

Bridge expansion joints are proposed at each abutment for the costing purpose.

TMR requirements for all bridges consisting of deck units with the in-situ topping slab require bearings at each end of the deck units. This has been included in the cost estimate.

2.13.3.5 Approvals and Communication with Authorities

- Carriageway clear width 10.4m has been confirmed by TMR NQ;
- Drainage discharge directly into waterway, complies with the requirement of EMP; and
- Services requirements have been confirmed with Service Authorities (Telstra & Ergon) as described in section 2.16 of this Report.

2.14 Drainage

The drainage element of the project was the primary focus of the Business Case development stage and, during the initial concept design development / options assessment stage, the associated hydraulic assessment undertaken primarily dictated the line and level of the new highway alignment, and the proposed bridge span configurations and total length. This iterative design process was therefore closely integrated with other key design disciplines to ensure the impacts of the hydraulic assessment were carefully considered and reflected in the other design elements of the concept designs being developed. The drainage design undertaken was ultimately fundamental in ensuring all Project Service Requirements were met.

This process was, however, a fine balance between achieving the desired flood immunity requirements associated with the highway, but not at the expense of detrimental environmental impacts on sensitive areas of the site or social impacts linked to afflux impacts on existing properties.

Another key consideration was to also ensure that the existing local drainage flow paths remained unchanged, so as not to create new flooding issues, in the surrounding area which previously did not exist.

Due to the condition of the existing cross drainage structures, issues were also raised with regards the perceived lack of maintenance works and the impact this issue as well as silting and debris build-up would have on the likely future hydraulic performance of these critical drainage assets.

This section of the Report includes all drainage structures excluding Bridges which are discussed in Section 2.6 of this Report.

2.14.1 Existing Drainage Arrangements

The terrain across the project area is very flat with no discernible drainage paths with the exception of the two existing creeks. The existing culverts present on the site are overgrown and silted up to varying degrees. There are minimal table drains and where they do exist they are flat and from available survey do not appear to flow to specific outlet points.

The existing survey is not of sufficient detail to review and revise the table drain arrangements and as such these low flow channels and exiting culverts are maintained as is. The following existing culverts are proposed to be extended or replaced to match existing conditions:

- Ch. 109,275m, 1 No. – 1.2m x 0.3m RCBC
- Ch. 111,675m, 1 No. – ϕ450mm RCP
- Ch. 113,180m, 1 No. – ϕ450mm RCP (To be duplicated)
- Ch. 113,445m, 1 No. – ϕ750mm RCP (To be duplicated)

The P90 estimate has made allowance for removal of all four. The first will be replaced by the new culvert requirements noted below. Allowance has been made for replacing the remaining three including duplication of the northern two.

2.14.2 Proposed Drainage Provisions

The hydraulic modelling has determined that the following culverts are required across the proposed alignment to achieve afflux requirements.

- Ch. 109,180m, 5 No. - 1.2m x 0.9m RCBCs
- Ch. 109,260m, 3 No. - 1.2m x 1.2m RCBCs
- Ch. 109,330m, 18 No. - 1.2m x 0.6m RCBCs
- Ch. 109,800m, 18 No. - 1.2m x 0.6m RCBCs
- Ch. 110,560m, 4 No. - 1.2m x 0.45m RCBCs

These are all located in the Southern Section. Culverts bases, aprons, head and wing walls are to be in-situ reinforced concrete.

Afflux requirements are achieved in the Northern Section through the extended Cattle Creek Bridge. This is a change from the original preferred NB2 option design where a combination of bridge and culverts was proposed to meet flooding requirements. During the Business Case stage a value engineering exercise and mini MCA were undertaken to compare the two options and determine the most appropriate solution for the project. It was concluded that an extended bridge would have cost, constructability and environmental benefits and as such was adopted. (For further details reference Appendix P Bridge vs. Culvert Technical Note).

Upon availability of more detailed survey, proposed culvert locations and sizes may be further optimised and additional table drain infrastructure can be incorporated. It is unlikely that this design refinement will significantly affect the prepared P90 cost estimates.

The culverts noted above and associated earthworks are shown on the concept design drawings (reference Appendix V for further details) and are included in the P90 cost estimate.

2.15 Stakeholder Requirements

A key consideration during the development and subsequent assessment of options included key stakeholder issues associated with the project, which included:

i. Potential afflux impacts on property;

ii. Potential increase in time of flood inundation on crops;

iii. Minimise changes to existing local drainage flow paths;

iv. Potential property resumption requirements; and

v. Provision and maintenance of property access.

The issues associated with the minimisation of potential impacts on existing property with respect to flooding (points i - iii above) were central to the options assessment and design development process and heavily influenced the final proposed highway alignment. The iterative design and hydraulic assessment process associated with achieving these key requirements are described in detail in Sections 2, 3 and 4 of this Report.

With regards to property resumptions (point iv) required to facilitate the design and construction of the project, these are relatively minimal, given that the proposed alignment is generally located within the existing road reserve. The proposed concept design alignment only requires one partial land resumption, of private property (approx. 900m²), at approximate Chainage 111,900m and is required to accommodate PUP relocation works necessary to facilitate the construction of the new road alignment. Further detailed are included in section 2.17 of this Report.

Given the proposed alignment largely sits within the existing road reserve there are no concerns with regards maintaining existing private accesses (point v) onto Bruce Highway and they will largely remain unchanged.

2.16 Public Utility Plant (PUP) Impacts

2.16.1 Background

No feature survey of the PUP was available or proposed for the Business Case development. Electronic CAD files were supplied from the concept design and Arup reviewed this against Dial Before You Dig (DBYD) information requested on the 15th of August 2013. DBYD highlighted that Ergon and Telstra have assets located within the road corridor. Optus and Vision Stream have assets located in the adjacent QR corridor located to the north of Pomona Road.

2.16.2 Site walk-over Survey

Following identification of PUP within the road corridor, a site walk over (undertaken on 20th August 2013) was organised to review and confirm the information. Co-ordinates of the assets that were visible on site were collected using a handheld GPS. Potential conflicts and hazards were also physically measured from the existing lane line. This information was used to revise and refine the existing CAD PUP information to more accurately locate it against the design. This allowed for a good indication of potential conflicts with the proposed design. Additional topographical survey was considered but not actioned due to associated time constraints of the Business Case development process. During the detailed design phase full feature survey will be required to accurately locate all existing PUP within the existing road reserve.

2.16.3 Ergon

A meeting with Ergon was held on 24 September 2013 with representatives from TMR, Arup and Ergon all present. The purpose of the meeting was to brief Ergon about the project, gather more detailed information on their assets and seek information on any planned or know upgrades for the project area. Ergon supplied their current design standards to enable Arup to undertake a conceptual design of potential relocations.

Ergon assets consist of 33kv (LV) and 66kv (HV) transmission lines that run parallel to both sides of the alignment as detailed on the PUP drawings (Appendix U). The majority of the assets are outside the proposed design and clear zone and as such should not require relocation works. In some locations 1 in 6 batter slopes could be locally adopted to reduce the clear zone width and mitigate relocations (Reference Section 2.10.9). For the Business Case Design, relocation requirements at these locations have been added to the unknown risk register and new positions have not been proposed. Sections that will require relocation works as a result of the revised alignment are noted in Table 16 below. These are to remove poles that are within the 13m clear zone in the proposed design. In the gazettal direction:

Table 16 - Ergon Relocations

Chainage	Type	Side
108,820 - 109,280	LV	RHS
110,100 - 110,520	HV	LHS
110,450 - 111,000	LV	RHS
110,450 - 111,000	HV	LHS
111,760 - 112,000	HV	LHS
112,960 - 113,740	LV	RHS

In order for Ergon to provide an estimated cost for the proposed works the Ergon relocation drawings were sent to Terrence Hopkins on the 22nd October 2013. Janelle Paull of Ergon provided an e-mail with a $1.13M estimated cost (2013 prices) on the 20th Nov 2013 from a preliminary investigation into the proposed works. TMR have requested that a further $1M be included in the unplanned risk for the services discussed in Section 2.10.9.

For further details associated with the existing Ergon services present on site, please refer to Appendix U of this Report.

2.16.4 Telstra

A meeting with Telstra was held on 1 September 2013 with representatives from TMR, Arup and Telstra. The purpose of the meeting was to brief Telstra about the project, gather more detailed information on their assets and seek information on any planned or know upgrades for the project area.

All existing Telstra assets are copper services, in the ground as solid state, are currently unprotected and generally run parallel to the existing alignment. There are a number of redundant Telstra assets also in the area, which are assumed to be as a result of farmers severing the cables while cultivating. The existing cables will require to be relocated to suit the new alignment and bridge locations. A single conduit is to be provided in all new bridges for Telstra assets.

Telstra provided an approximate cost estimate for a recent project in the area to assist to establish a comparable price associated with the relocation works required. Based on this information the estimated cost included in the P90 cost estimate for the project is $650,000 (2013 prices).

For further details associated with the existing Telstra services present on site, please refer to Appendix U of this Report.

2.16.5 Hinchinbrook Shire Council

Hinchinbrook Shire Council water supply assets were identified during the site walkover in the Toobanna Township between Pomona Road and Trebonne Creek. Phone discussions with the Council revealed that water supply feeds the township from the north, running along the Bruce Highway, terminating just south of Pomona Road. This has been identified on proposed scheme drawings, however, no further works have been undertaken, as this falls outside the current extents of the project.

For further details / drawings associated with the proposed PUP works please refer to Appendix U of this Report.

2.16.6 Powerlink

During the initial desktop PUP investigations, Powerlink assets were identified in the road corridor via Google street view. Further on-site investigation identified that these assets were relocated (in November 2011) to the west, out with the road reserve and as such will not affect this project.

2.17 Land Acquisition

Given that the proposed highway alignment falls within the existing road reserve only a single partial resumption is required as part of this project. The partial resumption is at a ‘pinch-point’ in the existing road corridor and has been resumed to relocate Ergon assets located outside of the clear zone. An area of 900 sq. m of lot 4/SP130991 (48.33ha) has been identified for resumption. This partial resumption (of unfarmed farming land) is required for both the preferred option and sub-option alignment.

The total value of the partial resumption has been estimated to be $32,000.

To minimise the impacts, Arup identified four potential alignment options for the alignment in this area. For further details of the four options, reference the Constrained Alignment Options Technical Note attached in Appendix R. A mini MCA was undertaken on the four options as discussed in Section 5 of this Report and the preferred option was taken forward.

For further details / drawings associated with the land acquisition requirements please reference Appendix T of this Report.

2.18 Constructability

The new proposed highway alignment largely follows the existing alignment, where possible, to maximise the use of the existing pavement, to avoid clashes with existing utilities and reduce requirements associated with potential land resumptions. Where the existing bridges are to be replaced (preferred option includes new Cattle Creek Bridge & sub-option includes both Cattle & Frances Creek Bridges), their alignment has to deviate away from the existing highway alignment to suit their new respective off-line locations.

Off-line construction is relatively simple and straight forward from a constructability point of view. Traffic remains on the existing alignment until the new alignment and bridge structures are complete. The only difficulty arises when the traffic has to be transitioned onto the new alignment following completion, which can be achieved by a staged traffic management approach being implemented.

On-line construction of new bridge structures on the other hand require traffic to be relocated to a temporary side track or "managed" via single lane operations. Side tracking can be an expensive solution especially if there are existing constraints and can also include a high degree of risk as temporary arrangements tend to be installed to a lesser standard due to their temporary nature. As such they may be deemed more vulnerable to the climatic conditions present in this region of Northern Queensland. It does however, minimise disruption to the Contractor and the Public. Traffic Management operations can also be expensive and lead to associated operational traffic and construction delays. The traffic management associated with the preferred option will differ depending on the site constraints at that time, TMR traffic management restrictions and preferences of the Contractor.

Two options are proposed for the southern section; the preferred option retains the existing Frances Creek Bridge, whilst the sub-option allows for its off-line replacement. Only one option is proposed for the northern section; a new off-line Cattle Creek Bridge structure.

Arup and TMR have identified and agreed a suitable cost effective constructability sequence for the project, based on the available survey information, for costing purposes. TMR have advised that 50kph speed limits for the proposed distances are acceptable at this stage and should be adopted where cost benefits are sizeable. This sequence is one of numerous possibilities; the project could be built in any number of ways as will be ultimately agreed between TMR and the Contractor, aimed at reducing the associated delay impacts to the road users.

With regards the two options considered from a constructability point of view they are both feasible, however the sub-option will require more temporary works

/ side tracks and traffic management provisions to facilitate the construction of the new Frances Creek Bridge. This will result in increased costs, the risk of additional delays and driver frustration being encountered and, subject to Contractor resourcing, may extend the construction program duration in comparison to the preferred option.

The proposed side track and traffic management provisions are discussed below and detailed in the constructability drawings attached in Appendix V of this Report.

2.18.1 Preferred Option (NB2)

Replacement of the existing Cattle Creek Bridge, and retention of the existing Frances Creek Bridge.

2.18.1.1 Southern Section – (Ch.108,890m – Ch. 111,780m)

The southern section preferred NB2 option is designed entirely on-line. The section from Pennas Road to Pombel Road will be subject to a significant overlay to meet flooding and cross drainage requirements whilst the remainder requires only a minimal overlay. There are overhead power lines on both sides of the road for the majority of the length at varying offsets. This makes construction of side tracks limited to areas free from obstruction (unless costly realignment of existing structures is considered).

The overlay proposed between Ch. 108,890m and Ch. 109,900m varies considerably in height over existing from a minimum depth (at the tie in) to a maximum depth of approximately 1.2m. Thirty two new culverts are also proposed to be installed in this section. For these reasons it is not practical to construct this overlay under traffic and, as such, associated side-tracking will be required.

