Feasibility Study

For

Truss Bridges

At

Nyora to Woolamai Rail Trail

Prepared by: Rob Nestic of TGA Engineers

Prepared for: Michael Smith & Associates

Date: 23 October 2024

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Re: Feasibility Study - Nyora to Woolamai Rail Trail Bridges

This investigation was carried out at Michael Smith and Associate's request with the object of assessing the structural integrity of the 11 bridges located at various points along the proposed Nyora to Woolamai Rail Trail.

This report has been prepared for the client named and for the purposes stated herein. No party should apply this report for any purpose other than that originally contemplated without first contacting TGA Engineers.

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1. Introduction

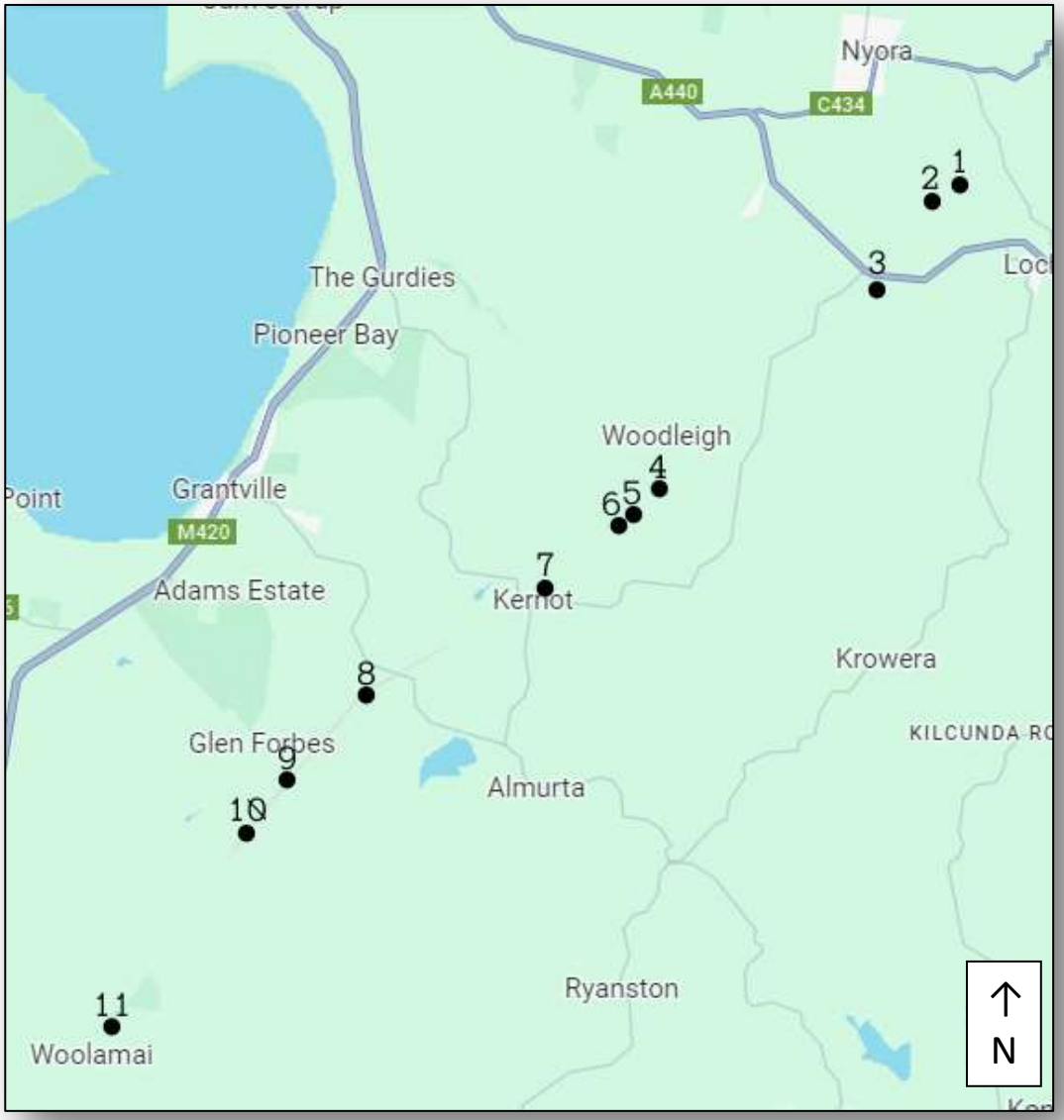
The Bass Coast Shire Council in conjunction with the South Gippsland Shire Council, commissioned a feasibility study to be prepared by Michael Smith & Associates for a proposed walking/cycling trail linking Woolamai to Nyora. The 25 kilometre track will form part of the existing Gippsland Odyssey Trail. The purpose of the feasibility study is to identify all the requirements that need to be met for the project to proceed to the detailed planning and design stage and ultimately construction phase.

TGA Engineers were engaged to assess the existing conditions of the former railway bridges located along the existing and Crown land reserve, and the structural requirements that would be necessary to ensure the bridges are compliant with the relevant Australian standards and safe for public use.

There are a total of 11 bridges located along the crown land reserve, starting at number 1 in Nyora at the northern end through to 11 in Woolamai at the southern end. A list of the bridges can be found below. Bridges 4 & 5 were not inspected, as it was instructed that Bridge 4 was too far gone to warrant reconstruction, and Bridge 5 had recently been reconstructed by the property owners and is in good condition.

#	Bridge Type	Location
1	Concrete Bridge 1	Approximately 3km southeast of Nyora, between Berry's Road and Bass River
2	Steel Bridge1	Crosses over Bass River approximately 400m south-west down the road from Bridge 1.
3	Timber Trestle Bridge 1	Crosses a creek along the existing Nyora-Wongthaggi Rail Trail, approximately 160m south of the South Gippsland Hwy and 4.5km south of Nyora.
4	Concrete Sleeper Bridge 1	Sits adjacent to existing Nyora-Wonthaggi Rail Trail about 800m south of Woodleigh St Hellier Road. This bridge requires complete replacement. *Not inspected.*
5	Concrete Bridge 2	Sits adjacent to existing Nyora-Wonthaggi Rail Trail, approximately 250m north of Gaws Road. *Not inspected.*
6	Timber Trestle Bridge 2	Crosses Wattle Creek south of Gaws Road, in-between Kernot (2km to south-west) and Woodleigh (2km to north-east).
7	Timber Trestle Bridge 3	Adjacent to Schier Road, approximately 150m north-east of the Kernot Community Hall.
8	Timber Trestle Bridge 4	Crosses Tennant Creek approximately 50m north-west of Almurta-Glen Forbes Road and 2.5km south-west of Glen Forbes.
9	Timber Trestle Bridge 5	Crosses a creek bed approximately 30m from Daylston –Glen Forbes Road and 150m north of the Glen Forbes Community Reserve.
9a	Brick Abutment Bridge 1	Adjacent to the number 9 bridge above.
10	Steel Bridge 2	Approximately 250m west of Eden Road and 1.5km south of Glen Forbes. Crosses Gorge Creek. *Not inspected.*
11	Concrete Bridge 3	Approximately 95m north of Turnbull-Woolamai Road, and 700m north-east of Woolamai. *Not inspected.*

