R E P O R T

Menangle Rail Bridge
Wrought Iron River Spans
Main South Line 64.404km

Investigation Report for Uplifting Speed Restriction across Bridge

Prepared for

Australian Rail Track Corporation

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URS

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Executive Summary

The following summarises the outcomes of the inspections, investigations and reports carried out on the wrought iron spans of Menangle Underbridge from March 2003 to June 2005 and recommendations on remedial works required to permit operation of current passenger and freight traffic at full track speed for the next 25 years. The outcomes and refurbishment recommendations from previous reports have been updated in light of recent inspections and investigations.

Menangle Bridge was erected in 1863 and carries the Main South Line over the Nepean River. The bridge is a twin track transom top structure. The current speed limit on the bridge is 40km/hr. The full line speed in this section of track is 115km/hr (freight) but due to track geometry, this is reduced to 95/105km/hr (freight/XPT) on the down approach and 110/120km/hr (freight/XPT) on the up approach.

The bridge superstructure is a through girder structure with wrought iron box girders and a transverse wrought iron and steel girder deck system. The main bridge originally had three spans of 48.8m (160ft), however intermediate piers were constructed in 1907 resulting in 6 spans of 24.4m. Supplementary cross girders and stringers were also added in 1907 to strengthen the deck system. The bridge substructure comprises the original sandstone piers founded on the underlying sandstone with the 1907 piers constructed from brickwork founded on the underlying sandstone and timber piles.

The bridge was closed to traffic following an inspection by Professor West in March 2003 due in the main to perceived problems relating to fatigue cracking of the secondary cross girder cleats and potential fatigue failure of the primary cross girder suspension bolts. Following inspections, analysis and testing by Professor Paul Grundy and URS which showed the cracking was not fatigue related and the bolts had sufficient capacity the bridge was reopened to traffic in April 2003 at a speed of 20km/hr. Following further analysis, in service strain gauge testing and replacement of the suspension bolts by RIC the speed was uplifted to 40km/hr in August 2003.

The key issues relating to the long term performance of the wrought iron spans of the bridge were identified as:

- Cracks in Secondary Cross Girder Connection Cleats.
- Cracks in Secondary Cross Girder Web Cover Plate Welds.
- Loose Rivets.
- Timber Stringers and connections.

Based on the investigations, analyses and testing carried out for the main river bridge, the following train speed and loadings/heaviest train consist are recommended (based on continued use of timber stringers):

- Heaviest train consist not to exceed 3 x Class 81 locomotives with 100t CHS/NHFF wagons, operating on each track simultaneously.
- Maximum axle load 25 tonne.
- Train speeds not to exceed 80km/hr for freight and passenger trains until review of detailed inspections following first 6 months of operation at 80km/hr.

The interim operating speed of 80km/hr for the first 6 months of operation has been recommended based on the testing and strain gauging program carried out at 80km/hr in July 2004 and as a precautionary measure to assess any deterioration of defects over an extended period (at higher operating speed) before uplifting to full track speed .

The main bridge superstructure members all have sufficient capacity or ratings in excess of 1.0 for the heaviest train consist (3 x Class 81 locos plus 100t CHS/NHFF wagons) operating on each track simultaneously.

BRIDGE SUPERSTRUCTURE MEMBER RATING AT 80km/hr			
MAIN LONG. GIRDER	**PRIMARY X GIRDER**	**SECONDARY X GIRDER**	**SECONDARY LONG. STRINGER**
3.15	**1.12**	**1.16**	**1.04**

SUPERSTRUCTURE CONNECTION RATING AT 80km/hr					
Primary X Girder to Main Box Girder (Bolts)	**Long Stringer to Primary X Girder (Rivets)**	**Secondary X Girder to Main Box Girder**			
		Complete Connection		**One Failed Web Cleat**	
		Rivets	**Cleats**	**Rivets**	**Cleats**
5.22	1.10	1.09	1.13	1.06	1.03

Except for the secondary cross girder cleats the projected fatigue damage index (to 2030) for the various members and connections is below 1.0. For the secondary cross girder cleats a specific program of inspection is required to be implemented as detailed in the Maintenance Plan (MP) to ensure safety of the bridge is maintained.

