

## Demolition of the Angellala Creek Bridges

Shane Crawford, Principal Engineer, RoadTek, Department of Transport and Main Roads

### ABSTRACT

On Friday 5 September 2014 a truck carrying ammonium nitrate rolled and exploded, destroying the road bridge carrying the Mitchell Highway over Angellala Creek, approximately 30 kilometres south of Charleville. The adjacent railway bridge also sustained significant damage in the blast.

Upon completion of the initial investigation and clearance of the site for further explosive material, the Department of Transport and Main Roads (TMR) took charge of the site on 13 September 2014 and began works immediately to restore access to this vital road link.

This paper describes the works undertaken to safely manage the demolition of the unstable remains of the two bridge structures.

### INTRODUCTION

Angellala Creek intersects the Mitchell Highway between Cunnamulla and Charleville, approximately 30 kilometres south of Charleville (Figure 1).



**Figure 1 – Location of the Angellala Creek Bridges (source: Google Maps)**

The creek was crossed at this location by:

- A concrete road bridge, carrying the Mitchell Highway over the creek.
- A railway bridge with steel, timber and cast iron components, located to the west of the highway. The rail line had been out of service for a number of years, but was still used during flood events when the adjacent road structure was closed.

On Friday 5 September 2014 at approximately 9:50pm, a road train carrying 53 tonnes of ammonium nitrate ran off the road and crashed on the eastern side of the Angellala Creek road bridge. The truck subsequently caught fire and burned for about an hour before exploding, causing severe damage to both the road and rail structures.

Early reports indicated that the road bridge was completely destroyed and that the adjacent railway bridge had sustained considerable damage to the steel spans. The site was immediately closed, and a 500 metre exclusion zone was put in place by the Queensland Police Service and representatives from the Explosives Inspectorate division of the Department of Natural Resources and Mines (DNRM), due to the possibility of residual ammonium nitrate being present at the site.



**Figure 2 – Angellala Creek Crossing – January 2012 (left) and September 2014 (right)**

## **INITIAL INVOLVEMENT**

From the date of the incident until the 12 September 2014, the site was under the management of the Explosives Inspectorate while they investigated the accident and assessed the safety of the site. During this period, TMR participated in the initial investigations by providing the following assistance:

- Field crews to commence the removal of debris, the dewatering of the blast area and to assist with the provision of safe access on site.
- Attempted recovery of vehicle components to assist with the investigation of the event (Figures 3 and 4).
- Surveyors undertook a detailed survey of the site using terrestrial laser scanners, in order to produce a digital 3D model of the site to assist with the development of management strategies.

- Inspection of the road and rail structures by a structural engineer, to assess the damage sustained as a result of the blast.



**Figures 3 and 4 – The attempted recovery of trailer components that were pinned under the road bridge**

The engineering assessment of the structures concluded that the remaining components of the road bridge should be demolished and the site cleared of debris, to facilitate the construction of a new structure on the same alignment of the existing bridge. It was also noted that the steel spans and cast iron columns of the rail bridge were dangerously unstable. To continue the remainder of the inspection safely, it was suggested that these components be brought down to ground level, to determine appropriate management actions.



**Figures 5 and 6 – Extent of the damage to the road and rail bridge structures**

On the evening of the 12 September 2014, full control of the site was given to TMR to demolish the remnants of the road bridge and commence construction of a temporary sidetrack, while planning and design of the replacement structure was undertaken.

## DEMOLITION OF THE ANGELLALA CREEK ROAD BRIDGE

The original road structure had five spans, with the deck consisting of prestressed concrete deck (and kerb) units, transversely stressed and surfaced with a layer of asphalt. The deck was supported by four reinforced concrete piers which were comprised of a large hammerhead-style headstock seated on a blade column and two cast in situ bored piles, and two reinforced concrete abutments also seated on cast in situ piles (refer to Figure 7 for the general arrangement details of the structure).