An 8m wide double lane side track is proposed to the west of the existing alignment from Ch. 108,890m to Ch. 109,900m. This is the preferred location, as there is less conflict with existing and proposed services, the track will be on the western side, as it limits interference with the formation of the proposed batter slope and there is an existing track on top of the bund for the majority of the length. A temporary concrete barrier has been allowed for in the P90 estimate to separate the existing road/construction site from the side track. Careful consideration is required at various locations along the side track. This includes cross drainage at the new culvert locations to channel flow during heavy rain periods and protection works for the power pole at Ch. 109,250m. An unplanned risk allowance has been made for relocating Ergon poles to suit this section of side track as required. (Reference Sections 2.10.9 and 2.16.3.1 for further information).

The remainder of the southern section from Ch. 109,900m – Ch. 111,780m is reasonably confined from the toe of the proposed batter slopes. This is due to existing structures, existing/proposed services, large trees and steep embankments. The proposed pavement depths within this section are consistently in the order of ~200mm or less. The design specifies milling out the existing asphaltic concrete (AC) (170mm) and replacing with 300mm cement modified base (CMB).

For this reason it is recommended that the overlay is constructed under traffic with a one way traffic management scheme. This type of construction allows the contractor to build one side and then switch traffic over to complete the remaining side. A 40kph speed restriction will allow works to commence with traffic cone delineation only, therefore, barriers are not to be included in the estimate for this section. Provision of traffic signals has been included to provide suitable coordination of traffic.

Two alternative solutions may also be considered during the detailed design phase. A single lane side track could be incorporated in the southern section to match the one way system employed further north in order to reduce side track costs. A temporary single lane widening could be introduced in the northern section to allow two-way traffic whilst avoiding existing services.

2.18.1.2 Northern Section – (Ch. 111,780m - Ch. 113,620m)

Only one option (NB2 option) for the northern section was taken forward in the Business Case. From a constructability point of view it will be discussed in three sections:

- On-line road construction (between Frances Creek and Cattle Creek);
- Off-line road construction (across Cattle Creek wetland area); and
- Off-line bridge construction (Cattle Creek Bridge).

On-line road construction

The section of road from Ch. 111,780m - Ch. 112,100m, transitions from on-line to off-line construction (just north of Frances Creek). This is an extension of the southern section discussed above and the same traffic management approach is proposed (one way under traffic lights.) Traffic signals will need to be located at the beginning of the works to coordinate the traffic into a split phase in preparation for the southern section.

The section of road from Ch. 113,000m - Ch. 113,620m will remain in its existing location with a proposed 400mm overlay. Given the height of new pavement material it is likely that construction time frames and safety will favour a side track. It is proposed that a double lane side track is provided a minimum of 3m to the west of the existing alignment for the entire length as there are no major constraints. This will allow for unhindered construction with no requirement for temporary traffic signals or barriers resulting in minimal disruption to the existing traffic conditions.

This side tracking allows for the entire northern section to be built with minimal disruption to the existing traffic and allows a suitable transition into the southern section that requires split construction.

Special consideration will need to be made between Ch. 111,850m - Ch. 111,950m where relocation of the existing overhead power poles is required. This would be expected to occur prior to the construction of the new alignment.

Two alternative solutions may also be considered for the northern section during the detailed design phase. A single lane side track under lights or a temporary road widening could be introduced to reduce side track costs.

Off-line road construction

The off-line component is between Ch. 112,100m and Ch. 113,000m and encompasses a new 437m (or 506m) bridge over Cattle Creek. This arrangement allows for a streamlined construction phase during the instalment of the bridge with minimal disruption to the public. It is noted that there is an overhead power line to the East of the site and a Telstra conduit in the existing bridge which is to be replicated in the new bridge. A minimum of 3m clearance from the Ergon poles to the toe of proposed batter/construction site boundary is required and has been provided in the Business Case design based on available survey.

Off-line Cattle Creek Bridge construction

The new Cattle Creek Bridge will be constructed over a flood plain. However it is expected that the Creek will be inundated only within 150m extent parallel to the existing Cattle Creek Bridge which is assumed to remain operational during the construction.

The off-line construction of the new bridge is assumed to be reasonably straightforward and achievable with minimal disruption to Bruce Highway traffic. The following key construction considerations have been observed:

- During construction of the abutment embankments, temporary support of the existing embankment may be required. This will depend on the preferred construction sequence and detail refinements in the next phase. This has been allowed for in the cost estimate;
- Some predrilling for the driven piles may be required and has been assumed in the cost estimate;
- A working platform and temporary water barrier will be required for the construction of the piers and deck, within the main channel, which is assumed to extend within the width of the existing Cattle Creek Bridge. This will depend on the construction methods and sequence. This has been allowed for in the cost estimate;
- Use of precast elements (deck units and piles) will contribute to faster construction and therefore beneficial from both programming and cost perspective. It is expected that these will be transported and supplied from pre-casting yards off site and be positioned using cranes located on the aforementioned working platform;
- Precast headstocks have been considered, however in-situ construction is preferred to maximise construction tolerances and to minimise any future issues with durability at the connections;
- The new longer Cattle Creek Bridge will require the supply of a large number of piles and deck units, therefore, lead time for these, early in the procurement phase, will need to be considered and taken into account in the programme. The deck units, however, will be standard and square and are expected to only require standard formwork;
- The deck units will be transversely stressed, which will further speed up the construction as opposed to decks with in-situ concrete slabs; and

- The structural form of the bridge is standard and it is therefore considered that specialist contractors will not be required to help facilitate the construction of the structures component element of the project.

2.18.2 SASR Sub-option (Proposed Frances Creek Bridge Off-line)

The sub-option varies to the preferred only between Ch. 111,160m and Ch. 111,780m. It transitions off-line to a new Frances Creek Bridge, east of the existing alignment before tying into the northern section. Being an off-line alignment, the construction of the new bridge can take place while traffic continues to use the existing bridge. This allows the split construction of the southern section to cease at Ch. 111,350m and return to the existing road.

The sub-option alignment requires on-line construction between Ch. 111,675m and Ch. 111,975m due to the new bridge location. Given the short distance, space available to the west and that the construction to the North and South are off-line, it is recommended a double lane side track is constructed to the west of the tie in location. A temporary concrete barrier to separate the existing road/construction site from the side track has been allowed for in the P90 cost estimate.

2.18.2.1 Proposed Frances Creek Bridge

The new bridge will be constructed over a section of the creek where its width gradually decreases from the upstream end to downstream end. The width of the creek on the upstream end is approximately 8m wider than that at the downstream end. The length of the proposed bridge has been reviewed from both structural and hydraulic perspective concluding that the optimum bridge opening at this location approximately corresponds to that along the bridge control line (centreline of the bridge). Thus a 40m long two span bridge was adopted and recommended to replace the existing 45m (3 x 15m span) bridge.

The off-line construction of the new bridge is assumed to be reasonably straight forward and achievable with minimal disruption to Bruce Highway traffic. The following key construction considerations have been observed;

- The upstream end will require extended abutment / embankment protection where the creek is locally constricted. This has been allowed for in the cost estimate. Abutment headstock is expected to be above the existing ground level at this end;
- In order to construct the northern embankment on the upstream end, Abutment B, temporary support of the existing embankment may be required. This will depend on preferred construction sequence. This has been allowed for in the cost estimate;
- The creek will require local widening at the downstream end, where the abutment headstock will be constructed in the cut. Local creek widening and excavation will be required for some distance downstream pass the bridge to allow smooth transition to a narrower natural creek width. This has been allowed for in the cost estimate;
- Predrilling for the driven piles may be required and has been assumed in the cost estimate;

- A working platform and temporary water barrier permits may be required for the construction of the central pier and/or abutments. This will depend on the construction methods and sequence. This has been allowed for in the cost estimate;
- Use of precast elements (deck units and piles) will contribute to faster construction and therefore beneficial from both programming and cost perspective. It is expected that these will be transported and supplied from pre-casting yards away from the site;
- Although on high skew, the deck units can be detailed to maximise repetition in detail and type, which will minimise construction cost;
- Precast headstocks have been considered, however in-situ construction is preferred to maximise construction tolerances and to minimise any future issues with durability at the connections. Larger bearing shelves will be detailed to accommodate large skew; and
- The structural from of the bridge is such that it is expected that plenty of known experience will be available from the contractors throughout Queensland.

2.19 Road Safety Audit

A Road Safety Audit was carried out to identify areas where the existing built road and road reserve has the potential to compromise road user safety and where the proposed Business Case design could potentially impact on road user safety. It was undertaken in accordance with the practices outlined in the Austroads Guide to Road Safety Part 6: Road Safety Audit (2009). The audit covers physical features of the existing roadways which may affect road user safety and it has sought to identify potential safety hazards and the extent to which the proposed reconstruction works address these.

A site visit covering the full extent of the Bruce Highway study area and was undertaken by the audit team as part of the road safety audit investigations on-site formed the basis of the existing audit findings. A review of the civil business case drawings formed the basis of the business case audit findings. A day time and night time site audit was completed and all traffic movements were driven by vehicle and parts of the road were inspected by foot where safe to do so.

A detailed investigation and feature/deficiency survey of the road sections was carried out prior to conducting speed runs at the posted speed limit in both directions. The investigation was conducted using the Stage 4 checklists from Austroads Guide to Road Safety.

Following a review of the existing road layout, 15 issues were raised, which included:

i. Reduced shoulder widths;

ii. Steep batter slopes;

iii. Steep edge drop-off, large trees, camera pole, culvert headwalls, electricity poles and large traffic signs (potential hazards) located within clear zone;

iv. Narrow and reduced length access/egress lanes to Frances Creek Rest Area;

v. Sub-standard turn treatments at existing intersections at Pombel Road, Pennas Road & Haughty's Road

vi. Central line markings give rise to potential head on crashes; and

vii. Bridge barriers not too standard.

Various suggested treatments to address the above issues proposed in the RSA Report have been carefully considered and reflected in the proposed layouts for both options.

Following this exercise a review of the proposed road layout was then undertaken and 12 issues were raised, which included:

i. Culvert headwalls and camera pole (potential hazards) located within clear zone;

ii. No turn treatments at Pennas Road, Haughty's Road and Pombel Road intersections;

iii. Central line markings give rise to potential head on crashes;

iv. The road cross-fall / superelevation in this road section is less than the standard 3% required for adequate drainage;

v. Unprotected fill embankments at the Cattle Creek bridge approaches (2.5-3m), with relatively narrow shoulders and no defined verge;

The various suggested treatments to address the above issues were subsequently considered and have been reflected in the finalised proposed layouts for both options, which will ultimately provide a safer and more forgiving road environment.

As part of the RSA process, a review of the crash history found that 15 crashes were recorded along the Bruce Highway in the study area in an 11 year period from December 2001 to February 2013. Of these crashes, two were fatal, six required hospitalisation, one required medical treatment and six involved property damage only. An assessment of the crash locations found just one location with a pattern of incidents. At the southern end of the study area near Pennas Road, there was a cluster of three crashes along a curve all involving vehicles losing control. In two of the three cases, this was due to water ponding on the carriageway, which has now been addressed in the proposed revised alignment. There does not appear to be any other geographical clusters of crashes in the study area. The most common type of crash was found to be head on crashes, which in part, will be addressed by the installation of the wide centreline treatment and audio tactile edge lining provisions. The NRSS identifies that there are three main crash types involved in serious casualty crashes, these being:

i. Head-on crashes;

ii. Run-off road crashes; and

iii. Crashes at intersections.

Just over 50% of the previous crashes recorded for this specific section of the Bruce Highway fall into the category of serious casualty crashes involving run-off crashes.

With both the Preferred Option and Sub-Option with the Base Case (existing crash history), there will be an improvement in traffic safety through the provision of:

- Wide centreline treatment to provide greater separation between traffic travelling in opposite directions. Note that the preferred option maintains the existing Frances Creek Bridge and therefore does not provide the wide centreline treatment on the bridge itself. It should be noted that this is not considered to significantly reduce safety when compared to the sub-option (bridge replacement) due to no previous crashes occurring on the bridge and the bridge cross section is similar to other existing bridges in the area between Townsville and Ingham;
- Improved safety at intersections through the provision of channelised right turn treatments and additional shoulder width for turning traffic; and
- Improved road geometry, specifically in the vicinity of Pennas Road intersection will contribute to a safer road environment being provided.

For further details associated with the Road Safety Audit Report please refer to Appendix J of this Report.

2.20 Summary

In summary, the technical assessment undertaken by the multi-disciplinary project team has remained strongly focused on achieving the desired Project Service Requirements. The key project outcomes of increased flood immunity, associated high level of certainty and providing improved levels of safety are understood as they key project drivers. In addition the technical assessment undertaken has also remained focused on achieving a value for money design solution by investigating numerous design related opportunities without compromising project, safety, stakeholder or budget constraint requirements.

The project team realised earlier in the assessment of each respective key technical discipline that an integrated approach was critical to achieving the desired outcomes, which led to the adoption and maintenance of a design integration register and key decision register throughout the entire commission, to help ensure that the project developed in a transparent, focused and collaborative manner.

Given the sensitive location of the project, within the extents of an existing Wetland Protection Area and the Great Barrier Reef Catchment Area, the comprehensive and rigorous approach to environmental assessment was key to ensuring the Business Case was ultimately suitably informed in terms of likely impacts, appropriate mitigation measures being identified/adopted and associated risks being highlighted and appropriately controlled. The potential existence of Mahogany Glider habitat as well as local Cultural Heritage issues on the project site also further reinforced the aforementioned approach being required to ensure the project was being appropriately managed.