The following table summarises the recommended major refurbishment works, their recommended implementation time and budget cost (rounded, Net Present Value):

Refurbishment Item	Implementation Period	NPV Budget Cost ($k)
Replacement of loose / defective rivets	within next 2 years	750
Timber Stringer Bolt Replacement/Repairs	within next 2 years	200
Major Bearing Service	within next 2 years	200
Clamping of Secondary Cross Girders	within next 5 years	350
Replace Primary X Girder Suspension Bolts	within next 5 years	500
Total		**2,000**

The Maintenance Plan (MP) has been updated by URS following the May 2005 inspections and is provided under separate cover.

Recommendation

The following summarises the key recommendations for the wrought iron river spans of Menangle Rail Bridge:

1. No immediate refurbishment works required.
2. Uplift current operating speed from 40km/hr to 80km/hr.
3. Heaviest train consist not to exceed current loading of 3x81 Class locomotives and 100t CHS/NHFF wagons (maximum axle load of 25 tonnes)
4. Replace all timber stringer broken or missing holding down bolts where possible.
5. Implement a staged inspection regime incorporating 3 off 2 monthly inspections for the first 6 months after raising of the track speed to 80 km/hr.
6. Following the final 2 monthly inspection after the first 6 months of operation at 80km/hr:
   - Carry out detailed engineering review of inspection reports.
   - Review dynamic load effects in accordance with current AS5100 requirements and confirm bridge rating at full track speed
7. If no deterioration of specified defects or additional defects are identified, and subject to AS5100 dynamic effects analysis and confirmation of bridge rating, then uplift track speed to full track speed in both directions.
8. Implement an inspection regime incorporating 3 off 6 monthly inspections for a further 18 months after the final 2 monthly inspection and review inspections results.
9. Implementation of updated MP to ensure continued safety of structure.
10. Specific refurbishment works to be carried out in nominated periods as noted above.

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Introduction

The following summarises the outcomes of the inspections, investigations and reports carried out on the wrought iron spans of the Menangle Underbridge from March 2003 to June 2005 and recommendations for remedial works to permit operation of current passenger and freight traffic at 95km/hr for the next 25 years. The current speed limit on the bridge is 40km/hr. The full line speed in this section of track is 115km/hr (freight) but due to track geometry, this is reduced to 95/105km/hr (freight/XPT) on the down approach and 110/120km/hr (freight/XPT) on the up approach. The proposal has been prepared in response to an invitation from Australian Rail Track Corporation (Design Brief No. 05/001).

Menangle Bridge was erected in 1863 and carries the Main South Line over the Nepean River.

The bridge superstructure is a through girder structure with wrought iron box girders and a transverse wrought iron and steel girder deck system. The main bridge originally had three spans of 48.8m (160ft), however intermediate piers were constructed in 1907 resulting in 6 spans of 24.4m. Supplementary cross girders and stringers were also added in 1907 to strengthen the deck system. While the original structure is wrought iron the strengthening works were carried out using mild steel.

The bridge substructure comprises the original sandstone piers founded on the underlying sandstone with the 1907 piers constructed from brickwork founded on the underlying sandstone and timber piles.

The bridge superstructure comprises a twin track, riveted wrought iron, transom top, through girder with a superstructure system comprised of the following key elements:

- Continuous welded 53kg rail with timber transoms supported on timber stringers spanning between the cross girders (continuous over girders in approx. 4.2m lengths)
- Original cross beams (termed secondary cross girders) originally spanning between the bottom box girder sections of the main longitudinal girders and later supported on longitudinal stringers at approximately third points. These girders were later strengthened with the addition of web plates.
- Supplementary hanging cross beams (termed primary cross girders) supported from the main longitudinal girders by U bolts (recently changed to 4 high tensile suspension bars).
- Supplementary longitudinal stringers (termed secondary stringers) spanning between the primary cross girders and supporting the secondary cross girders.
- Main longitudinal girders comprising top and bottom box girder elements and double stiffened plate webs with internal diaphragms.