2. Map



Source: © GoogleMaps 2024

GPS Co-ordinates

Bridge No.	GPS Co-ordinates	Bridge Type
1	38°21'18.4"S 145°41'19.2"E	Concrete Bridge 1
2	38°21'29.4"S 145°41'10.2"E	Steel Bridge1
3	38°22'22.3"S 145°40'28.2"E	Timber Trestle Bridge 1
4	38°24'21.4"S 145°37'31.1"E	Timber Trestle Bridge 2
5	38°24'44.0"S 145°37'04.3"E	Concrete Bridge 2
6	38°24'49.2"S 145°36'54.3"E	Timber Trestle Bridge 3
7	38°25'32.8"S 145°35'54.4"E	Timber Trestle Bridge 4
8	38°26'30.7"S 145°33'45.1"E	Timber Trestle Bridge 5
9	38°27'28.0"S 145°32'37.1"E	Timber Trestle Bridge 6
9a	38°27'28.0"S 145°32'37.1"E	Brick Abutment Bridge 1
10	38°28'05.5"S 145°31'58.2"E	Steel Bridge 2
11	38°29'59.2"S 145°30'12.1"E	Concrete Bridge 3

3 . Geology

Most of the bridge locations lie along the Bass Fault Line, in Recent Quaternary areas of stream alluvium, flood plan and low level terrace deposits, sand, silt, clay, gravel.

Others border on Pliocene Tertiary areas of gravel, sand, ferruginous sand and clay, which includes Baxter Sandstone and Boisdale Beds (Haunted Hills Gravels and equivalents). Bridge locations have been marked on the geological map extract below.



Source: Geological Survey Map of Victoria: Warragul, Sheet SJ 55-10, drawn by the Mines Department, Melbourne, First Edition 1971.

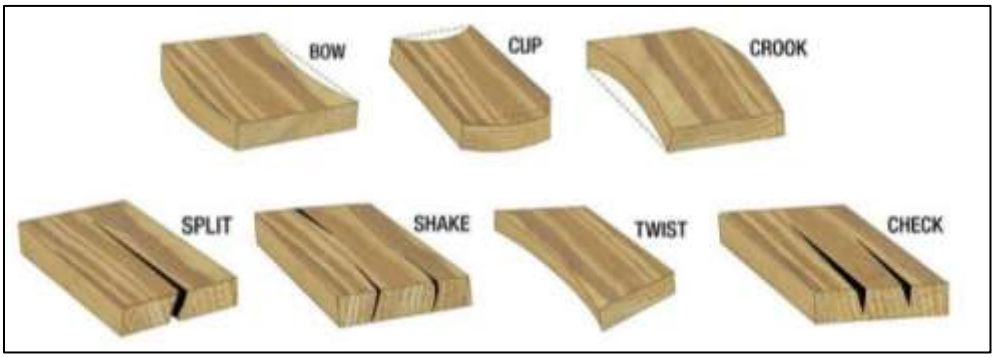
4. Inspection Methodology

There are four (4) main inspection methods utilised in this assessment:

1) Visual non-destructive inspection of timber frame

Visual inspection is one of the best qualitative methods of assessing the structural condition of the timber frame. Timber characteristics, such as splitting, checking, decay, mould, warping, distortion and settlement can be assessed for acceptance with general framing practice and the relevant Australian standard for timber, and the Guide to Standards and Tolerances (2015).

Figure 1. Examples of Timber Defects



2) Moisture content readings

Moisture content measurements are taken at control points that provide an indication of baseline moisture content and areas of elevated moisture. As previously noted, elevated and prolonged periods of moisture content above 20% will eventually result in decay of the wood fiber.

Figure 2. Example of moisture meter reader in timber



3) Chisel test

It is usually observed that weathering and exposure to sunlight will only affect the surface of the timber. A scrape or chisel will provide a good indication if the material below the surface is competent.

Figure 3. Example of chisel testing timber



4) <u>Drill test</u>

A drill test utilising a Ø4mm normal jobber drill bit on a slow speed cordless drill. This test is qualitative in nature as it assesses the extracted wood fibre for discolouration and ease of drilling. The operator experience will detect if the wood fibre density has been compromised.

Figure 4. Example of drill testing timber



5. Bridge 1 – Concrete Bridge 1



Bridge Number:	1
Description:	Concrete Bridge 1
Length:	17 metres
Location:	38°21'18.4"S 145°41'19.2"E
Inspection Date:	19/06/24
Condition Notes:	5 span bridge constructed from a combination of train rail beams and concrete slab

Observations

Bridge 1 is located within the existing rail corridor and divides existing farm paddocks. It spans over a floodway which appears to only flow during rain events.

As can be seen in the diagrammatical drawings and photos, it appears to have been reconstructed some time ago. Concrete/support piers are in-situ poured segments which exhibit minor weathering but no major signs of corrosion.

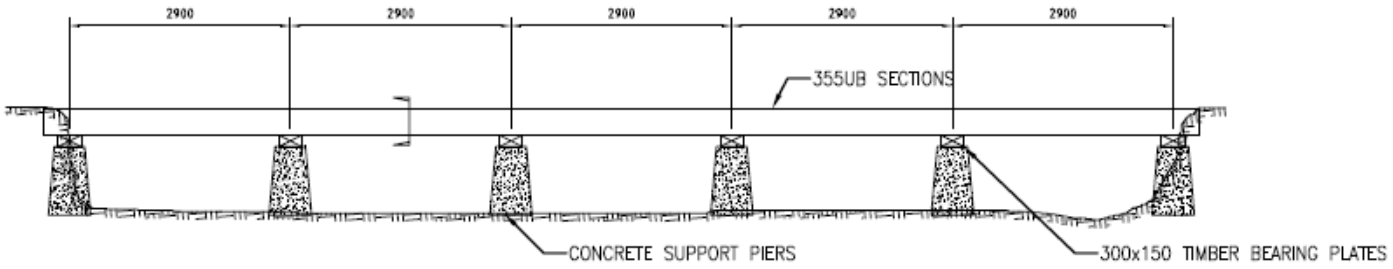
Construction of the deck consists of 360UB sections with rail track members spanning between piers. A concrete deck of approximately 180mm thick (reinforcement unknown) has been cast over and between rail tracks. A metal roof deck profile has been utilised as formwork. The spans are 2.9m and are not significant in respect to the construction. There is currently a timber header between the concrete piers and rail sections.

The property owner advised that harvesters and other farm machinery are frequently driven over this bridge, weighing in the order of 10 tonne.