To support the reduced impact of the project on the surrounding environment and help lower the capital cost and risk exposure of the project, the project ‘footprint’ was reduced wherever possible. This meant making best use of the existing highway asset, ensuring the proposed geometrical layouts remain within the existing road reserve and achieving the optimal balance of improved flood immunity vs. cost / impact outcome. Given the numerous design iterations undertaken the project team are confident that this balance has been successfully achieved.

This process was further informed by considering key constructability issues early in the design life cycle to ensure there were no inherent risks associated with the future delivery of the project. This was largely achieved by adopting efficient on-line pavement treatments for the southern section of the project and proposing mainly off-line pavement and bridge works for the northern section so traffic impacts would be kept to a minimal level.

The technical assessment completed has been a combination of reviewing existing project data, undertaking field investigation works, efficient application of design standards and ensuring liaison on project critical design with key TMR specialists took place (e.g. independent flood model validation by TMR Director of Hydraulics and seeking early agreement to bridge proposals by TMR Bridge Branch Chief Engineer).

The level of Technical Assessment undertaken is commensurate with the requirements to suitably inform a robust concept design proposal for reference in the Business Case submission, all key technical disciplines have been addressed which aims to achieve a high degree of certainty with regards scope, risk and costs associated with the options assessed, so ultimately a well-informed comparative assessment can then be undertaken and a sound and robust recommendation can be proposed.

3 Options Assessment

3.1 Introduction

In line with the requirements of the TMR Project Brief, Arup were tasked with completing a technical investigation and assessment of infrastructure-only options, including a preferred NB2 option and an SASR sub-option. The technical investigation and options assessment undertaken would then provide the basis for a sound comparison between the options, which would ultimately deliver a suitably robust and justified preferred option to be recommended for an investment decision to then be taken, regarding the future delivery of the project.

Following the initial Project Familiarisation stage, Arup informed TMR of various opportunities to amend/refine the previously identified options which could potentially deliver an improved value for money outcome, without compromising the Project Service Requirements. A number of these opportunities were considered to be design refinement and two opportunities were alternative options, incorporating the design/construction of new levees (earth bunds). The various design opportunities identified are described in more detail in Section 4 of this Report.

Table 17 below provides a schedule of all options assessed, which includes those as highlighted in the original Project Brief, 1 additional sub-option (as requested by TMR) and two alternative options, which were briefly considered early in the Business Case development process. This table is then followed by the associated technical investigation and assessment work which was undertaken in a fully collaborative and transparent manner with TMR and BMT WBM Consultants:

Table 17 - Schedule of Options

#	Option Reference	Brief Option Description
1	Preferred Option (NB2 Option & SASR)	• Minor regrading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek Bridge (southern section). • No new bridge crossing at Frances Creek. • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section). • Replace existing Cattle Creek bridge with a new wider and high level bridge to provide an increased Q100 flood immunity.
2	Sub-option (New Frances Creek Bridge – Off-line) (SASR Option)	• Minor regrading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek bridge (southern section). • New bridge crossing at Frances Creek (Off-line). • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section). • Replace existing Cattle Creek bridge with a new wider and high level bridge to provide an increased Q100 flood immunity.

#	Option Reference	Brief Option Description
3	Sub-option (Widen Existing Frances Creek Bridge) (SASR Option)	• Minor regrading of the Bruce Highway, on the existing alignment, between Pennas Road and Frances Creek bridge (southern section). • Widen existing bridge crossing at Frances Creek. • Major regrading & realignment of the Bruce Highway, off the existing alignment, between Cattle Creek bridge southern approach and Pomona Road (northern section). • Replace existing Cattle Creek bridge with a new wider and high level bridge to provide an increased Q100 flood immunity.

3.2 Preferred NB2 Option

3.2.1 Preferred NB2 Option Description

The preferred NB2 option involves the minor on-line regrading of the Bruce Highway, commencing immediately south of the existing Pennas Road intersection and heading in a northerly direction for an approximate distance of 2.6km. The alignment then utilises the existing Frances Creek bridge (maintaining same line and level) before continuing north on the existing alignment for an approximate distance of 300m.

At this point (Approx. Ch. 111,850m) the proposed alignment moves off-line and is raised in level running parallel to the existing alignment on the approach to a new Cattle Creek bridge crossing, for an approximate distance of 500m. The proposed alignment then crosses Cattle Creek on a new wider bridge structure (on the eastern side of the existing bridge at a higher level) for an approximate distance of 440m. On the northern side of the new Cattle Creek bridge the alignment then starts to reduce in level and sweeps west to tie back into the existing Bruce Highway alignment over an approximate distance of 500m, tying back in at approximate Ch. 113,300m. The alignment then continues north on-line regrading back to match existing levels, over an approximate distance of 300m, tying back in at approximate Ch. 113,620m, immediately south of the existing Pomona Road intersection.

For a graphical representation of this option, please refer to the concept design layout plans as included in Appendix V of this Report.

3.2.1.1 Preferred NB2 Option Benefits

The key benefits associated with this option included:

i. Meets all Project Service Requirements;

ii. Meets Vision Standards (with the exception of full WCLT provision on Frances Creek bridge);

iii. Cheaper in comparison to all other options – provides better value for money;

iv. Makes best use of existing infrastructure assets;

v. Quicker and easier to construct in comparison to all other options; and

vi. Least environmental impact in comparison with all other options.

The added benefits of points v and vi also result in a lower associated risk profile.

3.2.1.2 Preferred NB2 Option Limitations

The main limitations of this option included:

i. Could be deemed to be marginally less safe in comparison with the SASR sub-option (due to narrow existing Frances Creek bridge width which cannot meet full WCLT requirements and has older reduced standard safety barrier provision); and

ii. Existing bridge design life will not match that of a new bridge and so increased future maintenance costs will be incurred.

3.2.2 Cost of Preferred NB2 Option (Comparative Assessment)

A high level comparative assessment of the cost of this option was undertaken due to the reduced level of new infrastructure required (i.e. no new Frances Creek bridge) as such this option was ranked 1st overall.

3.2.3 Preferred NB2 Option Summary

The preferred NB2 option scores well against all assessment criteria due to it requiring less new infrastructure which means, in comparison with all other options, it is quicker to construct, costs less, has a reduced level of risk and has a smaller scheme footprint, so has a reduced environmental and social impact.

This option also meets all Project Service Requirements / vision standard requirements.

It does not allow for the proposed WCLT across the existing Frances Creek bridge. From a safety point of view it maintains existing level of safety provided on Frances Creek bridge and improves safety elsewhere along the overall section, due to the installation of WCLT, wider seal widths, a wider Cattle Creek Bridge, upgraded at-grade intersection configurations, provides flatter verge batters and reduces the potential for aquaplaning along most sections.

The only limitation of this option is the reduced design life and increased future maintenance costs, which could be argued makes better use of an existing asset in a good condition.

3.3 SASR Sub-option (New Frances Creek Bridge Off-line)

3.3.1 SASR Sub-option Description

The SASR sub-option (New Frances Creek Off-line) involves the minor on-line regrading of the Bruce Highway, commencing immediately south of the existing Pennas Road intersection and heading in a northerly direction for an approximate distance of 2.5km. The alignment then moves off-line to the east before crossing the existing Frances Creek on a new wider bridge structure for an approximate distance of 40m. On the northern side of the new Frances Creek bridge the alignment remains off-line continuing in a generally northerly direction.

At this point (Approx. Ch. 111,850m) the proposed alignment raises in level running parallel to the existing alignment on the approach to a new Cattle Creek bridge crossing, for an approximate distance of 500m. The proposed alignment then crosses Cattle Creek on a new wider bridge structure (on the eastern side of the existing bridge at a higher level) for an approximate distance of 440m. On the northern side of the new Cattle Creek bridge the alignment then starts to reduce in level and sweeps west to tie back into the existing Bruce Highway alignment over an approximate distance of 500m, tying back in at approximate Ch. 113,300m. The alignment then continues north on-line regrading back to match existing levels, over an approximate distance of 300m, tying back in at approximate Ch. 113,670m, immediately north of the existing Pomona Road intersection.

3.3.1.1 SASR Sub-option Benefits

The key benefits associated with this option included:

i. Meets all Project Service Requirements / Vision Standards;

ii. Provides a new bridge that will have wider carriageway width, allows for installation of WCLT, traffic barrier provision to current standards, and therefore from the current safety standards perspective provide safer environment than the existing bridge;

iii. Provides a new bridge that will have a longer design life which will meet current standards and will be more ‘future proof’ in regards to future potential increases in traffic volumes and loading. Reduced future maintenance costs;

iv. Off-line bridge construction provides an improved ease of constructability and allows existing bridge to remain open leading to minimal disruption to existing traffic flows during the construction stage; and

v. Provides an opportunity to improve geometry on both approaches.

3.3.1.2 SASR Sub-option Limitations

The main limitations of this option included:

i. The construction of a new bridge will increase the risk exposure from an environmental perspective due to a larger scheme footprint, in a sensitive area of the site. Specifically, this is with regards to potential impact on existing mahogany glider habitat, Creek disturbance, potential pollution / water quality and also cultural heritage issues; and

ii. The realignment on the southbound approach to the new bridge will require service relocations (i.e. Ergon) which will lead to increased project costs / risks.

3.3.2 Cost of SASR Sub-option (Comparative Assessment)

A high-level comparative assessment of the cost of this option was undertaken and due to more new infrastructure being required (i.e. New Frances Creek bridge) and less temporary side track provisions in comparison with NB2 option, this option was deemed to be more expensive overall in comparison with the other two options being assessed.

3.3.3 SASR Sub-option Summary

The SASR sub-option in comparison with the preferred NB2 option does not score as well against all assessment criteria due to it requiring more new infrastructure which means in comparison it costs more, has an increased level of risk and has a larger scheme footprint, so has a greater environmental impact, in an environmentally sensitive area of the site.

The SASR sub-option also meets all Project Service Requirements / Vision Standard requirements and has the marginal improved safety benefit of a full WCLT and an improved safety barrier provision across Frances Creek bridge crossing. The other key benefit of this option, given that it is a new bridge structure, is the increased design life and associated reduced future maintenance costs.

3.4 SASR Sub-option (Widen Existing Frances Creek Bridge)

Although a formal Preliminary Evaluation process was not carried out, TMR reviewed and refined the option/sub-options brought forward from the SASR, as is usually completed at the beginning of a Preliminary Evaluation. The SASR sub-option of widening Frances Creek Bridge was excluded from further serious consideration in the Business Case development stage. It is briefly reported on to provide a high level comparison only.

3.4.1 SASR Sub-option Description

The SASR sub-option (widen existing Frances Creek Bridge) involves the minor on-line regrading of the Bruce Highway, commencing immediately south of the existing Pennas Road intersection and heading in a northerly direction for an approximate distance of 2.6km. The alignment then utilises the existing Frances Creek bridge (maintaining same line and level) before continuing north on the existing alignment for an approximate distance of 300m. Works to the existing bridge would involve widening from its current width of 8.4m, by 2.0m up to 10.4m. This would then facilitate the provision of a fully compliant wide centreline treatment application.

At this point (Approx. Ch. 111,850m) the proposed alignment moves off-line and is raised in level running parallel to the existing alignment on the approach to a new Cattle Creek bridge crossing, for an approximate distance of 500m. The proposed alignment then crosses Cattle Creek on a new wider bridge structure (on the eastern side of the existing bridge at a higher level) for an approximate distance of 440m. On the northern side of the new Cattle Creek bridge the alignment then starts to reduce in level and sweeps west to tie back into the existing Bruce Highway alignment over an approximate distance of 500m, tying back in at approximate Ch. 113,300m. The alignment then continues north on-line regrading back to match existing levels, over an approximate distance of 300m, tying back in at approximate Ch. 113,620m, immediately south of the existing Pomona Road intersection.

3.4.2 Cost of SASR Sub-option (Comparative Assessment)

A high level comparative assessment of the cost of this option was undertaken and due to the reduced level of new infrastructure required (i.e. no new Frances Creek bridge and due to limited widening works to existing bridge, which will probably be quicker and cheaper in comparison) this option was deemed to be cheaper than the SASR Sub-option but more expensive than the NB2 option.

3.4.3 Sub-option Assessment / Summary

The assessment of this sub-option was not progressed in detail due to the unfeasible nature of widening the existing bridge given its existing form of construction. This sub-option would also involve either an extended period of single lane running on the existing Bruce Highway alignment (leading to an increased level of traffic disruption) or closing the existing bridge and running all traffic on a temporary side track arrangement (which from a risk perspective would be unacceptable due to the increased risk of experienced prolonged full road closures).

This sub-option was therefore discounted due to the option being deemed unfeasible and was therefore not taken forward into the MCA process.

3.5 Summary

With regards to the existing Frances Creek widening option and the Frances Creek Bridge (on-line replacement), these options were discarded due to major associated issues including constructability difficulties, unacceptable level of risk and potential major detrimental impacts on maintaining existing traffic flows during the construction stage.

The two alternative options identified were discarded as they are not a preferred method of achieving the level of desired flood immunity certainty the project requires. These alternative options also have the potential to raise significant opposition in terms of support from public, stakeholders and potentially may erode political support which the project currently has.

In summary of all the options identified and considered to varying extents, only the preferred option and sub-option (New Frances Creek Bridge off-line) were taken forward into the MCA process for further comparative assessment, due to their general achievement of the various key Project Service Requirement criteria.

4 Design Optimisation / Value for Money

4.1 Introduction

Throughout the process of both refining and assessing the two main design options being considered in the Business Case submission (the preferred NB2 option and the SASR Sub-option including a new bridge crossing at Frances Creek), the team maintained a strong focus on ensuring a high value for money design solution was ultimately achieved, which would help further support the project proceed to construction stage. During the comprehensive investigation of various design opportunities, which are detailed below, each design opportunity identified was assessed to ensure only the most efficient and cost effective solutions were then adopted, which had the added benefit of generally leading to a lower level of associated project risk being achieved.