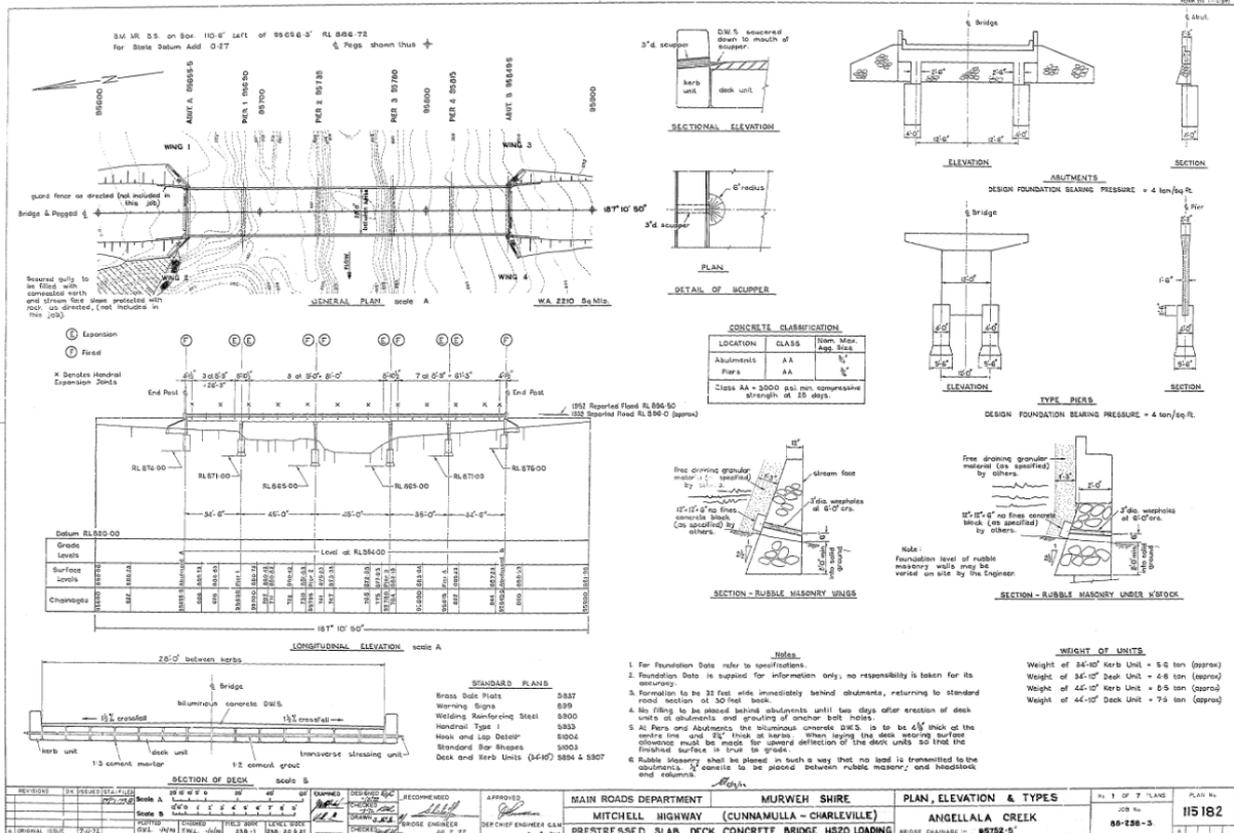


Figure 7 – Engineering drawing of the Angellala Creek Road Bridge

In developing the demolition plan for this structure, the following key risks were identified:

1. The potential for residual amounts of ammonium nitrate to be present on site at locations inaccessible during the initial investigation by the Explosives Inspectorate officers, due to the position of the partially-fallen bridge decks at spans 2 and 5. While relatively stable in its solid form, concern was raised that inadvertent exposure to flame may potentially result in the ignition of any residual ammonium nitrate.
2. Spans 1 and 5 of the structure were partially supported by the remains of the bridge substructure. Span 1 in particular was supported at the northern end by a pier which had been significantly damaged in the blast (Figure 8), rendering the span highly unstable.



**Figure 8 – Damaged pier supporting Span 1**

3. A large proportion of the deck components contained either prestressed reinforcement or post-tensioned transverse bars. While these components had been damaged considerably, concerns remained about the residual amount of potential energy stored in these elements, and the risks associated with breaking up the surrounding concrete and ‘releasing’ this energy during the demolition process.
4. Span 3 of the deck had been pushed directly under the main span of the adjacent railway bridge. To access these components would require plant to be positioned in close proximity to the partially-suspended railway spans, placing them at risk.