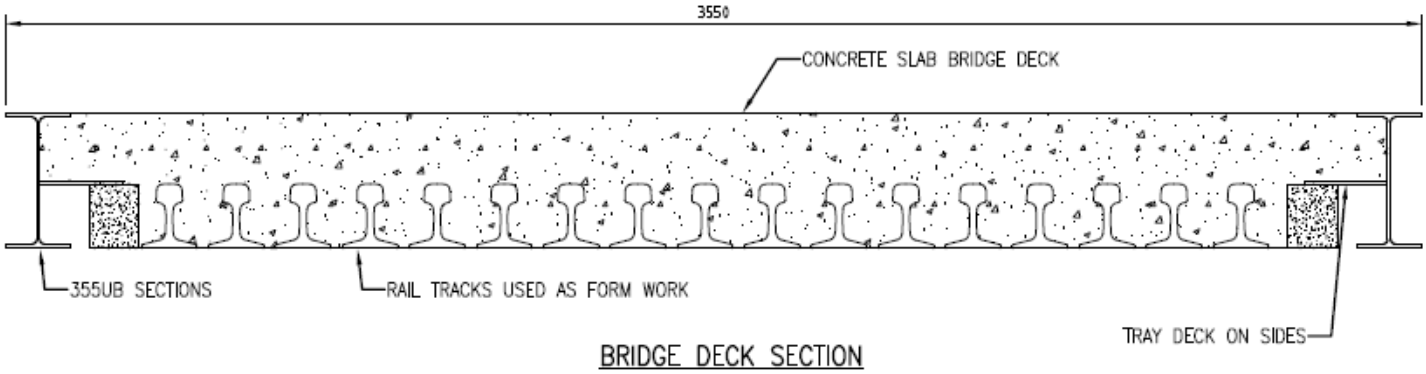
Based on the engineers' calculations of either reinforcement slab or rail track sections, this bridge would be suitable to support the imposed loads from the rail trail.

Remedial Action

It is recommended to remove the timber header between the concrete piers and rail sections, and to treat the corrosion of the steel members. Handrails and kick rail will be required.



BRIDGE ELEVATION



BRIDGE DECK SECTION

No.	Photo	Description
1		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
2		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
3		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**

4		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☒ Other **Corrosion**
5		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☒ Other **Corrosion**
6		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☒ Other **Corrosion**
7		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☒ Other **Corrosion**

8		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☐ Other _____
9		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☐ Other _____
10		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **View across bridge** _____
11		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **General view of bridge** _____

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6. Bridge 2 – Steel Bridge 1



Bridge Number:	2
Description:	Steel Girder Bridge 1
Length:	50-60 metres
Location:	38°21'29.4"S 145°41'10.2"E
Inspection Date:	19/06/24
Condition Notes:	Concrete abutment and piers, steel riveted girders with timber decking over girders.

Observations

Bridge 2 is a substantial structure consisting of concrete piers and riveted steel plate girders, with a 100mm x 200mm timber deck.

The plate girder beam spans vary in depth depending on span. Spans up to 9m are 890mm in overall depth (refer cross-sections). It is estimated the main 17 metre span the girder is approximately 1200mm in depth.

Based on historical use of the bridge, this bridge arrangement would be suitable to support the rail trail imposed loads.

Based on a visual inspection, the bottom flange exhibits surface corrosion and paint degradation, however the top flange exhibits more extensive corrosion in the order of 5mm. The timber deck system has almost completely decayed in sections and is not salvageable.

The concrete piers are in good condition and not exhibiting corrosion of reinforcements or spalling. No visible foundation movement was observed.

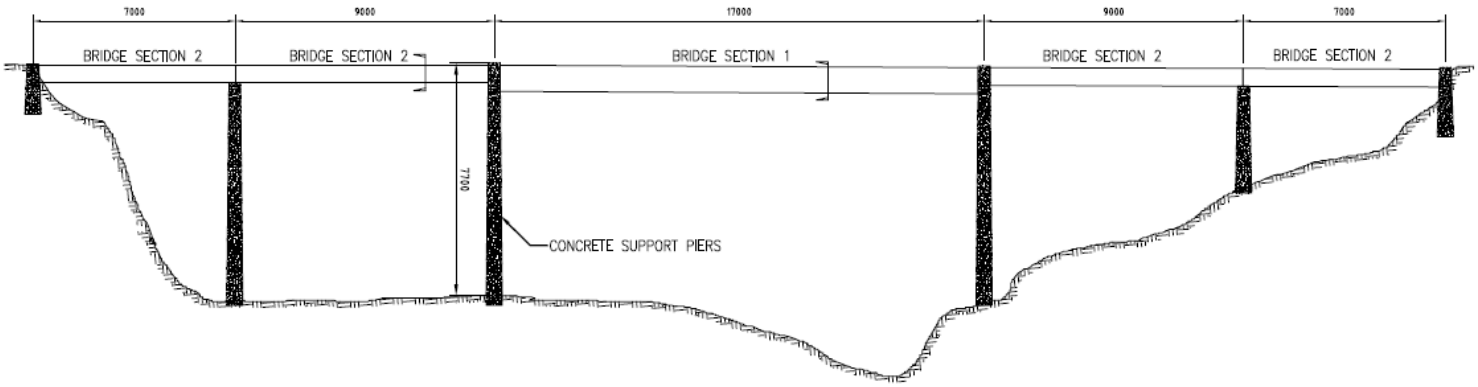
Remedial Action

It is recommended to remove and replace the timber deck with Class 1 Durability timbers, preferably seasoned, as this would reduce shrinkage of the members during their service life and reduce the required ongoing maintenance.