As discussed in the previous sections of the Report, only infrastructure solutions were considered during the Business Case design, as non-infrastructure solutions had been previously discounted and were seen as to only complement an infrastructure solution. The following design components were aspects on which effort was focused:

i. Cattle Creek Bridge optimisation;
   - Optimum form of superstructure
   - Optimum span length
   - Optimum vertical alignment
   - Optimum bridge length
   - Bridge drainage provisions

ii. Frances Creek Bridge optimisation;

iii. Increased level of flood immunity for new Cattle Creek Bridge (enhanced from Q50 to Q100);

iv. Intersection treatments upgraded;

v. Pavement treatments;

vi. Alternative levee options;

vii. Highway alignment optioneering;

viii. Enhanced cross drainage provisions;

ix. Minimised PUP impacts/relocations; and

x. Early consideration and conclusion of key constructability issues.

4.2 Cattle Creek Bridge Optimisation

Design optimisation for Cattle Creek Bridge was primarily focused on:

4.2.1 Optimum Form of Superstructure

Two key types of superstructure form were investigated; precast prestressed deck units with the in-situ topping slab, and transversely stressed precast prestressed deck units with high performance waterproofing membrane. The latter was selected as the preferred superstructure for this bridge location and purpose, as it provided a lower cost solution which was assessed as being sufficiently resilient at this location, some 15km from the coast away from tidal influences and associated salt water corrosion issues.

The two key forms of superstructure were considered and assessed in detail and the associated findings are highlighted in the following sub sections.

4.2.1.1 Precast Prestressed Deck Units with In-situ Topping Slab

This form of construction includes a combination of precast prestressed deck units with an in-situ topping slab, which acts compositely with the deck units to form a waterproofing barrier to the deck.

The superstructure would comprise a minimum 210mm thick topping slab, and 50mm deck wearing surface. The depth of the topping slab would, however, vary to accommodate variance in the deck unit's hog. Thus at the piers, the topping slab may be up to 280mm deep, depending on the length of the deck unit.

The deck units will be simply supported at each end, however, continuous topping slab is used to minimise the number of expansion joints and improve ride quality.

This type of deck is typically used on TMR highway bridges and is considered to be a robust and reliable option in short and long term. However, installation of the in-situ deck is costly. The installation requires highly skilled labour, and the construction program can be significantly affected by the casting processes and associated concrete delivery requirements.

4.2.1.2 Transversely Stressed Precast Prestressed Deck Units with Type C Waterproofing and Deck Wearing Course

The precast prestressed deck units are erected on site and transversely stressed, which provides adequate friction allowing the deck to act as one. Therefore, it does not require an in-situ topping slab, however, it requires a deck wearing surface which includes a high performance waterproofing membrane.

This type of deck is typically used on TMR roads and is generally considered to be more economical and faster to construct (e.g. no topping slab).

In recent years, this type of superstructure was mostly used on local roads, and not preferred on major highways due to durability concerns the department encountered with some older bridges of similar form of construction. However, TMR has recently updated their technical specifications to include the Type C proprietary waterproofing membrane which can be used in conjunction with the transversely stressed highway bridge decks, to address this concern.

Type C waterproofing membrane is a high performance waterproofing membrane, which will provide long term durability to an appropriate level required by TMR, provided that it is detailed and installed in accordance with TMR MRTS84 Deck Wearing Surface dated September 2013. Therefore, this solution will be accepted for Bruce Highway bridges and is considered to be appropriate option for the Cattle Creek Bridge.

TMR acceptance of the Type C waterproofing, however, will require both submission of the successful test results and the acceptable performance at the site trials. Testing is recommended to be in accordance with BD 47/99: Waterproofing and surfacing of concrete bridge deck issued by The Highways Agency, England.

MRTS84 also requires the Type C membrane to be identified during the concept design stage so to enable sufficient time for product evaluation. The proposal to use such membrane must be informed in writing to the Director (TMR Bridge and Marine Engineering) for review and acceptance.

At this stage of the project it is not expected such details are required, other than to seek approval in principle, which has been done. The application of transversely stressed deck for Cattle Creek has been discussed with TMR Bridge Branch and agreed in principle to be an appropriate solution. Further details, however, will need to be followed up and agreed with TMR Bridge Branch in the detailed design phase of the project.

Therefore, a transversely stressed deck was recommended and adopted as the preferred deck option for the Cattle Creek Bridge, mostly due to anticipated capital cost savings which are particularly related to speed of construction as opposed to the in-situ deck option.

It is estimated that 18 no. standard deck units are required per each span. Concrete kerbs, which support the steel guardrail, can be in-situ or part of a precast kerb deck unit, although in-situ kerb has been assumed as a preferred option for this bridge.

The overall depth allowance to accommodate the superstructure depends on a number of factors, however assuming constant cross-fall, the structural depth, and the hogging of the deck units will largely depend on the length of the span. Required deck unit depths for both in-situ topping and transversely stressed option were considered for a range of spans between 14m to 24m. These were estimated for the purpose of determining the optimum span length in this study, however it is expected that further refinement (the next phase of the project) will be used to determine the optimum depth for the preferred option.

The decision to adopt transversely stressed precast prestressed deck units with Type C waterproofing was made in consultation with TMR Bridge Branch (Deputy Chief Engineer Structures – Ross Pritchard) who fully supported the design proposal for specific use on the project.

4.2.2 Optimum Span Length

A range of span lengths from 14m up to 24m were considered and investigated to ensure the optimal span arrangement for the project would be ultimately proposed.

The hydraulic modelling and span length assessments were undertaken in parallel during the course of the study. Once the final iterations were completed, a bridge length of 437m was confirmed, as needed to satisfy the hydraulic performance requirements consistent with the Project Service Requirements, which focused on achieving Vision Standards for highway flooding closures and afflux requirements.

For the purpose of the concept design development, 250m and 360m long bridges were considered and compared. The purpose of the assessment was to identify the most optimum span length that would provide a ‘best value for money’ solution and minimise any project and long term risks, including future maintenance activities.

The 14m span was selected as a base case reflecting the current span arrangement. However the existing bridge site indicates debris trapped at the bridge piers and thus wider piers are preferred as a potential mitigation strategy to minimise this in future.

Longer spans were generally considered to be better overall from environmental perspective, and would arguably provide better hydraulic performance due to a less constricted opening. There are also economic benefits associated with longer spans, where the number of piers reduces the cost of their construction, and a lower number of deck units speeds up the construction program. The penalty of longer deck units is in marginal increase in cost of individual deck units which are not only longer but also deeper, which may create a tipping point where the balance between numbers of piers versus number of deck units reaches the optimum value. However, the increase of span length, the proportion of the dead weight to live load increases and the utilisation starts to decrease as the deck units become too long. Typically 25m deck units are considered to be at the upper bound of what would be considered to be economical solution. Such long deck units are typically used where long spans are required over a road or a railway. In such case the deck units are preferred to Teer-off Girders so to minimise the depth of the superstructure which is driven by limitations of the vertical alignment. In such case cost benefits are often found in minimising vertical alignment to either side of the bridge. In case of Cattle Creek Bridge 24m span was considered as the appropriate upper bound.

However, vertical alignment limitations have also been considered for this bridge. Final recommendations from the hydraulic modelling, undertaken by BMT WBM Consultants, recommended the soffit of the bridge to remain above RL 12.4m AHD which is estimated equivalent to Q100 level. At the same time, road alignment at the bridge approaches had to be dropped down as quick as possible to satisfy the overall strategy to minimise afflux (e.g. where the road alignment away from the bridge needs to be lowered). This balance between the quantities of the flood water passing under versus over the road is therefore driving the need for a shallow superstructure on Cattle Creek Bridge.

Only equal span options were considered for the purpose of the comparison, however repetition in detail is also preferred as it will have impact on the overall cost and construction programme (savings). It is assumed that the deck unit depths will need to be confirmed and further refined during the next phase of the project.

Table 18 below summarises number of deck units and piers for each span arrangement, and potential savings for two bridge lengths considered at the time. However, as outlined in Section 6 of this Report the preferred option has now also been further refined with a new total span length of 506m, which includes three additional spans to the north of Cattle Creek.

Table 18 - Summary of Deck Units and Piers Requirements

	For (approx.) 250m long bridge				For (approx.) 360m long bridge			
Span length (m)	**No of equal spans**	**No piers**	**No of reduced piers**	**Total No of DU**	**No of equal spans**	**No piers**	**No of reduced piers**	**Total No of DU**
14	18	17		324	26	25		468
15	17	16	1	306	24	23	2	432
16	16	15	2	288	23	22	3	414
17	15	14	3	270	21	20	5	378
18	14	13	4	252	20	19	6	360
19	13	12	5	234	19	18	7	342
20	13	12	5	234	18	17	8	324
21	12	11	6	216	17	16	9	306
22	11	10	7	198	16	15	10	288
23	11	10	7	198	16	15	10	288
24	10	9	8	180	15	14	11	270

4.2.3 Optimum Vertical Alignment

Bridge soffit is set to be at or above Q100 as required to meet the project objectives in regards to hydraulic performance and Vision Standards. The Q100 level was initially estimated to be at RL 12.25m AHD; however, the final iteration towards the end of the Business Case development confirmed that Q100 and the minimum soffit level may be estimated at RL 12.4m AHD. The final road level was set at 13.7m AHD. Bridge levels are directly related to selection of the superstructure form, and the optimum span length. It is, however, expected that the final vertical alignment and allowance for the superstructure depth will be further refined and confirmed during the detailed design phase of the project.

The depth of the deck units is, however, only a portion of the overall structural depth; topping slab (where applicable) and deck wearing surface (DWS) also need to be allowed for. Road level will also be influenced by geometrical requirements, including the cross falls and the deck unit hogs.

The deck units hog during curing, the amount of which varies over time. Due to variable factors which influence the amount of hogging it is difficult to accurately predict them, and in reality the theoretical hogs are found to be different to actual hogs, which vary significantly from girder to girder. This variance in hog creates an uneven deck surface which is usually eliminated either by using in situ topping slab or deck wearing surface. At this stage of the design a nominal hog allowance has been made for each span, with added tolerance through either topping slab or deck wearing surface (DWS) have been allowed for.

- For transversely stressed deck, it is assumed that the minimum thickness of DWS at any point will be 80mm; allowing 10mm for the Type C waterproof membrane and 70mm for the asphalt. Hence DWS will comprise of a tack coat, bituminous waterproof membrane, and a surfacing layer (e.g. DG14). Due to 3% cross fall and variation in hogs a corrector course will be required (e.g. DG10). It is also expected that the final hogs at transversely stressed deck will be greater than that for the in-situ topping deck, which will be corrected by the weight of the concrete.
- For the in situ topping deck, tolerances are expected to be corrected by the (min) 210mm thick topping slab, thus only nominal 50mm DWS (e.g. DG14).

The recommended depth allowance for the range of span lengths has been estimated as shown in the following tables. At the piers, this depth effectively represents the difference between; the design level along the control line (e.g. the crest) and the lowest point of the bridge soffit, which will occur at the piers along the external deck units (e.g. along the edge of the bridge structure).

Table 19 - Recommended Depth Allowances

Composite Precast Deck Units with 210 in-situ topping slab			
Based on: 10.4m clear width between the kerbs, AS5100 SM1600 loading, zero skew			
Assuming: steel guardrail & kerb arrangement, two-way cross-fall, 50mm DWS, nominal HOG allowances ranging between 25 and 75			
Span length (m)	**Recommended Deck Unit depth (mm)**	**Recommended depth allowance at mid-span (mm)**	**Recommended depth allowance at Piers (mm)**
14	600	1028	1053
15	650	1078	1108
16	675	1103	1138
17	700	1128	1168
18	750	1178	1218
19	775	1203	1248
20	800	1228	1278
21	825	1253	1308
22	875	1303	1363
23	**900**	**1328**	**1393**
24	925	1353	1423

Table 20 - Recommended Depth Allowances

Transversely Stressed Deck Units with Type C Waterproofing Membrane			
Based on: 10.4m clear width between the kerbs, AS5100 SM1600 loading, zero skew			
Assuming: steel guardrail & kerb arrangement, two-way cross-fall, 80mm DWS, nominal HOG allowances ranging between 30 and 125			
Span length (m)	**Recommended Deck Unit depth (mm)**	**Recommended depth allowance at mid-span (mm)**	**Recommended depth allowance at Piers (mm)**
14	625	873	903
15	675	923	963
16	700	948	998
17	725	973	1028
18	750	998	1063
19	800	1048	1123
20	825	1073	1158
21	850	1098	1193
22	900	1148	1253
23	**950**	**1198**	**1313**
24	1000	1248	1373

Therefore to allow clear bridge opening below Q100 level, where RL 12.4mAHD has been assumed as Q100 = lowest bridge soffit level, recommended road level at the bridge abutments along MC00 (the bridge centreline) are:

Table 21 - Road Levels

Road Levels at Abutments		
Levels assumed at the bridge centreline		
Span length (m)	**In-Situ topping slab option RL (m AHD)**	**Transversely stressed deck units RL (m AHD)**
14	13.453	13.291
15	13.508	13.351
16	13.538	13.386
17	13.568	13.416
18	13.618	13.451
19	13.648	13.511
20	13.678	13.546
21	13.708	13.581
22	13.763	13.641
23	**13.793**	**13.701**
24	13.823	13.761

The above values have been determined assuming adequate tolerances for the waterway blockage were allowed for in the hydraulic modelling (which were subsequently assessed following corresponding sensitivity analysis being undertaken), which would account for minor construction tolerance and minimise the likelihood of debris accumulation during the Q100 flood event.