To manage these risks during the demolition process, the original design drawings and recent inspection information for the structure were obtained and reviewed to determine:

- the location and extent of prestressed / post-tensioned steel elements
- the composition of the deck units and location of the internal voids
- the existence of any pre-existing defects that might affect the behaviour of the structural components during demolition.

Upon completion of this review, the following measures were developed and documented in the formal demolition plan to mitigate and manage the identified risks:

- An exclusion zone of 500 metres was established around the site to manage the uncertainty of residual ammonium nitrate on site.
- The demolition of the prestressed concrete decks would commence with the release of the transverse stress holding the individual units together. Where

accessible, an attempt would be made to release each nut with a breaker bar. If this proved unsuccessful, the outer kerb unit would be broken up by a 30 tonne excavator with a hammer attachment, working from one end of the unit to the other, gradually releasing the residual prestress in the tendons and simultaneously releasing the transverse stressing bars.

- The decks of spans 2 and 5 would be the first segments to be attended to. Once the transverse stress within these spans were released, the individual units would be separated as much as possible using an excavator, with discrete sections of the deck units broken up to enable observation of the ground beneath the units by the Explosives Inspectorate officers. The deck units would be broken up directly over the internal voids, to reduce the effort required. As the northern end of Span 5 was still suspended from the abutment, efforts were concentrated at the opposite end of the span.
- Once the site had been declared clear of residual ammonium nitrate, the exclusion zone would be relaxed and the remainder of the suspended concrete components would be brought to the ground in a similar fashion to the processes described above. The damaged pier supporting Span 1 had the headstock pulled over by two excavators (Figures 9 and 10), and the concrete blade column broken back with the excavator-mounted hammer until the northern end of Span 1 had been lowered to ground level.



**Figures 9 and 10 – Damaged pier being removed from under Span 1**

- The suspended ends of Spans 1 and 5 were then broken back with the excavator-mounted hammer and the spans dropped to ground level.
- At this stage, all concrete components would be resting directly on the ground, and be progressively demolished. The Span 3 deck would remain in place until the main span of the railway bridge was brought down to ground level and the tops of the concrete piers cleared of loose or damaged concrete.

Demolition of the road bridge commenced on the 13 September 2014 and was successfully completed on the 16 September 2014. This allowed safe access to the site by TMR geotechnical and structural engineers to commence investigations into a

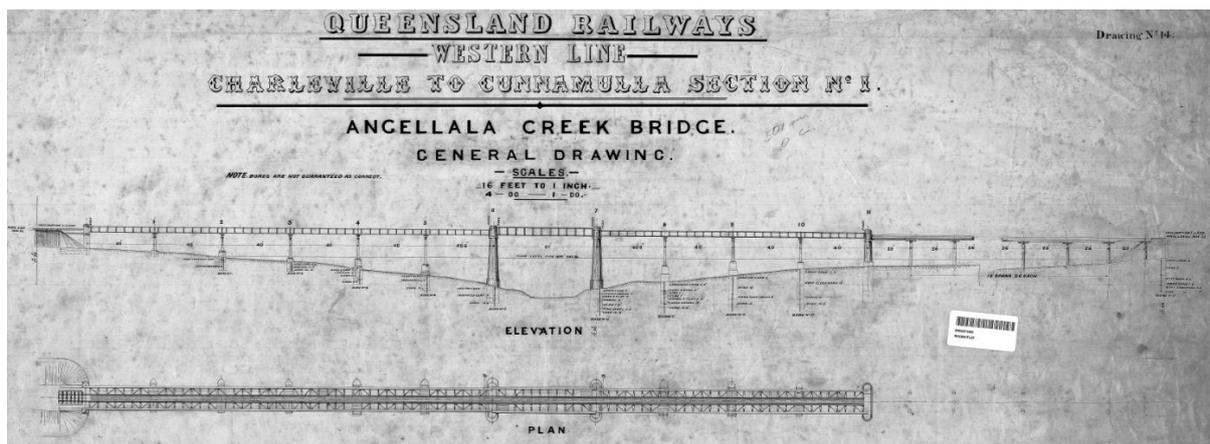
replacement structure. Local TMR surveyors were also able to collect the information required to progress the design and construction of a fully-sealed side track, which was completed and opened to traffic on the 7 October 2014.