The recent history of inspections and investigations from March 2003 is as follows:

- Inspection and Prelim assessment by Prof. West of Wollongong University, March 2003.
- Inspection and Report by Prof. Grundy of Monash University, April 2003.
- URS Stage 1 (prelim analysis) Report April, 2003.
- URS Stage 2 (detail analysis) Report, June 2003.
- URS Stage 2A (detail analysis & inst) Report, August 2003.
- Prof Grundy Final Report June 2004.
- URS Stage 2A Addendum 1 - Bolt Saddle Analysis and Box Girder Bottom Cell Web Plates, Feb 2004.
- URS Stage 2A Addendum 2 – Testing at 80km/hr July 2004.

2.1 Instrumentation/Strain Gauging

A comprehensive instrumentation program was undertaken on the bridge by RIC Scientific Services in June 2003 and in May 2004. The program focussed on the bridge deck and in particular the secondary cross girders and their connection to the main box girders. The instrumentation was carried out for a test trains comprising 1 x Class 81 locomotive and 10 x 70t ballast wagons and 2/3 x Class 81 locomotives and 45 x 100t NHSH wagons running at various speeds and applied braking on the down track.

To check the computer models comparison was carried out with the results from the instrumentation program. For the main structural elements the computer model results were in general agreement with the instrumentation results.

2.2 Superstructure Rating

2.2.1 General

The following load ratings have been taken from the investigation and analysis reports as detailed in Section 1 and supplementary analyses carried out following the inspection by URS on 19th May 2005.

Load ratings for the bridge superstructure system are based on the following:

- **Reference Loading** – Three coupled Class 81 locomotives with trailing 100t CHS/NHFF wagons
- **Member Condition** – 'As Is'

The details for the bridge and its components were taken from the existing drawings and from field measurements. Allowances were made for corrosion (generally 5% of section thickness) to the various structural members. For the longitudinal stringers an increased corrosion allowance of 10% was included to allow for localised areas of wear in the flange areas below the secondary cross girders. For the secondary cross girder end connection a corrosion allowance of 50% (web thickness reduced from 6mm to 3mm) has been allowed based on recent inspections carried out.

Defects in the connections (ie cracks in secondary cross girder web cleats) were not modelled in the analysis although they were taken into account in the ratings.

Member ratings were calculated for the complete deck system.

With respect to properties of the wrought iron these were taken from the tests conducted by Monash University in June 2003 on samples of the wrought iron cleats and tests carried out by Scientific Services in 1992 on samples of the wrought iron angles. A yield stress of 172 MPa was used in the rating.

2.2.2 Member Rating

The critical loading for the bridge superstructure members are with 2 tracks loaded and the main ratings have been determined for this case. The following table summarises the ratings of the various members of the bridge superstructure for the 'As Is' condition. For the main longitudinal girders the capacity has been based on a buckling analysis of the girder top chord box member taking into account the restraining effect of the secondary cross girder U frames.

Table 1: Member Rating for Class 81 Locomotives with 100t Wagons at 80km/hr

Member	Rating
Main Longitudinal Girder	3.15
Main Longitudinal Girder Bottom Cell Web Buckling	1.45
Primary Cross Girder	1.12
Secondary Cross Girder (No gap between Flange of Girder and the Supporting Stringer)	1.22
Secondary Cross Girder (3 mm gap between Flange of Girder and the Supporting Stringer)	1.16
Secondary Longitudinally Stringer	1.04

The rating for the secondary cross girders has been based on a section with the original web only (no account has been taken of the web cover plates which have some cracks in the welds over the longitudinal stringers).

2.2.3 Member Connection Rating

The critical loading for the bridge superstructure connections are with 2 tracks loaded and the connection ratings have been determined for this case.