The transversely stressed deck will have a shallower superstructure than the deck with the in-situ slab of the same length, and the final road level will be lower than that for the in-situ deck.

In summary the optimisation of the vertical alignment and corresponding waterway area led to reduced afflux impacts, achieved the desired reduced closure times and supported the achievement of wider benefits including an improved level of flood immunity certainty being provided.

4.2.4 Optimum Bridge Length

Bridge lengths of 250m (the original preferred NB2 option) and 360m were initially considered during the Business Case development and before the development of concept design. The final bridge length of 437m was adopted, for the MCA process, as a result of several iterations between relevant disciplines towards the completion of the concept design stage. The final bridge length was driven by hydraulic performance and bridge versus culvert optimisation. Following the MCA process, further design refinement resulted in a bridge length of 506m being proposed. It is however, expected that the bridge length may be further refined and confirmed during the next phase of the project.

To further supplement the optimisation of the span length, a high level cost benefit analysis was undertaken to investigate the movement in cost between options that have different span lengths. This analysis was not undertaken to inform the actual cost of options, it was used only to allow a *comparison* between them, which was used for discussion purposes and confirmation of assumptions. Options for 250m and 360m long bridge and span arrangements from 14m to 24m were investigated.

Although the results of the analysis are not included in this Report, due to these being of a very 'high level' nature to inform the options comparison, the following indicators were found to agree with initial assumptions.

- The variation in cost was mostly affected by the cost of (additional) piers and variation in cost for changing the deck unit depths;
- The difference in price between the deck units used for 14m spans option and deck units for 24m spans option, was found to be similar for both bridge lengths. Therefore the cost of the deck units was not found to be sensitive to overall bridge length;
- For the 360m long bridge, the difference in price between deck units (of varying depth) was similar to difference in price for the piles (of varying number). Likewise for the 250m long bridge, the difference in price for the deck units was similar to difference in price between the piers (of varying number). In other words, for a longer bridge option the price penalty for having deeper deck units appeared to be well compensated by the savings achieved by minimising the number of piers, whereas this effect was less prominent for the shorter bridge; and
- Based on high level assumptions, the most economical span arrangement for the 360m long bridge was 22m, whereas for the 250m long bridge the most

economical span was 19m long. This is primarily due to the balance between numbers of piers that can be eliminated with each incremental increase in the span length. Therefore longer spans are likely to be more cost effective for longer bridge.

The high level cost comparison undertaken was based on supply costs only, and amongst other, savings from the associated construction programming was not included. However, it is assumed that the speed of construction, where there are less piers, will provide further associated cost savings, which further favours the longer span option recommended.

In conclusion, and from the high level cost comparison undertaken the longer spans were found to represent best value for money, particularly for the longer bridge span option.

4.2.5 Bridge Drainage Provisions

The bridge length influences drainage requirements and quantities. Several options were considered including; bridge with a flat longitudinal fall, two way cross-fall, and scuppers freely draining into the waterway. The latter was adopted as the best value for money solution. This option is compliant with the current EMP requirements, however it is expected that the compliance will need to be further confirmed during the detailed stage of the project.

Assumptions considered to be common for all options considered include;

- The flood velocities are generally very low and it is understood that the orientation of the piers will not have significant impact on hydraulic performance and afflux. Therefore all piers and abutment were assumed to be square with the deck.
- Vertical clearance above the ground level is generally low, approximately between 2.5m and 3.5m.
- Bridge proportions however may not be the predetermining factor in this case as there is little concern in regards to bridge aesthetics within the site surroundings due to a very low profile of the bridge.
- Prestressed concrete deck units are considered to be most economical form of superstructure at this bridge site, with adequate robustness in detailing, this will provide certainty of reliability with minimal maintenance intervention in long term. These are widely used for the main roads throughout Queensland and there is plenty of experience within TMR and local contractors to deliver this solution. The precast form will also allow faster construction, and with repetition in detail provide further cost benefits. At the onset this form of construction was preferred to other forms of precast construction (e.g. Teer-off Girders) by TMR NQ, primarily for whole life cost associated reasoning.

Typically the drainage system is designed to minimise the amount of water flowing across deck joints, and in such a way that all drainage structures are readily accessible for cleaning and maintenance purposes.

The following options were considered for Cattle Creek Bridge:

4.2.5.1 Drainage Option D1

D1 - Longitudinal free drained; this option is generally most desired as it requires minimal detailing and minimal long term maintenance as it does not require a separate drainage system or detailing on the structure.

However, due to the long bridge length, the minimum level difference between the two abutments was estimated in excess of 1200 depending on the bridge length and longitudinal fall, which could range between 3 and 5%. This was not preferred as the scheme required the bridge abutment levels to be as low as possible from hydraulic requirements. A crest in the middle of the bridge was dismissed for several reasons (e.g. to avoid a kink in the road, as well as for the safety reasons to avoid a high point on a structure during the flood event).

Therefore, this option was not taken for further considerations.

4.2.5.2 Drainage Option D2

D2 - Drainage structure including scuppers on either one side (i.e. one way fall) or both sides (i.e. two way cross fall) of the bridge.

The surface runoff could be freely discharged into the waterway as standard practice for long bridge structures in North Queensland. Alternatively the runoff is collected via drainage pipe system which is rarely utilised in the region.

TMR Guideline for Bridge Design Clause 4.12.1.b Cross-fall Gradient and Drainage specifies that bridge drainage over streams shall satisfy the requirements of the Environmental Management Plan (EMP). In general, TMR suggest, collection and treatment of drainage water is not required unless specified in the EMP. However where drainage pipes are required, they must be able to be cleaned effectively and placed between beams or behind an edge skirt to maintain clean lines on the bridge profile. Thus two options are being considered.

4.2.5.3 Drainage Option D2a

D2a - Drainage system preventing a direct discharge into waterways; this would require an adequate pipe size in conjunction with adequate longitudinal fall. It is expected that collection and treatment of the first flush only would be needed. This option would attract additional capital cost and additional long term maintenance cost, as well as require replacement of all removable parts 50 years after construction.

Therefore the recommendations were made for EMP to consider overall benefits versus value achieved by this option. Risks associated with potential scenario where the lack of available funds to maintain the drainage system would impact on its overall effectiveness should also be considered.

This option was not preferred from the cost and long term maintenance perspective.

4.2.5.4 Drainage Option D2b

D2b - Surface water discharged into the waterway via scuppers. This is a commonly adopted solution for new bridges in North Queensland. This is due to the lower traffic volumes compared to urban areas and associated lower levels of pollutants, combined with high rainfall levels which make it more costly to retain and filter the 'first flush' of surface water. It is generally considered to be a reliable solution in a long term. The scuppers will require regular maintenance and will be detailed to minimise risks of blockage. The scuppers can be detailed to minimise the risks of blockage and be adequately spaced for efficient drainage (although typically preferred at diaphragm beams). Such details are expected to be resolved at later stage of the project, after the completion of the Business Case.

This option is compliant with Environmental Management Plan in regards to waterway management strategy for Cattle Creek.

This is a preferred option from the cost and long term maintenance perspective.

Therefore Option D2b (Surface water discharged into the waterway via scuppers) is recommended as preferred, as confirmed as being a compliant option in the Environmental Management Plan.

4.2.6 Discussion

General benefits comparing 'long' and 'short' span lengths were considered during the options assessment as summarised Table 22 below:

Table 22 - Long and Short Span Length Comparison

Longer Spans		**Shorter Spans**	
***	Less number of deck units hence faster construction	*	Less weight in individual deck units, marginally easier handling during the construction
***	Reduced number of piers, hence faster construction and significant cost benefit	*	Potentially reduced reinforcement quantities in the piers, possibly shorter pile length
**	Reduced environmental footprint (less piles) and desirable mitigation for the maintenance associated with debris trap	*	Reduced carbon footprint in regards to overall concrete quantities in the deck girders
**	Reduced number of expansion/bridge joints, minimised capital cost and long term maintenance, improved ride-ability	*	Potentially smaller bearings (less vertical loads), furthermore, for transversely stressed decks and spans less than 21m bearings are not required at fixed ends
***	Reduced number of bridge elements, reduced long term maintenance	**	Shallower superstructure allows lower vertical road alignment (marginal), thus improves flexibility in road geometry, and marginally less visually intrusion
*	Larger embankments, where needed can use deeper culverts thus better from long term maintenance perspective	**	Marginally smaller embankments thus less capital cost
***** - assumed as significant contributing factor ** - assumed as moderate contributing factor * - assumed as low contributing factor**			

Indicative scores are shown to assess a potential contribution to the overall scheme however no weighing has been applied.

A high level cost benefit analysis indicates that there are economical disadvantages to increasing the span length with an increase in the total bridge length, which for 250m appears to be 19m, and for 360m appears to be 22m. The predominant advantage of the longer span is in reduction of number of construction elements (e.g. piers and deck units) and thus the impact it will have on the overall construction program as well as long term maintenance issues.

However, longer spans will push vertical alignment upwards, which in turn will have an impact on cost of approaches and possibly on hydraulic modelling. Therefore, based on hydraulic modelling iterations and the bridge length option which met all of the project objectives, a 437m long bridge with the road level at RL13.7m AHD, and 19 equal 23m long spans was recommended, as an outcome of the MCA process. However, further design refinement resulted in a 506m long bridge (as outlined in Section 6 of this Report). It is expected that this may be further rationalised and refined at the next phase of the project.

4.2.7 Cattle Creek Bridge - Record of Key Opportunities, Considerations, and Actions

Table 23 below serves as a record of key opportunities, design issues and associated design actions requiring further consideration during the detailed design stage of the project.

Table 23 - Cattle Creek Bridge Opportunities, Considerations and Actions

	Opportunity	Consideration	Action	Done
1	Investigation into drainage via scuppers directly discharged into waterway	1: Environmental impacts and compliance 2: Potential cost escalation if drainage structure confirmed at a later stage 3: Long term maintenance	1: Arup to investigate compliance requirements 2: TMR NQ to confirm preference and provide comments 3: Civil/Structures to follow up the outcomes 4: Civil/Drainage to confirm details, if needed	1: yes 2: yes 3: yes 4: n/a
2	Investigate impacts of having longer spans (than proposed by earlier studies)	1: The bridge alignment being increased in height may / will influence bridge approaches 2: The alignment being pushed upwards may have cost impact at the bridge approaches 3: Bridge will need to be designed for Q2000 which is yet to be understood although based on current information not expected to be an issues (e.g. levels and velocities)	1: Arup to investigate and confirm that the impact on bridge alignment at the approaches is minor for small changes 2: WBM to investigate the assumptions and sensitivity associated with impact of the levels at the approaches, and confirmed that the impact on hydraulic modelling is minor 3: Arup Geotech. to check/confirm no impact on piers 4: Arup Geotech. to check impact on embankments 5: Arup to investigate the high-level cost-value benefit between the ‘deeper’ deck unit vs. ‘longer’ span; 14m, 19m, and 24m	1: yes 2: yes 3: yes 4: yes 5: yes

	Opportunity	Consideration	Action	Done
3	Optimise vertical alignment	1: Certainty in regards to allowed freeboard tolerances 2: Impact on vertical road alignments at the embankments 3: Impact on afflux	1: TMR NQ to confirm agreement 2: Arup Civil to confirm minimal impact on overall scheme 3: WBM to confirm minimal impact on overall scheme	1: yes 2: yes 3: yes
4	Minimise number of expansion joints	EJ at every second span vs. EJ at every third span	1: Arup to consider if robust at this stage of the project 2: TMR NQ to confirm preference	1: yes 2: yes
5	Investigate transversely stressed Deck Unit option	1: TMR Bridge Branch concerns over long term durability for major roads 2: Ability to achieve necessary approvals	1: Arup to investigate and follow up with TMR bridge branch 2: TMR NQ to confirm preference	1: yes 2: yes
6	Confirm proposed preferred arrangement	Technical note and attachments	1: Arup disciplines to confirm agreement 2: TMR NQ to confirm the preferred GA	1: yes 2: yes

4.3 Frances Creek Bridge Optimisation (Sub-option)

Design optimisation for Frances Creek Bridge was primarily focused on:

4.3.1 Bridge skew

The existing Frances Creek Bridge is set on a horizontal alignment with a high 45 degree skew. High skew in bridges complicates detailing and has impact on efficiency of the bridge girders. The proposed new alignment is very similar to existing bridge, however, with a small improvement to geometry. A skew of 40 degrees has been recommended, however, it is expected that this will be further refined and optimised during the detailed design.

4.3.2 Optimum form of superstructure

This bridge is on a very high skew therefore precast prestressed deck units, with the in-situ topping slab, was adopted as the preferred option. Use of transverse stressing on bridges with such high skews is not permitted by TMR.

4.3.3 Optimum bridge length

The new Frances Creek Bridge will be constructed over a section of the Creek where the Creek width gradually decreases from one end to another. As observed at the soffit of the bridge structure, the width of the Creek on the upstream end is approximately 8m wider than that at the downstream end. The length of the new bridge was reviewed from both structural and hydraulic perspective, with the conclusion that the optimum bridge opening at this location approximately corresponds to that along the bridge control line (centreline of the bridge). A 40m long two span bridge was adopted to balance the required level of earthworks with the desired hydraulic performance. It is expected that this will be further refined and optimised during the detailed design stage of the project.

4.3.4 Optimum span length

Three principal span arrangements were considered, the preferred arrangement is to allow a single central pier in a two equal span arrangement, as shown in Table 24 (40m bridge length, point C).

4.3.5 Optimum bridge vertical alignment (height)

Bridge soffit is set by recommendations from BMT WBM Consultants hydraulic modelling and will be such that the soffit of the bridge will be same as the existing bridge, thus at the level of RL12.1mAHD. This level was confirmed to be above Q100 flood level.