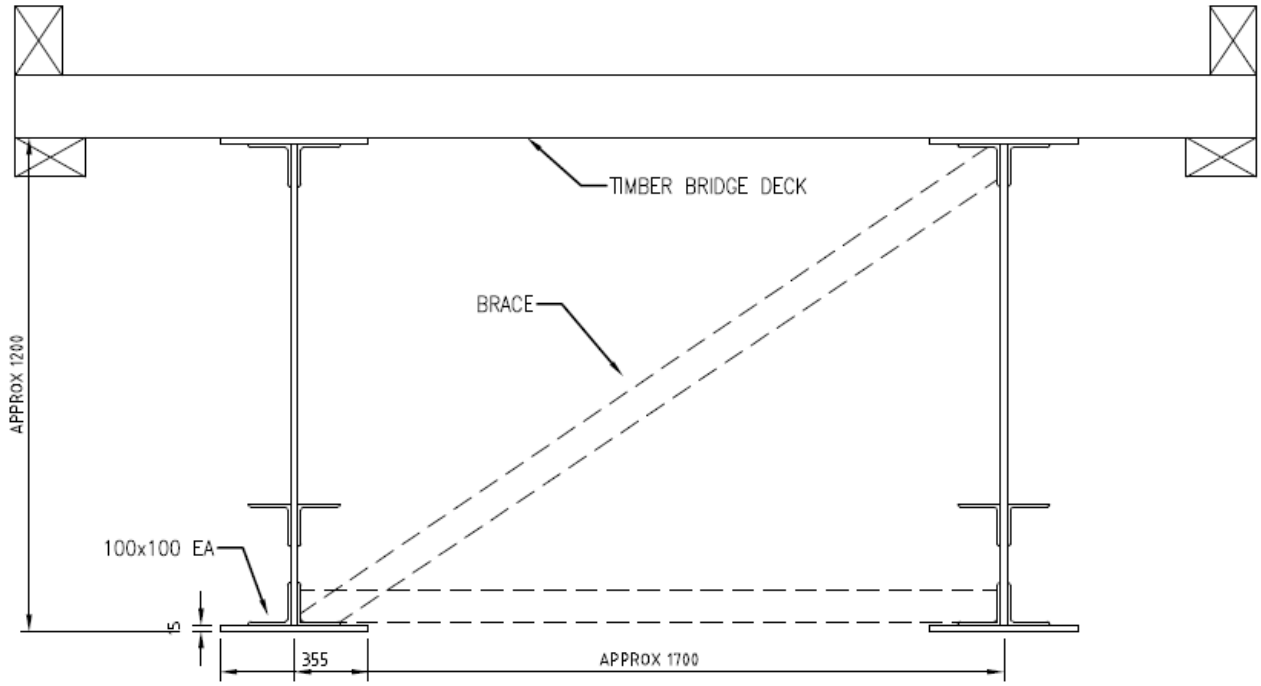
The girders require corrosion treatment and further investigation into the structural adequacy of the plates, as not all elements were completely inspected.

It is also recommended that the new deck be dipped fastened to the girder flange at more frequent intervals than it is currently to provide additional restraint and reduce timber movement.

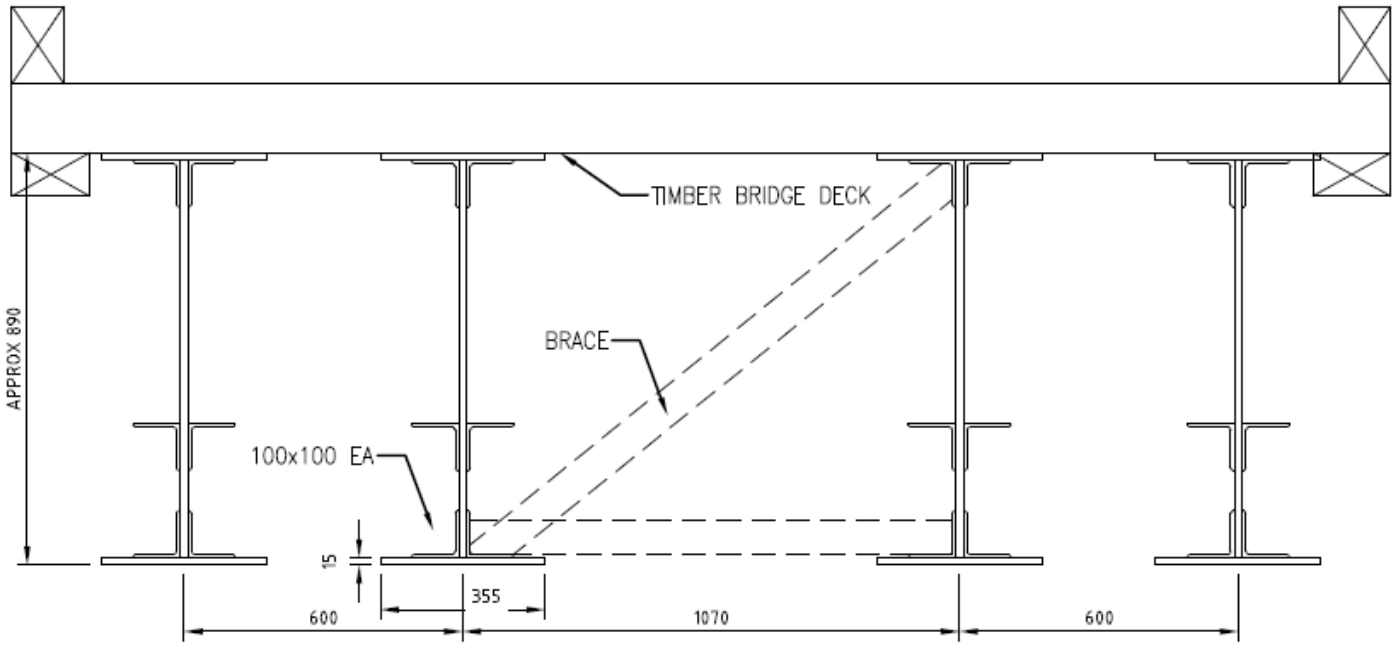
Handrails and kick rails will be required.



BRIDGE ELEVATION



BRIDGE SECTION 1



BRIDGE SECTION 2

No.	Photo	Description
1		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
2		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
3		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**

4		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
5		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
6		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**

7		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
8		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
9		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**

10		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
11		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
12		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☐ Other

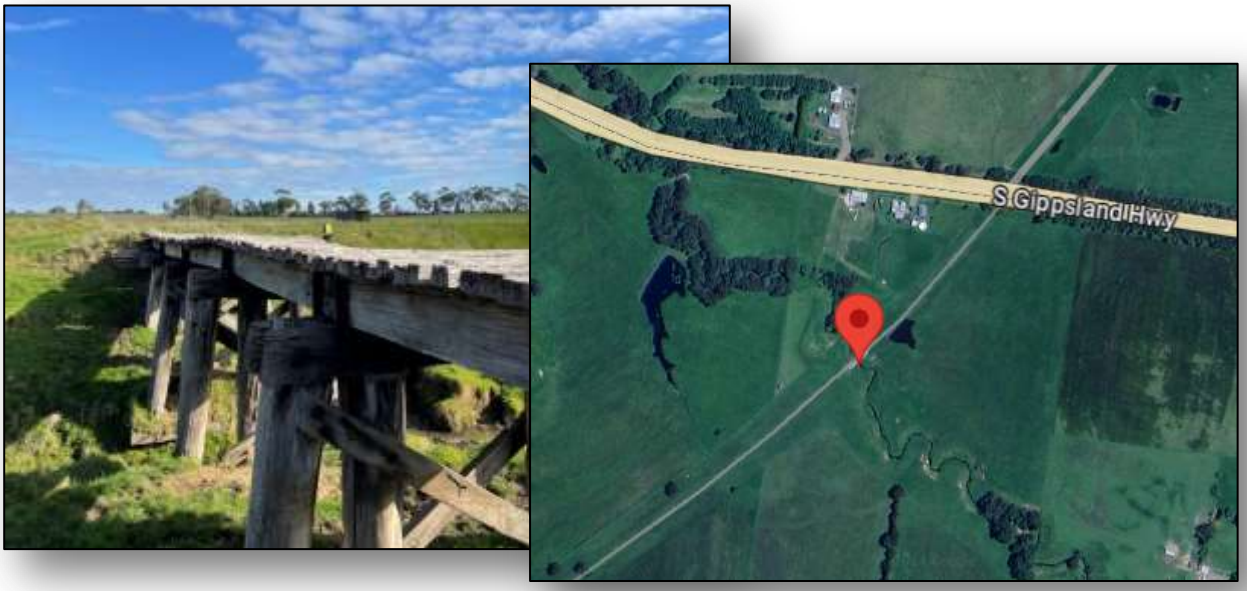
13		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☒ Other **Corrosion**
14		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
15		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other **View from below deck decay**