Ratings have been determined for the critical deck member connections as noted below:

- **Primary Cross Girder to Main Box Girder** – The original U bolts have been replaced with high tensile bolts. The ratings determined are for the new bolts and the suspension saddles in the main box girder.
- **Secondary Cross Girder to Main Box Girder** – The secondary cross girder end connection comprises 2 riveted web cleat angles on the girder and a riveted gusset plate connection from the top flange of the secondary girder to the web T stiffeners of the main box girder. For this connection the rating has been determined for the complete connection and for a connection where one side of the

web cleat connection has cracked rendering it ineffective. Ratings have been determined for the rivets as well as the cleats.

In addition to the cleat angles, ratings have also been determined for the rivets connecting the various elements of the secondary cross girder to the main longitudinal girder, in particular the capacity of the rivets in the corroded web section of the girder as recently identified.

- **Longitudinal Stringer to Primary Cross Girder** – This connection comprises 2 riveted web cleat angles. No account has been taken of the stringer bearing on the bottom flange of the girder.

The following table summarises the ratings of the above connections.

Table 2: Member Connection Rating for Class 81 Locomotives with 100t Wagons at 80km/hr

Member Connection	Rating
Primary Cross Girder to Main Box Girder Bolts (Installed 2003)	5.22
Primary Cross Girder to Main Box Girder Bolt Saddles	1.15
Longitudinal Stringer to Primary Cross Girder Rivets	1.10
Secondary Cross Girder to Main Box Girder Rivets	1.09
Secondary Cross Girder to Main Box Girder Cleats	1.13
Secondary Cross Girder to Main Box Girder (Assuming 50% corrosion of web plate)	1.31

The following table summarises the ratings of the connections for the train consist travelling at 95km/hr assuming one of the secondary cross girder web cleat has failed.

Table 3: Member Connection Rating for Class 81 Locomotives with 100t Wagons at 95km/hr

Member Connection	Rating
Secondary Cross Girder to Main Box Girder Rivets	1.06
Secondary Cross Girder to Main Box Girder Cleats	1.03

2.2.4 300LA Railway Traffic Loading

The following table summarises the ratings of the deck members for the 300LA train loading on two tracks travelling at 95km/hr (As Is condition).

Table 4: Member Rating for 300LA at 95km/hr

Member	**81 Class Locomotive with 100t Wagons Equivalent Loading at 80km/hr**	**Design Load Rating**
Primary Cross Girder	210LA	240LA
Secondary Cross Girder	250LA	290LA
Longitudinal Stringer	280LA	295LA

2.2.5 Key Rivet Locations

From the various computer analyses and field observations the following rivet locations were identified as having relatively high fluctuating or reversal of stresses that could lead to rivet loosening:

- Secondary Cross Girder to Main Box Girder (Gussets and cleats) – The critical rivet locations are the rivets connecting the gusset plate to the top flange of the cross girder and the top and bottom rivets closest to the root of the angle connecting the angle cleats to the box girder.
- Box Girder Web T Stiffeners (Gusset to T stiffener and T stiffener to box girder web) – The critical rivet locations are at and adjacent the secondary cross girder gusset plate connection.
- Box Girder Bottom and Centre Diaphragms – The critical location is the inside face of the lower and centre diaphragm connections.

2.3 Superstructure Fatigue

The main river bridge was erected in 1863 and strengthened in 1907. The original superstructure is of riveted wrought iron construction with mild steel being used for the 1907 strengthening.

The fatigue resistance of the superstructure system members has been evaluated in terms of projected damage to 2030. Loading history has been based on actual loads recorded on the line over the last year and advice from RIC on recent and past load history. The fatigue analysis includes for the effects of loading on different tracks.

The fatigue analysis has been based on BS5400, Part 10. The fatigue damage has been calculated using appropriate S/N curves/formulae from BS5400 and the Palmgren - Miner linear damage summation.

For each train on the bridge, a simplified reservoir method of cycle counting that included the number of cycles associated with the peak stress ranges was adopted. For superstructure deck members, locomotives were assumed to represent a number of stress cycles equal to twice the number of locomotives (stress peaks generated by locomotive bogie axle groups) and for wagons the number of stress cycles were assumed to be equal to the number of wagons (stress peaks generated by coupled axle groups).
The stresses in the superstructure members have been taken from the instrumentation programme carried out in May 2004.