4.3.6 Bridge drainage

The bridge has a flat longitudinal fall, two way cross-fall, and scuppers freely draining into the waterway were adopted as preferred option. This is compliant with the current EMP requirements, however it is expected that the compliance will need to be revisited and further investigated during the next phase of work. Alternatively further refinement in the next phase should consider free drainage to one end of the bridge by introducing minimal longitudinal fall, which would require minimal difference in the abutment levels due to a very short bridge length.

Details associated with each item above were considered through iterative process as summarised in the following Table 24:

Table 24 - Design Optimisation for Frances Creek Bridge

Bridge length	Span arrangement	General arrangement common for all scenarios
38m – minimum bridge length governed by the Creek opening at downstream end, requires minimal earthworks downstream, however potentially constricting the Creek at the upstream end	a. 3 No 12.5m long equal spans, as per original bridge; minimum superstructure depth with 625 DU; however potential issues regarding debris trap due to constricted span length b. 2 No 9m long back spans and one 20m long central span; optimum superstructure depth and 825 DU; however with two piers in the Creek which is both costly and less desired from hydraulic perspective c. 2 No 19m long equal spans, with optimum superstructure depth and 800 DU; central pier not considered less beneficial over option b from either environmental or hydraulic perspective due to nature of the Creek and low Creek velocities	a. Bridge soffit to be at or above the existing bridge of RL12.1mAHD, hence maximum road level at 13.515mAHD is recommended for all options b. Bridge abutments and piers to remain parallel rather than changing the deck unit length from one side of the bridge to another. This will maintain repetition in detail to minimise the cost. c. Bridge skew to be minimised, 40 degrees skew recommended which is an improvement from the existing bridge by 5 degrees. d. Assume expansion joints at each abutment, however expect this to be reviewed in the next phase of works and potentially eliminate (or reduce to one) expansion joints. e. Bridge drainage via scuppers and two-way cross fall preferred to other more costly alternatives. It is however expected that further refinement in the next phase would consider free drainage to one end of the bridge by introducing minimal longitudinal fall.
40m – optimum bridge length, governed by the Creek opening along the control line: PREFERRED SUB-OPTION	a. 3 No 13.5m long equal spans, as per original bridge; minimum superstructure depth with 625 DU; however potential issues regarding debris trap due to constricted span length b. 2 No 10m long back spans and one 20m long central span; optimum superstructure depth and 825 DU; however with two piers in the Creek which is both costly and less desired from hydraulic perspective c. 2 No 20m long equal spans, with optimum superstructure depth and 825 DU; central pier considered more beneficial in comparison to option b, from both an environmental and hydraulic perspective due to nature of the Creek and the associated low velocities: PREFERRED SUB-OPTION	
46m – similar to existing bridge length, governed by the Creek opening at upstream end, would require substantial earthworks and Creek widening downstream	a. 3 No 15m long equal spans, as per original bridge; minimum superstructure depth with 675 DU; however potential issues regarding debris trap due to constricted span length b. 2 No 13m long back spans and one 20m long central span; optimum superstructure depth and 625 DU; however with two piers in the Creek which is both costly and less desired from hydraulic perspective c. 2 No 23m long equal spans, with biggest superstructure depth and 925 DU; central pier not considered less beneficial over option b from either environmental or hydraulic perspective due to nature of the Creek and low Creek velocities	

4.4 Increased Level of Flood Immunity for New Cattle Creek Bridge (enhanced from Q50 to Q100)

The NB2 design proposal provided a bridge immunity of Q50. Following flood modelling during the Business Case stage it was found that afflux levels at Toobanna were greater than 10mm. At the NB2 option development stage, TMR had assumed that reducing the project scope by 400m (not raising the road between Pomona Road and Trebonne Creek Bridge) would be sufficient to reduce afflux at Toobanna. However, because it is a floodplain at this location, not localised flooding, hydraulic investigations for the Business Case development stage revealed that this scope change alone could not achieve the desired reduction in afflux. As a result, additional flow area was required across the alignment to reduce afflux. This could be provided by lowering the road and/or raising the bridge. The latter has the beneficial effect of all the area under the bridge being available for water passage and the former allows increased flow area over the road. Lowering the road, however, reduces the depth of embankment and, as such, the height of culverts that can be used. A longer length of culverts is then required to provide the same flow area.

The above outlines the delicate balance between afflux, road immunity, road height, bridge height and culvert height. Following various iterations, the flood modelling determined that in order to achieve the afflux criteria the soffit of the bridge would need to be raised to the Q100 level.

Increasing the height of the bridge only affects the length of the piles and the height of approach embankments. These increases represent a small proportion of the total bridge costs and as such represents good value for money for the additional flow area provided. This solution also has the added benefit of increasing the flood immunity of the bridge, which corresponds to the associated bridge design life of 100 years.

4.5 Intersection Treatments Upgraded

The turn treatment assessment detailed in the Traffic & Transport Report in Appendix G, showed that several intersections may require improvements to turn treatments as noted below:

- Bruce Highway / Pennas Road: Basic left turn (BAL) treatment required from the south, basic right turn (BAR) treatment required from the north;
- Bruce Highway / Pombel Road: Basic left turn (BAL) treatment required from the north, basic right turn (BAR) treatment required from south;
- Bruce Highway / Frances Creek Rest Area (south): Basic left turn (BAL) treatment required from the south (check currently provided turn lane width and length to ensure it conforms to the GtRD Part 4A) as existing;
- Bruce Highway / Frances Creek Rest Area (north): Shortened channelised right turn CHR(S) recommended from the north (check currently provided turn lane width and length to ensure it conforms to the GtRD Part 4A); and
- Bruce Highway / Haughty’s Road: Basic left turn (BAL) treatment required from the north, basic right turn (BAR) treatment required from the south

(check currently provided turn lane width and length to ensure it conforms to the GtRD Part 4A), which is currently a CHR.

The existing CHR/CHR(s) are to be maintained and TMR have noted a preference to upgrade all intersections to CHR(s) as a minimum, for safety reasons and to align with the emphasis in the National Road Safety Strategy, (critical design consideration of reducing the potential for serious casualty crashes at rural intersections). As such, CHR(s) with additional AUL(s) left turn provision are preferred for all intersections within the study area. The design layout has not been revised but there is an associated financial provision being included in the P90 estimate. There are no associated issues envisaged of concern with regards modifying the design layout as part of a future detailed design stage.

The Pomona Road / Pinnacle Hill Road is located at the northern boundary of the project extents. This intersection is proposed to be upgraded in 2014/15 to a channelised right turn treatment as a planning condition of the nearby North Queensland Bio-Energy development. The future detailed design of this project will need to consider tie in points with the upgraded intersection layout.

4.6 Pavement Treatments

The following pavement options were considered, to meet the Project Service Requirements:

i. Concrete – Preferred for flood resilience, however has a high initial capital cost but longer design life and is considered not to represent a value for money solution;

ii. Asphalt overlay – A large section of the existing pavement consists of asphalt pavements over granular pavement, therefore the majority of the existing asphaltic concrete would likely be fatigued by the time construction is likely to occur, and would need to be removed prior to reconstruction. An asphalt pavement is recognised as only having an approximate 10-12 year design life and therefore would require replacing quicker in comparison to the other options considered, and thus is not deemed to be cost effective in comparison;

iii. In-situ Cement Modified Pavements – Provides good flood resilience and is suitable to maximise re-use of existing pavement; and

iv. Plant Mix Cement Modified Pavements – Provides good flood resilience and is considered appropriate for use on projects where new pavement is required.

Arup recommended a combination of the two cement options: in-situ cement modified pavement, where possible, to maximise re-use of existing pavements, and plant mix for where overlay depth allowed placement of 300m new plant mix material. All of the options were discussed with TMR, and ultimately for flood resilience and to tie in with adjacent pavement and typical local construction, plant mix cement modified pavement was chosen.

4.7 Alternative Levee Options

Two alternative levee options were briefly considered for the project. Following an initial high level summary, TMR confirmed that this type of alternative design solution was not preferred due to likely negative stakeholder / public perceptions with regards their general effectiveness and also due to the direct contradiction of the River Trust and Council's long term program of minimising / eliminating the construction of new levees. For these reasons TMR instructed that no further assessment work should be undertaken with regards developing these alternative options.

4.8 Highway Alignment Optioneering (Approx. Ch. 112,000m)

The proximity of a residential property constrains the possible alignment options available for this specific location of the project site, however, not to the extent that suitable alternatives are not achievable. The existing house is not affected in the final design options. The location of existing Ergon poles however, did warrant the investigation, of a partial resumption in this area of the site, to provide the necessary clear zone for associated safety reasons. At approximately chainage 111,800m to 112,200m, the new northern alignment connects to the existing southern alignment immediately north of the Frances Creek Bridge. The new curve takes the alignment closer to the existing road reserve boundary and Ergon overhead power lines to the East. At this location there is an existing residential property (L5 SP130991) and an area of farmland. TMR have instructed that ideally no residential property is to be resumed as part of the project.

Arup developed five options at this section that required various partial resumption of the farmland and relocation of Ergon Assets, with associated benefits and drawbacks. All options avoided any property resumption requirements. A summary of each option is outlined below:

- 1(i) – Introduce reverse curve onto bridge to reduce resumptions. Relocate existing Ergon poles, 450 sq. m partial resumption;
- 1(ii) – Maintain existing straights and fit single curve between. Relocate existing Ergon poles, 750 sq. m partial resumption;
- 1(iii) – As Option 1(ii) but more generous geometry. Relocate Ergon poles, 850 sq. m partial resumption;
- 1(iv) – Same road geometry as Option 1(i) but with a protective barrier. No Ergon pole relocation and no resumption required; and
- 1(v) - Minor widening on west side to improve geometry. Depending on extent, possibility of no Ergon pole relocations or resumptions.

Option 1(iii) and (v) are the preferred options due to associated constructability and safety implications and to achieve good geometrical design practice (safer solution), and so a hybrid option of the two has been selected as the preferred solution. A partial resumption of 900 sq. m of the adjacent unfarmed farmland is required at a cost of approximately $32,000 and the relocation of existing Ergon assets in this immediate area are also required. A 1 in 6 batter slope will be required through this location, to reduce associated clear zone requirements.

Reference drawing numbers CI-PP-1005, CI-PP-2005, CI-UT-1003 and CI-XS-1009/1010 in Appendix V for details.

For further details associated with the alignment options developed please reference the Constrained Alignment Options Technical Note in Appendix R of this Report.

4.9 Enhanced Cross-Drainage Provisions

4.9.1.1 Northern Section

As a secondary benefit arising from the primary objectives of increasing the waterway area to reduce the extent and frequency of flooding closures and to reduce afflux, an extended 253m long bridge with culverts and a 437m long bridge, both with soffit level at Q100 were considered. The improved cross-drainage will allow for enhanced cross-drainage provisions across the Cattle Creek wetland. The only variance between the options is the footprint they require. Installing a series of culverts with scour protection introduces a larger artificial element. An extended bridge introduces a series of piles that require a smaller footprint while maintaining the existing ground surface. This reduced disturbance is considered more favourable environmentally.

Both options also have the potential for associated fauna passage benefits. An extended bridge will allow increased distance for terrestrial fauna movement opportunities under the bridge in natural conditions. The shorter bridge and culverts option will present a much larger distance for under road fauna passage, although this will be constricted in height and width.

The secondary benefits outlined above will also apply to the 506m bridge, which is the recommended Business Case option (following post-MCA design optimisation).

4.9.1.2 Southern Section

The additional culverts included in the southern section (in proximity to Pennas Road intersection) will also enhance cross drainage provisions to directly address the corresponding drainage/hydrology related Project Service Requirements. Upon availability of more detailed survey, proposed culvert locations and sizes may be further optimised and additional table drain infrastructure can be incorporated. Appropriate allocation has been provided in the planned risk for the P90 cost estimate to allow for this future design optimisation.

4.10 Minimised PUP Impacts / Relocations

The alignment was positioned to minimise PUP impacts and associated relocation wherever possible. There is a short section of Ergon at the start of the southern section and a similar section at the northern extents that are currently within the clear zone and require relocation despite maintaining the existing alignment. A section of Ergon at the interface of the two sections requires relocation to suit the revised alignment. These would require to be relocated or protected, in the existing situation if current standards were to be met. Details of options considered to minimise the later relocation are discussed in the Constrained Alignment Options Technical Note in Appendix R of this Report.

Following discussions with Telstra it was confirmed that no existing fibre optic cables are located within the existing road reserve. Telstra did confirm however that existing copper cables of varying sizes will require relocation to suit the new proposed bridge arrangements. Telstra have not provided an estimate for these relocations and, however in discussion with Telstra a cost provision of $650k for full replacement of the existing cables for the full length of the project has been included in the P90 cost estimate.

For further details associated with PUP relocations, reference the PUP relocation drawings in Appendix U.

4.11 Early Consideration of Constructability Issues

During the course of the Business Case design Arup has considered how the project will be constructed and has developed a sequencing strategy to allow a safe and cost effective construction process. A combination of off-line new road/bridge and online rehabilitated/widened road has been adopted as discussed in Section 2.18.

The early consideration of how the project will be built and what temporary works will be required, highlights where major hazards exists and allows these to be designed out or mitigated against and minimises the likelihood of unforeseen issues during construction.

A Safety in Design Register (Appendix D) was updated through the design phase capturing where these issues have been identified and what steps have been taken to remove or reduce the hazards. The residual risks associated with the construction sequencing have been considered and included within the P90.