16		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other **View from below deck decay**
17		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **View to creek.** **No erosion of pier footing.**
18		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **View to creek.** **No erosion of pier footing.**

19		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **View to creek.** **No erosion of pier footing.**
20		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Corrosion**
21		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Current condition**

22		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Current condition**

7. Bridge 3 –Timber Bridge 1



Bridge Number:	3
Description:	Timber Trestle Bridge 1
Length:	41 metres
Location:	38°22'22.3"S 145°40'28.2"E
Inspection Date:	19/06/24
Condition Notes:	Current bridge condition varied from completely rotten in parts to some areas which are salvageable.

Observations

Bridge 3 is a traditional timber bridge system in line with Victoria Railways construction. It spans over an intermittent creek which at the time of inspection was at a low flow. Due to the terrain and erosion patterns, at times the creek will have reasonable flow that undermines the pier's foundations.

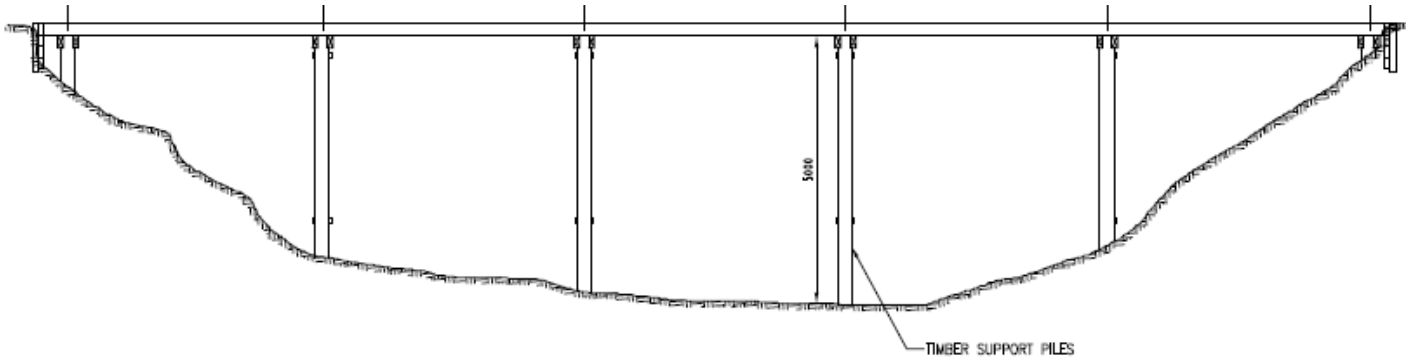
As can be seen from the site measurement, the spans and member sizes are in line with the normal rail bridge constructions. As a 5 span bridge, it is approximately 23 metres in overall length and approximately 5 metres at its highest point from the creek bed.

Subsequently, severe decay and weathering has occurred. As normal practice, the original timber would have been a high durability species. In this case, the species could not be determined. Considering the bridge is approximately 80-100 years old, the degradation is what would be expected.

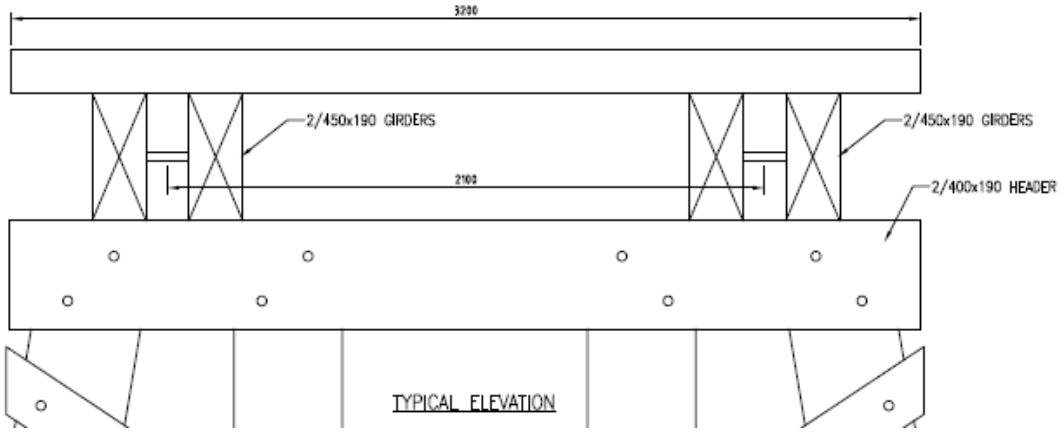
Headers and girders have been reduced to a fibrous bundle with no integrity. On the hammer test was utilised on this bridge to determine the competency of the section and piers that may have a degree of integrity. Unfortunately, this bridge did not contain any element that could be salvaged or re-purposed. The bridge is in severe disrepair and not considered suitable for use.

Remedial Action

Based on the hammer test, the piers are hollow, indicating complete decay of ground line. Based on the current observations and conditions, it is recommended that this bridge be reconstructed as per the original design, utilising local natural durable timber. Alternatively, the current bridge could be kept and fenced off from the public, as display of a historical bridge. A new route and rail trail would be needed to traverse the creek. A suitable location for a new ford-type concrete crossing or concrete box culverts or a FRP deck type boardwalk/bridge could be located 20-25 metres to the north of the existing bridge. These alternatives would all require handrails and kick rails.



BRIDGE ELEVATION



TYPICAL ELEVATION

No.	Photo	Description
1		☒ Decay ☐ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
2		☒ Decay ☐ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
3		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

4		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
5		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier settlement** _____
6		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier settlement** _____
7		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Corrosion** _____

8		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Girder decay**
9		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other
10		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other
11		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other

12		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier settlement**
13		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other
14		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other
15		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other

16		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
17		☒ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☒ Other **General view of collapse**
18		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
19		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

20		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier decay within creek bed**
21		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Timber brace failure**
22		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other

23		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
24		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
25		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

26		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
27		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
28		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
29		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

30		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
31		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
32		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
33		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Creek bed with original ballast** _____

34		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
35		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
36		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
37		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **General condition of structure** _____

38		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
39		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
40		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
41		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

42		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
43		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
44		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
45		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

46		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
47		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
48		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

49		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
50		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
51		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
52		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

53		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
54		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
55		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

56		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier has decayed off ground line**

8. Bridge 6 - Timber Bridge 2



Bridge Number:	6
Description:	Timber Trestle Bridge 2
Length:	25 metres
Location:	38°24'49.2"S 145°36'54.3"E
Inspection Date:	19/06/24
Condition Notes:	Current condition of bridge timber members have minor decay in part with some elements fully decayed.