The projected damage to 2030 for the various superstructure members and connections are summarised below:

Table 5: Member Fatigue Damage Index to 2030

Member	Damage Index
Main Longitudinal Girder	0.23
Primary Cross Girder	0.06
Secondary Cross Girder	0.34
Secondary Longitudinally Stringer	0.21

Table 6: Member Connection Fatigue Damage Index to 2030

Member Connection	Damage Index
Primary Cross Girder to Main Box Girder Bolts (Installed 2003)	0.16
Longitudinal Stringer to Primary Cross Girder Rivets	0.20
Secondary Cross Girder to Main Box Girder Rivets	0.99

Table 7: Member Connection Fatigue Damage Index to 2005

Member Connection	Damage Index
Secondary Cross Girder to Main Box Girder Cleats	1.89

Except for the secondary cross girder cleats the projected fatigue damage index (to 2030) for the various members and connections is below 1.0 .

The fatigue damage index for the secondary cross girder cleats to 2005 is greater than 1.0 which indicates that the cleat has reached its nominal fatigue life. An index greater than 1 does not mean that cracking will necessarily occur, however in accordance with AS5100.7 Clause 8, a program of inspection is required to be implemented to ensure that any fatigue cracks are detected and, where appropriate, the structure is suitably repaired before the cracks have grown to the extent that the structure's ability to carry its applied load is endangered. The inspection frequency, intervention level and responses are included in the updated Maintenance Plan (MP).

With the exception of the secondary cross girder cleats all of the key members and connections have a low damage index and based on current traffic there are no components that will be fatigue life expired in next 25 years.

2.4 Substructure

A preliminary analysis of the bridge substructure was carried out based on available data. The bridge substructure comprises the four original sandstone piers constructed in 1863 and the three strengthening brick piers constructed in 1907. The majority of the piers (piers 1 to 5 from the Sydney end) are founded directly on the underlying sandstone with Pier 6 (one of the newer brick piers) founded on timber piles. It is not known whether the original country abutment pier (Pier 7) is founded on piles or on a spread footing at depth.

The original sandstone piers are considerably larger than the brick piers and founding levels and details are unknown. Details of the 1907 brick piers are known, including Pier 6, which is supported on timber piles. The brick piers carry the same superstructure vertical and lateral loads as the original sandstone piers (except for Pier 4 which is the longitudinal fixed pier) and therefore the capacity assessment was carried out for the brick piers only.

The capacity assessment was carried out for Pier 4 which is located at the centre of the bridge in the permanent waterway and is founded on the sandstone bedrock, and Pier 6 which is founded on timber piles. The piers were analysed under the action of the bridge superstructure dead, live and wind loads, loads from flood flows for a 1 in 100 year flood event (stream flow and debris loads) and earthquake loads. With respect to lateral loads the critical loading is the flood flow loads. It was assumed that newer brick piers are solid with an outer skin of brickwork and an inner core of concrete.

Pier 4 is supported on a mass concrete footing founded on Class IV to V sandstone with an estimated minimum allowable bearing capacity of 1000 kPa. Under the action of dead, live and flood loads the maximum stress under the footing is 506 kPa. The pier has adequate resistance against sliding and overturning

Pier 6 is supported on reinforced concrete footing founded on 52 Nos 12 x 12 inch timber (turpentine) piles. The pile cap is located at a depth of approximately 5 m below the river bank surface level. Under the action of flood loads and neglecting passive resistance of the alluviums the maximum pile load in the timber piles is 50t. While no information is available on the pile driving records the pile length detailed on the drawings indicates that the piles were driven to refusal on bedrock based on the available geotechnical data (pile length approx 14m). It is estimated the pile capacity would be of the order of 100-150t

Since the bridge closure and re-opening in 2003 the main river bridge has been subject to a regular (2 weekly) cycle of inspections focused on the key areas of concern as nominated in the bridge TMP, primarily the secondary cross girder end connection cleats and the secondary cross girder web stiffener welds over the stringers. The results of these inspections are included in Appendix B. The inspections show that none of the cracks in the secondary cross girder cleats or web stiffener plate welds have propagated under the current limited speed regime for the past 2 years.