4.12 Summary

Various different design opportunities have been identified, investigated and assessed to ensure only efficient and cost effective design solutions were adopted in the Recommended Business Case Option. The assessment undertaken was based on a range of criteria including performance, constructability, environmental, maintenance, risk and cost considerations. As a result it is deemed that only minimal design refinement will be required during the detailed design phase, and the Business Case therefore has a corresponding high level of associated cost certainty.

As a direct result of the revised project strategy adopted by the Project Team and the value for money cost saving opportunities which were identified, assessed and subsequently developed, this has resulted in the P90 estimate for both the Preferred Option (approx. $77m) and Sub-Option (approx. $84m) being significantly less than the approved project budget of $105m (2012 prices excluding escalation). This then enabled a proportion of this saving (approx. $4m) then being reinvested back into the project to further refine the preferred option and improve the level of flood immunity achieved by the project in the vicinity of Cattle Creek Bridge and associated approach roads. This design refinement is further discussed in Section 6 of this Report.

Further design optimisation will be possible at detailed design, particularly in regard to culvert locations and sizes in the southern section. During the next phase of the project it is recommended that a detailed topographic survey be undertaken to further refine the preferred option design solution and to check the accuracy of the existing survey data used to inform the Business Case development stage.

5 Multi-Criteria Assessment (MCA)

5.1 Introduction

Following the completion of the comparative technical analysis of all options, a multi-criteria assessment process was undertaken, to ultimately identify the best value for money option which met all the Project Service Requirements.

The criteria upon which the options were assessed fell into the two distinct categories relating to project service and cost requirements, to ensure the most appropriate option was chosen which would ultimately best deliver against the desired project outcomes.

A well-defined and concise weighting and scoring system was jointly developed and agreed between TMR and Arup prior to the MCA workshop which focused on ensuring that there was no 'gold plating' of project outcomes and that the subjectivity of scoring was reduced as much as possible. The following sections of this chapter highlight the MCA process the project team jointly completed.

5.2 MCA Scope and Process

The scope of the MCA process was to assess the concept design opportunities initially identified, investigated and discussed during the earlier stages of the Business Case development process and to then assess the agreed design options (as referenced in the Project Brief) which included the Preferred NB2 Option and the SASR Sub-option.

The first part of the workshop was held to conduct a "mini" multi-criteria assessment (mini-MCAs) on five specific key design elements of the Cattle & Frances Creeks Upgrade Project. TMR requested that an initial "mini" MCA process be carried out on five key design components with the aim to review and document the decision making process completed to date, in a transparent way while avoiding the risk of over-expenditure on these initial assessments. The "mini" MCA process used the same criteria as the full MCA process, with the exception of costs, for which a high level quantitative based assessment of costs was used, which was in line with the key P90 cost estimate components.

The five 'mini'-MCAs documented design decisions that had previously been made and included:

Northern Section

i. Mini-MCA: Cattle Creek Bridge – Hydraulic performance optimisation;

ii. Mini-MCA: Road alignment selection; and

iii. Mini-MCA: Cattle Creek Bridge deck construction.

Southern Section

iv. Mini-MCA: Frances Creek Bridge deck construction; and

v. Mini-MCA: Frances Creek Bridge alignment.

The whole of design full MCA was also completed during the workshop, which included:

i. Do Nothing scenario (Base Case);

ii. Preferred NB2 Option; and

iii. SASR Sub-Option (As for the Preferred Option but including New Frances Creek Bridge Off-line).

Each option was scored between 0 and 3 against the following, project service requirement criteria:

i. Achieve Vision Standards (TOC & AATOC);

ii. Acceptable level of certainty regarding flood immunity improvements;

iii. Construction affordability & appropriateness;

iv. Safety;

v. P90 total project cost / value for money;

vi. Social impacts (afflux, changes to flow patterns, time of inundation, resumptions);

vii. Environmental and/or cultural heritage impacts;

viii. Risks, and;

ix. "Fit for purpose" solution (with regards to durability, resilience & maintenance).

The criteria and weightings are included in the attached MCA template (See Appendix M for further details).

5.3 MCA Workshop

The multi-criteria analysis workshop was held on 29 October 2013 at Arup's office in Townsville. Workshop attendees included:

Table 25 - MCA Workshop Attendees

Name	Position	Organisation
Tony How Lum	Project Manager	TMR
Lindel Ryan	Assistant Project Manager	TMR
Ben Cotton*	Senior Environmental Officer	TMR
Nicole Smart	Graduate Engineer	TMR
Lee Hudson	Project Manager	Arup
Donald Ewen	Civil Lead	Arup
Rachel Brazier*	Environmental Lead	Arup
Tim Procter	Risk Lead & Facilitator	Arup

* Only included in environmental/cultural heritage impacts portion of the MCA scoring process

The MCA process focussed on revisiting and validating the rationale of the specified design decisions. The process included an initial pass/fail assessment for design decision options where appropriate. This allowed the workshop group to save time by allowing clearly unsuitable decision options to be eliminated from the MCA without undergoing the scoring process.

The scoring process addressed each criterion, with pre-decided weightings applied to determine the best option. Each pass/fail and score for each option had comments recorded to document the workshop group's rationale.

The five mini-MCAs and the full MCA were discussed in the workshop. They are listed and described as follows:

5.4 Mini MCA Key Components

5.4.1 Northern Section

Mini MCA: Cattle Creek Hydraulic Performance Optimisation

Review of the design decision taken associated with the proposed bridge structure arrangement at Cattle Creek, aimed at achieving an optimal design solution which provides a fully Project Service Requirement compliant level of hydraulic performance, as well deemed to represent a good value for money outcome. Five options were assessed in total which were a combination of differing new bridge span arrangements, a mix of bridge and culverts and an alternative levee option arrangement.

The results of this assessment are detailed in Section 5.6 and shown in Table 26.

For further details associated with this assessment please refer to the Bridges vs. Culvert Technical Note in Appendix P of this report.

Mini MCA: Road Alignment Options

Review of the design decision taken associated with various highway alignment options proposed at approximate Ch. 111,750m – 112,000m, aimed at achieving a safe design layout with reduced associated social impacts (land resumptions). Four options were assessed in total which were a combination of differing curve radii used for the proposed alignment.

The results of this assessment are detailed in Section 5.6 and shown in Table 27.

For further details associated with this assessment please refer to the Constrained Alignment Options Technical Note in Appendix R of this report.

Mini MCA: Cattle Bridge Deck Construction

Review of the design decision taken associated with the bridge deck construction proposed for Cattle Creek Bridge, to meet Project Service Requirements, with specific regard to capital cost, resilience, maintenance and whole of life cost considerations.

The results of this assessment are detailed in Section 5.6 and shown in Table 28.

For further details associated with this assessment please refer to Section 2.13 of this report.

5.4.2 Southern Section

Mini MCA: Frances Creek Bridge Deck Construction

Review of the design decision taken associated with the bridge deck construction proposed for Frances Creek Bridge, to meet Project Service Requirements, with specific regard to capital cost, resilience, maintenance and whole of life cost considerations.

The results of this assessment are detailed in Section 5.6 and shown in Table 29.

For further details associated with this assessment please refer to Section 2.13 of this report.

Mini MCA: Frances Creek Bridge Alignment Options

Review of the design decision taken to compare off-line versus on-line bridge alignments aimed at achieving an optimal layout with specific regard to assessing capital cost, risk and key constructability issues.

The results of this assessment are detailed in Section 5.6 and shown in Table 30.

For further details associated with this assessment please refer to Section 2.13 of this report.

5.5 Full MCA: Whole of Design Options

The whole of design MCA considered three options/scenarios:

i. Base case (maintain existing road and bridges);

ii. Preferred NB2 Option (Cattle Creek Bridge and retain existing Frances Creek Bridge); and

iii. SASR Sub-Option (As preferred option but including new off-line Frances Creek Bridge)

5.6 MCA Outcomes

Summaries of the results of each mini-MCA are provided below. The tables show only the weighted total scores. The full MCA tables and scoring justifications can be referenced in Appendix M of this Report.

5.6.1 Mini MCA Design Component Options

The preferred options are highlighted in green.

5.6.1.1 Northern Section

Table 26 - Cattle Creek Hydraulics (weighted score)

	250m bridge + culverts (weighted)	350m bridge (weighted)	437m bridge (weighted)	New levee option (Toobanna) (weighted)	New levee option (southern section) (weighted)
Total out of a possible 30	17	17.5	19.5	17.5	14

The 437m bridge option ranked first in comparison with the other options and was preferred due to the following key reasons:

- Simpler and quicker form of construction in comparison to 250m bridge + culverts option;
- Reduced capital costs in comparison to 250m bridge + culverts option;
- Easier to maintain (maintenance access, removal of blockages & continuity of maintenance regime) in comparison to 250m bridge + culverts option; and
- The 350m bridge & new levee options were discounted as they did not achieve all Project Service Requirements in terms of hydraulic performance and flood immunity certainty requirements.

Table 27 - Road Alignment Options (weighted score)

	Alignment 1i (weighted)	Alignment 1ii (weighted)	Alignment 1iii (weighted)	Alignment 1iv (weighted)
Total out of a possible 30	19	18.5	20	18.5

The alignment option 1iii ranked first in comparison with the other options and was preferred due to the following reasons:

- More cost effective from a construction affordability perspective due to greater length of on-line road construction; and
- Marginal safety benefits in comparison with the other options – more forgiving horizontal alignment.

Table 28 - Cattle Creek Bridge Deck Construction (weighted score)

	Transverse stressed (weighted)	Topping slab (weighted)
Total out of a possible 30	20	18.5

The transverse stressed option ranked first overall in comparison with the alternative topping slab option and was preferred due to the following reasons:

- Minimal difference noted between the two bridge deck construction options, however the topping slab, including waterproof membrane, is deemed to represent better value for money due to an overall reduced deck construction thickness. Overall the transversely stressed construction is preferred.

5.6.1.2 Northern Section

Table 29 - Frances Creek Bridge Deck Construction (weighted score)

	Transverse stressed (weighted)	Topping slab (weighted)
Total out of a possible 30	19	18.5

The transverse stressed option ranked first in comparison with the alternative topping slab option and was preferred due to the following reasons:

- The transverse stressed deck construction option is deemed to represent better value for money, but the skew angle at Frances Creek makes the transverse stressed design option impracticable, therefore the topping slab option is preferred.

Table 30 - Frances Creek Bridge Alignment Options (weighted score)

	On-line bridge alignment (weighted)	Off-line bridge alignment (weighted)
Total out of a possible 30	20	18.5

The on-line bridge alignment option ranked first in comparison with the alternative option and was preferred due to the following reasons:

- Minimal difference noted between the two bridge alignment options, however associated risks were deemed significantly different, due to the on-line solution having a longer associated construction period and therefore has a greater corresponding potential risk exposure; and
- The risk of new construction therefore not being complete by the end of the wet season for on-line bridge construction, results in an unacceptable potential risk of an extended break in Bruce Highway being potentially experienced. As such, the off-line bridge alignment option is preferred.

5.6.1.3 Full MCA Whole of Life Design Options

Table 31 - Whole of Design MCA (weighted score)

	Base Case (weighted)	Preferred Option (weighted)	Sub-option – New Frances Creek Bridge Off-line (weighted)
Total out of a possible 30	13.5	21	18.5

The preferred NB2 option ranked first in comparison with the base case and SASR sub-option and was preferred due to the following reasons:

- The base case option was discounted as it did not achieve the Vision Standard or Project Service Requirements, specifically with regards to the existing level of flood immunity provided;

- The preferred NB2 option requires less new infrastructure than the SASR sub-option to achieve the Vision Standard and Project Service Requirements and, as such, is deemed to represent a better value for money outcome; and

- The construction footprint of the sub-option in comparison to the preferred option is bigger and as a consequence has a larger environmental impact on the existing environmentally sensitive Frances Creek area. This increases the associated risk profile of this sub-option.

5.7 Preferred MCA Option

As a result of the MCA process followed, a single option has been identified for recommendation in the Business Case. This option is the 'preferred MCA option' and is described as follows:

Southern Section (Pennas Road to Frances Creek)

- Minor on-line re-grading of existing Bruce Highway alignment;
- Minor cross drainage improvements;
- PUP relocation works of associated with existing Telstra & Ergon assets:
- Minor upgrading of intersections with local rural roads (Pennas Road, Pombel Road & Haughty's Road);
- Reinstatement of the entrance and exit to the Frances Creek Rest Area; and
- Compliant seal width, in line with BHAP Vision Standards including new wide centre line treatment (WCLT) except on existing Frances Creek bridge, with audio tactile line marking (ATLM) if feasible.

Northern Section (Frances Creek to Toobanna)

- Replacement of existing Cattle Creek bridge with a wider, longer, higher-level bridge to provide Q100 flood immunity;
- Major realignment of existing Bruce Highway off-line, to run adjacent to the existing highway;
- Minor upgrading of cross drainage provisions;
- PUP relocation works of associated with existing Telstra & Ergon assets:
- Minor upgrading of intersections with local rural roads (Pomona Road / Pinnacle Hill Road); and
- Minor partial resumption of 900m² (Ch. 111,750m – 112,000m)
- Fit-for-purpose seal width, in line with BHAP Vision Standards including new wide centre line treatment (WCLT), with audio tactile line marking (ATLM) if feasible.

5.8 Cost of Preferred MCA Option

A risk adjusted P90 cost estimate has been prepared by Aquenta Consulting Pty Ltd in liaison with TMR and Arup for the preferred MCA option and is included in Appendix K for information. The scope, cost and risk provisions associated with this estimate have been jointly agreed and have been independently verified by TMR Project Manager (Tony How Lum), TMR Risk Manager (Tony Arden) and TMR Assistant Director – Delivery Risk (Ian Gray).