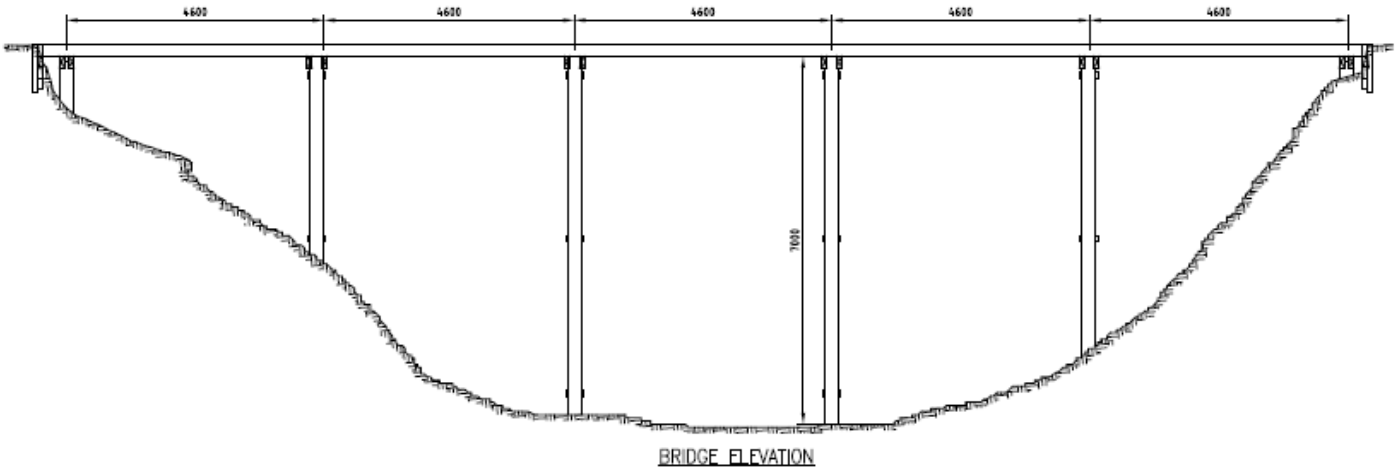
Observations

Bridge 6 over Wattle Creek on first observation appears to be in reasonable condition. It is a standard Victorian railway bridge construction with 6 equal spans and approximately 6 metres in height above the creek bed.

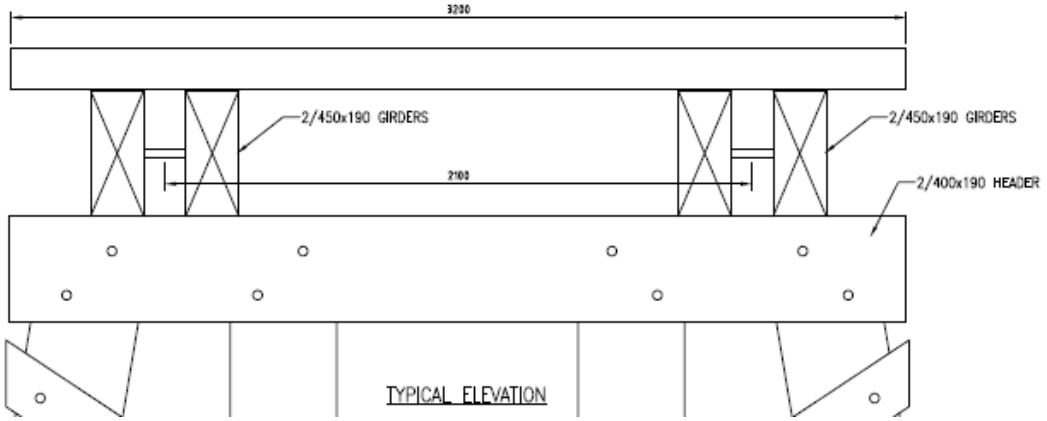
In the main, the majority of members are in a good sound condition and would be suitable for use in a rail trail bridge. The bridge is currently used for light vehicles only.

Remedial Action

On the southern side, around 3 piers would need to be replaced due to ground line decay, and the two header pairs would require replacement as well as a brace. It would also be advised the deck be replaced and upgraded to support current expectations. It appears certain deck planks have already been replaced. Handrails and kick rails will be required.



BRIDGE ELEVATION



TYPICAL ELEVATION

No.	Photo	Description
1		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **General condition**
2		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other
3		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other

4		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
5		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
6		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Rust/corrosion** _____

7		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Pier settlement**
8		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other
9		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other

10		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **General pier condition**
11		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Piers decay**
12		☐ Decay ☐ Weathering ☒ Structural ☐ Non-structural ☐ Other
13		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **General view of bridge**

14		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Brace**
15		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **General view of bridge**
16		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other
17		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Collapse**

18		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Collapse**
19		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other
20		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other
21		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other

22		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
23		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **General condition of cross head** _____
24		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
25		☒ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

26		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **Erosion**
27		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Creek aspect**

9. Bridge 7 –Timber Bridge 3



Bridge Number:	7
Description:	Timber Trestle Bridge 3
Length:	35 metres
Location:	38°25'32.8"S 145°35'54.4"E
Inspection Date:	03/07/24
Condition Notes:	Current condition of timber components would be considered non salvageable. There is extensive decay, weathering and collapse.

Observations

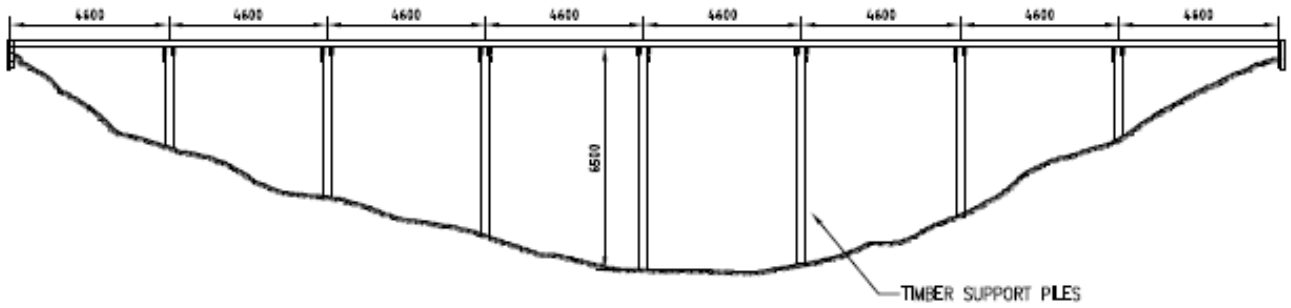
Due to the terrain and accessibility problems due to overgrown vegetation (mainly blackberries and crataegus), it was not possible to conduct non-destructive testing. Only visible observations were conducted.