The bridge has also recently been subjected to a detailed inspection by Paul Stone. The main river bridge was inspected on the 21st and 22nd May 2005, and the viaducts on the 28th and 29th May 2005. The results of the inspection on the main river bridge are included in Appendix B. These inspections have supplemented the inspections carried out in 2004 and are presented together with these 2004 inspection results. URS have reviewed the results of the inspection and have not identified any significant changes in the bridge condition. The major items identified remain the large number of loose rivets, and cracks in the secondary cross girder cleats and web stiffener plate welds.

As part of this commission an inspection of the key deck defects namely the secondary cross girder end connections and cleats and the web plate weld cracks, was carried out by URS on the 19th May 2005. The inspection did not identify any further deterioration of the current bridge condition.

4.1 Major Refurbishment Works

The following summarises the recommended and optional refurbishment works and their recommended implementation time:

Table 8: Major Refurbishment Works & Implementation Period

Refurbishment Item	Implementation Period
Replacement of loose / defective Riverts	within next 2 years
Timber Stringer Bolt Replacement/Repairs	within next 2 years
Major Bearing Service	within next 2 years
Clamping of Secondary Cross Girders	within next 5 years
Replace Primary X Girder Suspension Bolts	within next 5 years

4.1.1 Replacement of Loose / Defective Rivets

There are approximately 2,000 loose or defective rivets in the main box girders primarily in the connections of the internal diaphragms of the main box girder webs. These rivets will need to be replaced with high tensile bolts. These works are recommended to be carried out within the next 2 years

4.1.2 Timber Stringer Bolt Repairs

The existing stringers on the main river bridge consist of large timber sections of approximately 4.2m length. The stringers are notched out over the secondary and primary cross girders and bolted to the top flange of the girders. Due to the flexibility of the steel girder and timber stringer deck system there is continual movement at the stringer girder interface resulting in breakage of a large number of bolts. To maintain the bridge in an operational condition the failed bolts need to be replaced. It is recommended that a bolting system with resilient spring type devices be used that can accommodate the cyclic loadings. While the bolts can be replaced progressively it is recommended that approximately 250 bolts need to be replaced within 2 years.

4.1.3 Bearing Remedial Works

The bearings for the bridge main longitudinal girders all require to be serviced. For the roller bearings this may require jacking of the girders to service the roller assemblies.

4.1.4 Replacement of Primary Cross Girder Suspension Bolts

The original primary cross girder suspension U bolts were replaced in 2003 with high tensile bolts due to concerns regarding fatigue failure of the U bolts. The new bolts were installed with the understanding that the bridge was to be replaced in the near future (within the next 5 years) and the bolts were installed with no corrosion protection. With the bridge proposed to be retained in service for 25 years the bolts will need to have an adequate corrosion system applied or replaced. Painting of the bolts in situ will be very difficult and it is proposed to replace them with ones with a suitable corrosion protection system.

These works are recommended to be carried out within the next 5 years

4.1.5 Clamping of Secondary Cross Girders to Stringers

The older secondary cross girders are supported at approximately third points by the newer steel under stringers that span between the primary cross girders. Between the cross girder bottom flange and the stringer top flange there is a variable thickness steel packer plate that is connected to the bottom flange of the cross girder only. Movement of the deck system under load results in pumping of the connection and degradation of the stringer top flange and packer.

It is proposed that new packers be installed with the cross girder clamped to the under stringer using bolted connections to eliminate the excessive movement.

These works are recommended to be carried out within the next 5 years

4.2 Routine Maintenance Works

4.2.1 Cleaning Box Girder Flange Enclosures

Pigeons have over a long period of time roosted in the ends of the box girders. It is possible to access the main part of the box and it is understood that the bird’s droppings were cleaned out to some extent during the bridge closure in 2003.