This risk adjusted P90 cost estimate indicates that the preferred MCA option can be delivered for a cost of $74,330,341m (2012 prices, excluding escalation), which is well within the budget constraint of $105m (2012 prices, excluding escalation) as required by TMR. The project is therefore deemed to be affordable for delivery, subject to approval by IIC to pass through Gate 3 and feedback from Treasury.

With regards the risks associated with this option, following a detailed 3 stage approach to risk identification, qualification and quantification, a comprehensive risk register was compiled by the project team and identified 31 risks all of which have been quantified and are included in the associated P90 cost estimate. A summary of the key high rated risks which have the potential to be encountered includes the following:

i. Funding issues;

ii. Resumptions required to meet afflux criteria;

iii. Community / public / industry opposition;

iv. Low benefit cost ratio (BCR);

v. Changing standards / requirements / policies (including physical constraints);

vi. Change to scope – revised design fails to deliver acceptable standard of performance on completion;

vii. High tender prices;

viii. Safety incident / near miss;

ix. Environmental incident;

x. Underestimation of weather impacts and associated flooding impacts during construction;

xi. Upstream or downstream changes to flooding characteristics;

xii. Stakeholder dissatisfaction with project outcomes with regards TOC and AATOC; and

xiii. Premature pavement failure.

For specific details of these risks associated with the preferred option (and sub-option) please refer to the Risk Report included in Appendix L of this Report. For a detailed breakdown of all project related costs, please refer to the P90 Cost Report included in Appendix K of this Report.

5.9 Summary

In summary, the multi-criteria process adopted by the team, to aid the assessment of the short-listed options, is clearly demonstrated to fully align with the Project Service Requirements, reduce the subjectivity of scoring options, transparently record the associated decision making process and provides suitable justification as to why the preferred option has been chosen in comparison to the other options considered in the mini MCA and full MCA processes.

Furthermore the process has also clearly highlights and records several of the key design decisions taken by the team, the rigour with which these decisions have been validated and also clearly demonstrates the areas of the project where an increased value for money outcome has been achieved.

The preferred MCA option has been shown to achieve the various Project Service Requirements, scores well in comparison to other options considered and can also be delivered well within the critically important project budget constraints of $105m (2012 prices, excluding escalation).

6 Preferred MCA Option Design Refinement

6.1 Design Refinement Reasoning

Following the completion of the multi criteria analysis process, a preferred MCA option was confirmed which achieved all the desired Project Service Requirements and specifically the 48/10 flood immunity criteria and associated afflux requirements. The P90 cost estimate was then subsequently finalised, which confirmed that the cost of the preferred option chosen was approximately $27m (25%) lower than the approved $105m scheme budget.

Upon reflection, the hydraulic assessment results were revisited which confirmed that the level of improved flood immunity the project would ultimately deliver would only improve the existing level of flood immunity from Q1 - Q2 to Q5. The key objective of the project was to reduce the level of disruption caused by flooding closures, according to Vision Standards in the BHAP (48 hours TOC; 10 hour AATOC). However, as a complement goal, TMR generally also attempts to improve the existing level of flood immunity. A decision was therefore taken by TMR at this point to reinvest part of this potential saving back into the project (circa. $5m), to achieve an increased level of flood immunity, in addition to achieving Vision Standard requirements. This additional design refinement would still ensure the project remained affordable, but the associated project benefits would be further enhanced and were deemed to be a worthy investment to contribute to improving the overall link standard of flood immunity and to be more consistent with the adjoining sections.

6.2 Extent of Design Refinement

The extent of the design refinement undertaken included adding a further three additional spans to the proposed Cattle Creek Bridge (two additional spans on the northern side of Cattle Creek and one additional span to the south) and increasing the level of the proposed approach carriageways (on both the northern and southern approaches) by 80mm over a total distance of approximately 1km.

The extent of the design refinement identified above followed a process of analysing 3 separate design refinement options, which included:

i. Three additional bridge spans to the north of Cattle Creek and increasing the RL on the southern bridge approach by 50mm (11.40m RL) and by 50mm (11.39m RL) on the northern approach;

ii. Two additional bridge spans to the north of Cattle Creek and one additional span to the south and increasing the RL on the southern bridge approach by 100mm (11.45m RL) and by 100mm (11.44m RL) on the northern approach; and

iii. Two additional bridge spans to the north of Cattle Creek and one additional span to the south and increasing the RL on the southern bridge approach by 80mm (11.43m RL) and by 80mm (11.42m RL) on the northern approach.

Following the assessment of the above options, refinement option iii above, was ultimately adopted as the refined preferred option, because in comparison to the other options, its hydraulic performance was superior, providing an increased level of flood immunity from Q5 (preferred option) up to Q8-17 and still achieved all other corresponding Project Service Requirement criteria.

For further details of the assessment work undertaken, please refer to the Hydraulic Assessment Report included in Appendix E of this report.

6.3 Further High Level Technical Assessment

Following the completion of the preferred MCA option concept design refinement process, a high level technical assessment was undertaken which covered the core design elements of the project. The following sub sections highlight the key findings of the technical assessment process completed.

6.3.1 Hydraulic Analysis

With the primary reason behind the change being aimed at achieving a further improved level of hydraulic performance and flood immunity there are no associated concerns or issues with the design refinement which has been completed. As the original flood model has been used to complete this design refinement exercise and due to the previous validation of this model, the same high degree of flood immunity certainty exists with regards the accuracy and confidence associated with the refined preferred option design proposal.

The revised outcome achieved an increased level of flood immunity in the range of Q8 – Q17 which is an improvement on the previously identified level of flood immunity of Q5, associated with the preferred MCA option. With regards associated afflux impacts, these are unchanged and remain within the previously identified constraints.

The Base Case has a flood immunity of Q1-Q2, so achieving Q5 was a worthwhile but still relatively minor improvement. In general, TMR aims to achieve Q20 trafficability, if it is deemed to provide a worthwhile and affordable benefits.

For further related findings of this additional hydraulic analysis completed, please refer to Appendix E of this Report for further details.

6.3.2 Civil Assessment

From a general civil perspective this design refinement change is deemed minor in nature and will result in a slight change to the proposed pavement treatment extents (noting the same pavement treatments still apply). The height of the proposed highway approach embankments to Cattle Creek will increase slightly by 80mm and so the associated embankment footprint will marginally increase.

The associated change in pavement and embankment quantities has been calculated and has been used in the preparation of a revised P90 cost estimate.

With regards constructability, again given the relatively minor change in the refined design proposal there are no associated concerns with regards the future construction of this refined preferred option.

6.3.3 Structures Considerations

From a bridge design and construction perspective this design refinement is not considered a major change and does not impact on the previously preferred form of construction or optimal span length for the proposed Cattle Creek Bridge. The total bridge span will increase in length from 437m, by an additional 69m, to 506m. One additional span will be added to the southern side of the Cattle Creek and two additional spans to the northern side of the creek. The original abutment locations will change but the same size design is assumed appropriate given the relatively consistent ground conditions observed in the area.

The associated change in bridge sub-structure and super-structure quantities has been calculated and has been used in the preparation of a revised P90 cost estimate. Other minor associated changes included:

i. Overlap of new abutment construction with existing embankment – therefore associated temporary works allowance has been included; and

ii. The existing Cattle Creek channel runs parallel to new bridge structure (western side); therefore a longer length of embankment protection has also been included.

6.3.4 Environmental Impact

Given the marginal increase in height (80mm) of the proposed approach embankments on either side of Cattle Creek the associated project 'footprint' has increased slightly in size. Such a small increase is deemed to be minimal and so in comparison to the preferred option there is no real difference in terms of environmental impact of the project on the existing area or associated risk.

It is also noted that, given the three additional bridge spans proposed are located outside the immediate area of the Cattle Creek Wetland (outer edge of the wetland area), the associated slight increase in project 'footprint' is of a lesser concern.

For further related comments / observations relating to this design refinement exercise, please refer to Appendix F of this Report for further details.

6.4 Revised P90 Cost Estimate

A risk adjusted revised P90 cost estimate has been prepared by Aquenta Consulting Pty Ltd in liaison with TMR and Arup for the refined preferred MCA option and is included in Appendix K for information. The scope, cost and risk provisions associated with this revised estimate have been jointly agreed and have been independently verified by TMR Project Manager (Tony How Lum) and TMR Assistant Director – Delivery Risk (Ian Gray).

This risk adjusted revised P90 cost estimate indicates that the refined preferred option can be delivered for a cost of $79,752,801m (2012 prices, excluding escalation), which remains well within the budget constraint of $105m (2012 prices, excluding escalation) as required by TMR. The project is therefore still deemed to be affordable for delivery, subject to associated funding being approved by IIC.

With regards the risks associated with the refined preferred option, following a high level assessment of the increased risk potential, no new risks have been identified associated with this refined preferred MCA option.

For specific details of these risks associated with the preferred option (and sub-option) please refer to the Risk Report included in Appendix L of this Report. For a detailed breakdown of all project related costs, please refer to the P90 Cost Report included in Appendix K of this Report.

6.5 Summary

In summary, as a result of this additional design refinement of the preferred MCA option, an increased level of flood immunity has been achieved (in the order of Q8 - Q17), which is an improvement on the previously identified level of flood immunity of Q5, associated with the preferred MCA option and a significant improvement on the Base Case immunity of Q1-Q2. This increase in the level of flood immunity provided has led to further improved projects benefits being achieved, which include increased flood immunity, further improved section and link connectivity / reliability and wider associated social and economic benefits. No additional risks have been identified as a consequence of this relatively minimal design change.

7 Recommendation

7.1 Summary of Technical Analysis & Options Assessment

The conclusion of this Report has found that from TMR's NB2 submission, the preferred NB2 option, as refined through the Business Case development process, is ranked first in comparison with the sub-option, as discussed in Section 5 of this Report and due to the main reasons as summarised below:

i. Fully achieves all the Project Service Requirements, without compromise;

ii. Meets the $105m (excluding escalation) budget constraint and is therefore deemed to be affordable;

iii. Requires less new infrastructure (in comparison with the sub-option) to achieve the same level of required flood immunity, certainty & connectivity and is therefore deemed to represent a better value for money solution; and

iv. In comparison to the sub-option, has a reduced construction 'footprint' and construction program duration, which ultimately means it has less associated project delivery risk and social/environmental impact.

In summary, the preferred option is feasible, fully compliant with current design standards and makes better use of the existing Frances Creek bridge asset. The reduced capital cost of this option also supports the vulnerability of the benefit cost ratio of the project, which is acknowledged to be a key consideration in the ultimate investment decision which will be made by IIC.

The issue of reduced risk should also not be underestimated. The project is located in a highly sensitive environmental area and geographical location and is therefore exposed to a high degree of associated risk. The reduced size of the project 'footprint' is therefore very important as is the potential time it will take construct the project, due to its continued vulnerability to the risk of further future flooding.

With regards the EPBC Referral, despite the reduction in impacts through design considerations it is still considered prudent and best practice to refer the project to the Commonwealth Department of Environment for determination of 'controlled action' status. As well as minor impacts to Mahogany Glider, the project is within the Great Barrier Reef catchment and Cattle Creek Wetlands provides habitat for Saltwater Crocodiles and migratory birds. Impacts to water quality and the wetlands will be temporary and managed through a Construction Environmental Management Plan. Impacts associated with a reduction of habitat connectivity will be mitigated and reduced through design considerations, including limiting vegetation clearing, revegetation works and installation of glider poles.

The design and construction mitigation measures are considered sufficient to reduce the risk of obtaining a controlled action determination for the project. With the installation of glider poles and revegetation works, the impacts to Mahogany Gliders will not be significant. The sub-option has a greater impact to habitat connectivity for gliders as it will result in the clearing of more movement habitat and result in a greater width between habitat patches. For this reason the sub-option involves a greater risk of receiving a controlled action determination, which will require detailed assessment and approval from the Department of Environment.

Given the key benefits of preferred option in comparison with the sub-option, as summarised above, the preferred option is recommended to be further developed, subject to funding approval being granted by IIC.

7.2 Further Development & Assessment of Preferred Option

To further increase certainty of the benefits associated with the preferred option and support the continuing reduction of risk exposure of the project, the following have been identified as key actions to consider as part of the next stage of the project delivery cycle:

i. Complete a detailed topographical survey of the site area to confirm existing ground levels upon which the geometrical design and hydraulic assessment are based; and

ii. Subject to the above survey results complete further design refinement and hydraulic assessment to optimise the preferred option project outcomes.

7.3 Recommendation

This Report recommends that the refined preferred MCA option (which will now be known as the Business Case recommended option) should now be considered by the IIC for consideration to approve the project to progress through Major Project Gate 3 (Approval of Business Case) of the PAF governance process. This would provide a sound basis for the project to ultimately progress to construction implementation stage, once funding is made available.

Appendix A

TMR Design Development Report

Appendix B

Design Integration Register

Appendix C

Key Decisions Register

Appendix D

Safety in Design Register

Appendix E

Hydraulic Assessment Report

Appendix F

Review of Environmental Factors Report

Appendix G

Traffic & Transport Report

Appendix H

Geotechnical Report

Appendix I

Pavement Report

Appendix J

Road Safety Audit Report

Appendix K

P90 Cost Report

Appendix L

Risk Report

Appendix M

Multi Criteria Assessments

Appendix N

Survey Technical Note

Appendix O

Safety Barrier Technical Note

Appendix P

Bridge vs Culvert Technical Note

Appendix Q

Geometry Checklist

Appendix R

Highway Alignment Options
(Northern Section

Ch. 111,750 – 112,000m)

Appendix S

Previous Cost Estimates Review

Appendix T

Land Acquisition Drawing

Appendix U

Public Utility Plant Drawings

Appendix V

Concept Design Drawings