## DEMOLITION OF THE ANGELLALA CREEK RAIL BRIDGE

As the railway line was not operational, there was no immediate urgency to demolish the damaged spans. However given the unstable nature of the damaged elements, it was recommended that the spans be brought down to ground level and made safe prior to the construction of the replacement road bridge. Queensland Rail commissioned RoadTek to undertake these works.

The adjacent rail structure consisted of 23 spans in total. Refer to Figure 11 for the general arrangement details of the structure.

- The southern portion of the bridge comprised of 12 timber girder spans, supported by timber piers and founded on timber sill logs on top of a concrete plinth. This portion of the structure was largely unaffected by the incident, and as such was not to be demolished.



**Figure 11 – Engineering drawing of the Angellala Creek Rail Bridge**

- The northern portion of the bridge comprised of 11 steel ‘half-through’ girder spans, with the main span seated on large concrete pier walls. The remaining spans were supported by cast iron columns seated on concrete plinths. The main span of the bridge had been completely pushed off the concrete piers, and was hanging suspended from the western side of the bridge. The adjacent steel spans and cast iron columns either side of the main span had been pushed sideways to varying degrees based on their proximity to the main span. The spans immediately adjacent to the main span appeared to have moved sideways approximately 2-3 metres, while the spans most distant from the main span showed little or no signs of transverse movement (Figures 12 and 13). The deck spans and cast iron columns were to be brought down to ground level and relocated out of the waterway so as not to obstruct the flow of the creek.



**Figure 12 – View of the main steel span - Angellala Creek Rail Bridge**



**Figure 13 – View of the displaced approach spans - Angellala Creek Rail Bridge**

Over the course of planning the works, the following key risks and challenges were identified:

1. The main span was suspended from the top of the concrete piers on the downstream side of the bridge at a height of approximately 10 metres. The ends of the span appeared to be caught against the steel rail; however, it was difficult

to confirm whether or not this was the case as access to this area was problematic.

2. The combined instability and elevation of the steel spans and cast iron piers made investigation of (and potentially working in the proximity of) the damaged portions of the structure a high risk activity.
3. While the main span appeared to be supported on the steel rails, there was a lot of uncertainty as to how much tension the rails were under, and how the rails and the suspended portions of the structure might respond, if the rails were severed at the bridge abutments. However, removing the rails was considered essential to enable the demolition of the steel spans, and was deemed a necessary part of the process.

As with many structures of this age, the original bridge drawings were lacking in detail, making it difficult to ascertain the bearing arrangements at the abutments and main concrete piers. In addition, the closure of the railway line meant there were no longer regular inspections of the structure, so the current condition of the bridge components prior to the blast was unknown.

The final demolition plan for the structure incorporated innovative solutions along with a 'belt-and-braces' approach, to ensure contingencies were in place to accommodate the numerous possible behaviours of the structure once demolition works commenced.

Various options were considered to enable the severing of the steel rails. The main criteria considered for this task were:

- The rails would be completely severed, with no remaining connectivity.
- The works would be conducted with construction crews located a safe distance away from the structure, to ensure any sudden movements of the rails or adjacent structure resulting from the release of tension would not cause harm to anyone.

The solution, developed by the RoadTek demolition supervisor in conjunction with the local RoadTek workshop in Roma, was to purchase and modify two drop saws to allow them to be operated from a safe distance with levers and a thin steel cable (Figure 14). The concept was tested in the workshop and successfully used on site to separate the rails at the bridge abutments to allow for removal of the rails from the bridge deck.



**Figure 14 – The modified drop saws used to sever the rails at the bridge abutment**

In order to safely bring the steel deck spans to the ground without placing construction crews in the vicinity of the anticipated fall path of the components, the following approach was developed and implemented on site:

- Thin nylon lines were looped over the outer girder on the downstream side of the bridge at a couple of locations for each span. This was achieved by throwing a weighted line over the top of the outer girder and retrieving the weighted end from beneath the structure using an extended pole with a metal hook attached to the end. Once this 'loop' had been established, the nylon lines were used as a leader line to feed through thin steel cables, which were then tethered to the ground a number of metres away from the bridge on the downstream side.
- Once this was completed, the concrete keeper walls on the piers and abutments were pulled down with an excavator, to ensure that they would not act as a barrier to prevent the movement of the deck spans (Figure 15).
- With the keeper walls removed, the excavator positioned itself on the upstream side of the bridge and attempted to push the approach spans sideways and off the substructure. This was attempted at a number of locations while the deck spans were observed from a safe distance.
- If the excavator could not dislodge the deck spans, the steel cables were to be used to feed load-rated Kevlar recovery lines through the bridge deck, which would then be connected to a D9 dozer located approximately 30 metres downstream of the bridge. The dozer would then attempt to pull the spans sideways and off the substructure.