Two inaccessible smaller box sections above and below the main box area form the girder flanges. These flange enclosures need to be cleaned out and sealed. To gain access it may be necessary to cut small openings in the side of the girder. The cleaning would be limited to the end spans only.

4.2.2 Patch Painting

The existing coatings vary in age from 20 to 30 years and all the older coatings are breaking down. Based on the present surface condition of the various aged coatings it appears that repainted surfaces have lasted 15 to 20 years before break down. It is important to note that it is more economical to re-coat before peeling of the surface occurs thus eliminating the need for extensive surface preparation.

Crevice and pitting corrosion has taken place around a considerable number of the riveted connections and at isolated member locations. The reason for this local corrosion is most likely due to one or a number of the following causes:

- Entrapped water, ponding around the connection.
- Excessive build-up and cracking paint.
- Joint movement due to loose rivets.
- Build-up of brake dust, sand and deleterious materials from the tracks.
- Accumulation of birds droppings and nesting material.

A large proportion of the cost associated with repainting is in scaffolding, environmental controls and bridge possession time.

Due to the very high cost associated with shrouding associated with any blasting operations it is not intended to remove any of the existing sound coatings from the structure. It is proposed to water wash and clean-down any loose flaking paint particles, coat seal to bind the surface and existing coatings (including the red lead) and repaint with two coats of multi-purpose epoxy paint.

Environmental protection will be required during washing down and cleaning operations. This will involve hanging under-slung tarpaulins and fine netting (Geofrabric) under the work area to separate and collect the dust particles and collect and recycle the wash down water.

4.3 Access/Inspection Works

Main longitudinal box girders

Access to the box girders is currently only available from the ends of the girders (146m long). With the number of diaphragms (160 total) and the narrow openings between them it is very difficult to access the centre areas of the girders particularly for maintenance works (rivet replacement). To facilitate maintenance access inspection hatches could be installed in the sides of the girders which can be accessed from the centre walkway.

The requirement for inspection hatches should be subject to an OHS/Maintenance risk study

Underdeck Inspection and Maintenance Gantries

Due to the height of the main river bridge and restricted access from the ground due to the Nepean River access to the underside of the deck for inspection and maintenance has been restricted. An under-deck scaffold system has recently been erected to permit detailed inspection of the deck following the closure of the bridge, however this is a temporary structure and will require to be removed.

To enable future inspection and deck maintenance works to be carried out more efficiently inspection gantries could be installed under each of the 6 spans. The gantries would be accessed from the deck of the bridge and have a simple manual operation system.

The requirement for inspection gantries should be subject to an OHS/Maintenance risk study.

Preliminary construction cost estimates were prepared for each refurbishment item based on historical cost data, labour material and plant rates and cost estimates obtained from suppliers. Detailed spreadsheets for the cost estimates are included in Appendix B. It should be noted these costs were prepared in late 2003.

The costs estimates include a 20% physical and design cost contingency to allow for unforeseen design and construction complications.

It has been assumed that refurbishment works will be carried out over a number of years and costs for these items are net present value costs (NPV) calculated with a discount rate of 7%.

The total refurbishment cost estimates for the wrought iron main river bridge are as summarised below:

TABLE 9

MAJOR REFURBISHMENT WORKS (MPM) COST ESTIMATES (NPV) ($k)

ITEM	Within next 2 years	Within next 5 years
Replacement of loose / defective Rivets	725	
Timber Stringer Bolt Replacement/Repairs	185	
Major Bearing Service	190	
Clamping of Secondary Cross Girders		350
Replace Primary X Girder Suspension Bolts		460
TOTAL	**$1,100**	**$810**
	$1,910	

Maintenance Plan

A Maintenance Plan was developed by RIC for the main river bridge in 2004. Based on inspections carried out in 2004 and 2005 the MP has been updated by URS and ARTC and is provided under separate cover.

Limitations

URS Australia Pty Ltd (URS) has prepared this report for the use of Australian Rail Track Corporation in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 27 April 2005.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 27/4/05 and 9/9/05 and is based on the data available at the time of preparation.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A
Inspection Reports

Appendix B
Refurbishment Works Cost Estimate Schedules