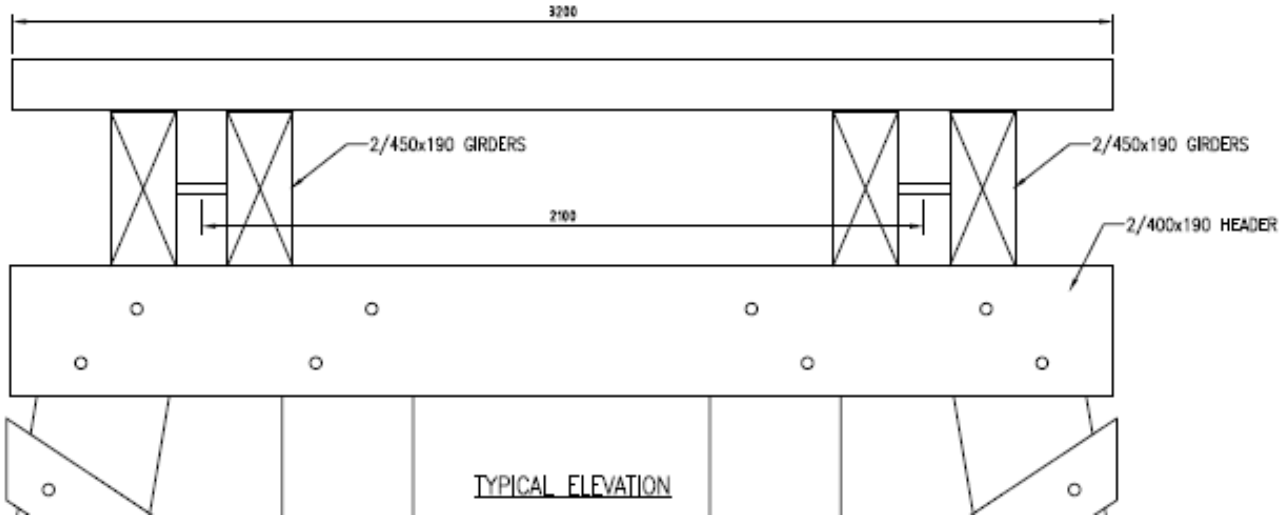
Based on the visual observations, this bridge has decayed, weathered, and in parts collapsed. The timbers are not in a salvageable condition. Significant decay in all members has occurred. Piers in the creek bed region are hollow and decayed, and the piers exhibit splitting and settlement.

Bridge 7 has 8 spans at the standard spans and spacings. It appears to be in line with the standard Victorian Railway structure. The overall height is estimated to be 6.5 metres above the creek bed.

Remedial Action

It is recommended that this bridge and deck be completely replaced due to excessive decay and collapse. An alternative route was sought using Schier Road's existing timber 12 tonne limit road bridge and in discussion with the consultant team, a link a path to the Kernot Community Hall. Refer to recommendations in the main report.





No.	Photo	Description
1		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
2		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
3		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

4		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
5		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
6		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

7		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
8		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Settlement** _____
9		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

10		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
11		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
12		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
13		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

14		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
15		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
16		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
17		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

18		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
19		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
20		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

21		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
22		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
23		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

24		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
25		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
26		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
27		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

28		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
29		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
30		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

31		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
32		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
33		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Collapse** _____
34		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

35		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
36		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
37		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
38		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

39		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
40		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Collapse** _____
41		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Decay of pile in creek bed** _____
42		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

43		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **General view of foliage**
44		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **General view of foliage**
45		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **General view of foliage**
46		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **General view of foliage**

47		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Decay of pile in creek bed**
48		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **General view of foliage**
49		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other
50		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other

51		☒ Decay ☐ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier decay at creek**
52		☒ Decay ☐ Weathering ☐ Structural ☒ Non-structural ☒ Other **Pier decay at creek**
53		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other
54		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other

55		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
56		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
57		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
58		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

59		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
60		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
61		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
62		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

63		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

10. Bridge 8 – Timber Bridge 4



Bridge Number:	8
Description:	Timber Trestle Bridge 4
Length:	35 metres
Location:	38°26'30.7"S 145°33'45.1"E
Inspection Date:	19/06/24
Condition Notes:	Current condition of timber components would be considered non salvageable. There is extensive decay, weathering and collapse.

Observations

Bridge 8 is a standard Victorian Railway bridge structure, typical to this line. It is approximately 7 metres from bridge girder to the bed of Tennant Creek.

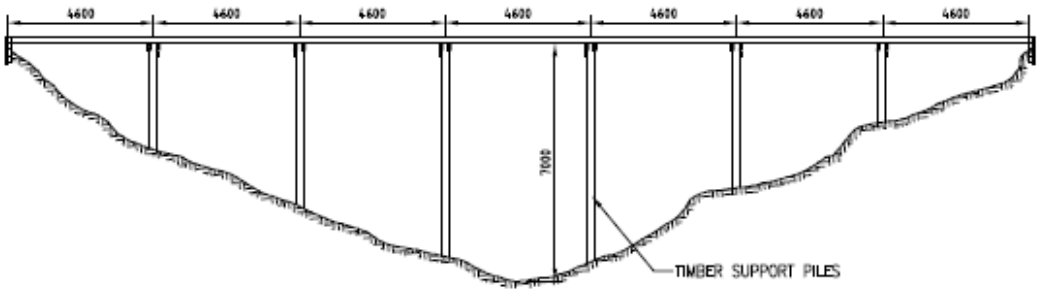
Significant collapse and decay was observed with potential for further collapse, making this bridge a risk for possible site explorers. Elements of the bridge were on the verge of collapse at the time of inspection. A high wind gust may topple some elements and piers.