The primary intention was to have a contingency plan in place that could be utilised safely in the event that the excavator failed to dislodge the deck spans. The leader lines were placed prior to conducting any other works on the structure, to ensure that

construction crews were able to undertake the necessary works prior to the introduction of further potential instability, by attempting to move the deck spans with the excavator.



**Figure 15 – Removal of the abutment keeper wall**

Ultimately, the excavator did successfully dislodge the deck spans and the steel cables were not required (Figure 16). Once dislodged, the spans were pulled sideways by the dozer until they were fully resting on the ground. They were then cut into smaller segments using oxy-acetylene torches and towed out of the waterway using the dozer and the Kevlar recovery lines. The cast iron columns were brought down with the excavator, a number of which were later used in a memorial erected at the site of the new structure (Figure 17)



**Figure 16 – Demolition of the southern approach spans**



*Figure 17 – The Angellala Creek Bridge Memorial*

## **KEY LEARNINGS**

The following key learnings were obtained from the delivery of these two unique projects.

### **The Importance of Maintaining Structure Records**

Having a full set of detailed drawings and relatively current condition information made the demolition of the road bridge slightly easier. There was no ambiguity regarding the location of the prestressed steel reinforcement, voids in the deck units or the hold-down details at the supports. This facilitated the development of a demolition plan despite the bridge components being in a highly unstable state.

Conversely, the lack of detailed information on the railway bridge added an additional layer of complexity to the demolition planning for this structure. Additional contingencies were developed for the principal part of the demolition to cater for the lack of certainty about the support configuration and the inability to closely inspect these areas.

### **‘Innovation’ Doesn’t Need To Be Expensive**

The development of the modified drop saw system for the severing of the rails at either end of the rail bridge ensured the safety of crews while conducting the works, as well as being the cheapest option by a considerable margin.

With the current national and international push towards innovative thinking, it's important to highlight that this doesn't necessarily translate to expensive, highly-technical solutions.

### **Prepare for the Unexpected (Particularly In Remote Areas)**

With this project there was a great deal of uncertainty as to how the rail structure would behave during the course of the demolition works. However, given the remoteness of the site (with the nearest town being Roma, approximately a three-and-a-half hour drive away), the need to stop work while additional plant and equipment was sourced would have resulted in large delays to the works. Conversely, procuring additional plant and equipment as a precautionary measure would have added significant additional costs to the project.

Thorough and careful planning of the works and a good understanding of the plant being utilised made it possible to develop contingency plans to accommodate the possible behaviour of the rail structure with the plant that was available on site, for minimal additional cost.

### **CONCLUSION**

A memorial erected adjacent to the new road bridge describes this event as 'the most powerful explosion in Australian transport history'. As shown in Figure 17, a section of the memorial consists of six cast iron columns that were salvaged from the rail bridge. It commemorates the enormity of the event, and the bravery and selflessness displayed by the firemen and police officers that responded to the event.

RoadTek is proud to have been able to contribute these salvaged columns for the purpose of the memorial and to the rapid restoration of this critical transport link as described in this paper.

## **REFERENCES**

Angellala Creek Bridge:  
Explosion to Reconstruction  
Responses by Transport and Main Road's technical disciplines  
Department of Transport and Main Roads Queensland (2016)

Investigation Report  
Ammonium Nitrate Explosion  
Angellala Creek, Charleville Queensland Australia on 5<sup>th</sup> September 2014  
Department of Natural Resources and Mines Queensland (2017)

Angellala Creek Bridge  
Post-Blast Inspection  
BIS ID 16171  
Structures Management Services, RoadTek  
Department of Transport and Main Roads Queensland (2014)

## **ACKNOWLEDGEMENTS**

The author would like to thank Jon Bundy, David Gibson and the crews involved from the Roma and Toowoomba RoadTek depots for the planning and effort that went into the successful completion of these projects.