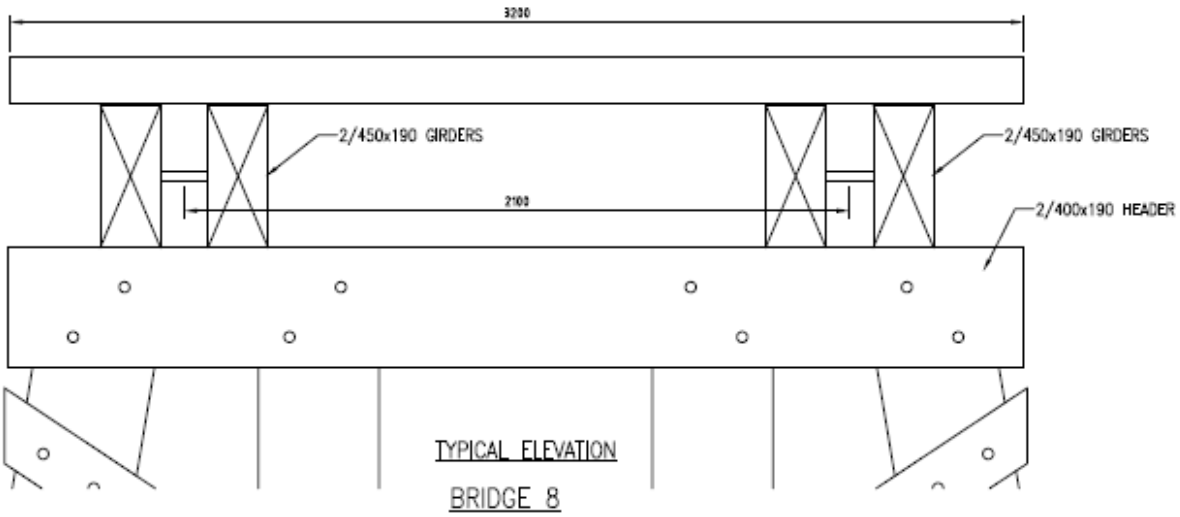
A close examination of the piers showed the piers to be hollow with ground line decay. This was on the majority of piers. Girders and headers have disintegrated and are no longer bearing or supporting the structure.

Excessive splitting and checking was also observed, which significantly reduces the structures integrity, durability and strength. The approach abutments and bracing are no longer salvageable.

Remedial Action

It is recommended the entire bridge be replaced with a like-for-like structure, sourced from local durable timbers. Alternatively, the structure could be kept as a relic, fenced off from the public with a diverted rail path provided just below the side of the Almurta-Glen Forbes Road, or traversing into the ravine and returning up to other bank.





No.	Photo	Description
1		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
2		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
3		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **General view of bridge collapse** _____

4		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
5		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
6		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

7		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
8		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
9		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
10		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

11		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
12		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
13		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

14		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
15		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
16		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

17		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
18		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
19		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

20		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
21		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
22		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

23		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
24		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
25		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

26		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
27		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
28		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
29		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

30		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
31		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
32		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

33		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
34		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

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11. Bridge 9 - Timber Bridge 5 & 9a - Brick Abutment Bridge 1



Bridge Number:	9
Description:	Timber Trestle Bridge 5
Length:	35-40 metres
Location:	38°27'28.0"S 145°32'37.1"E
Inspection Date:	03/07/24
Condition Notes:	Current condition of timber bridge by visual inspection and hammer test indicates considerable weathering and decay in piers and girder, and at the northern end, one section of the bridge has been removed.

Bridge Number:	9a
Description:	Adjacent Brick Abutments
Length:	35-40 metres
Location:	38°27'28.0"S 145°32'37.1"E
Inspection Date:	03/07/24
Condition Notes:	Brick abutments leftover from previous structure are in good condition.

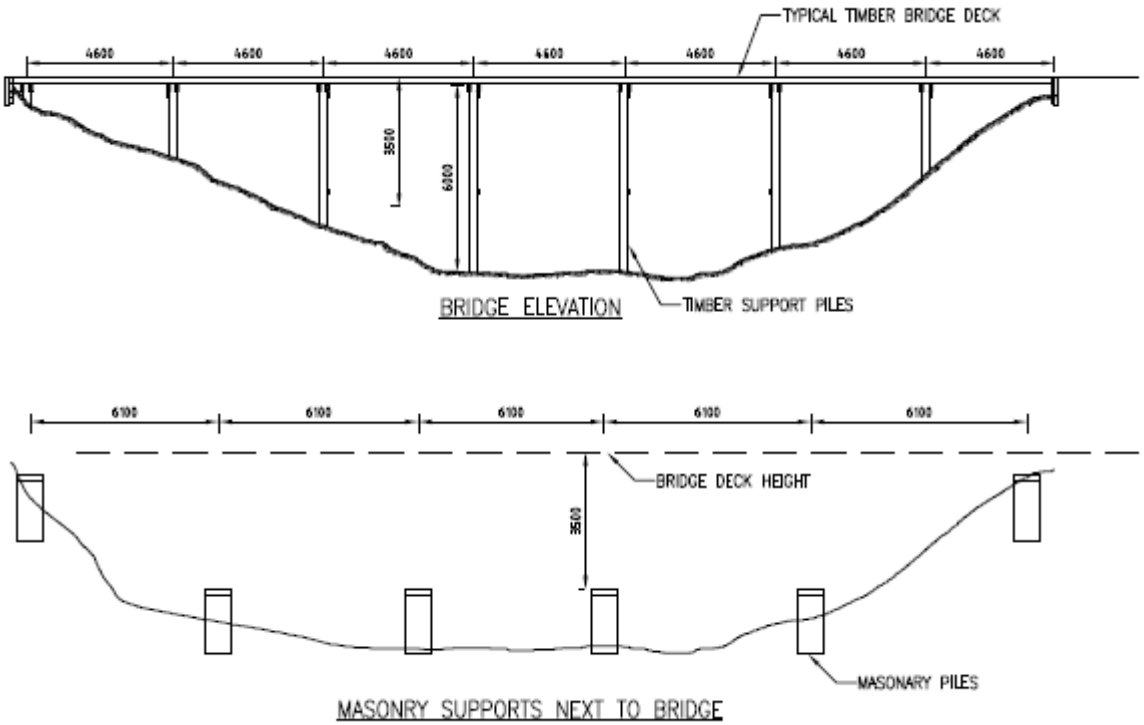
Observations

Bridge 9 is an unusual situation. At first appearance it appears to be a standard timber bridge over the creek below. On approach it was observed there are a number of brick abutments and piers alongside and to the east of the timber bridge.

Remedial Action

Due to significant decay and weathering, Bridge 9 would not be considered suitable for the rail trail path, with one section at the northern end completely missing. A complete new structure would need to be considered.

Alternatively, the existing masonry piers would be considered structural and capable of supporting a new bridge/boardwalk closely adjacent to the current timber structure. The new bridge/boardwalk could be of FRP decking with handrails and kick rails. It would be possible for the old bridge to be cordoned and fenced off, so it could be viewed from the new adjoining structure.



No.	Photo	Description
1		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
2		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
3		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

4		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
5		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
6		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

7		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
8		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
9		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

10		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
11		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
12		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
13		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

14		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
15		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Masonry pier** _____
16		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Pier arrangement & masonry piers** _____
17		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Pier arrangement & masonry piers** _____

18		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **General condition of bridge** _____
19		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☒ Other **Collapse** _____
20		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
21		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☒ Other **Pier arrangement & masonry piers** _____

22		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
23		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
24		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

25		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
26		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
27		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____

28		☒ Decay ☒ Weathering ☒ Structural ☐ Non-structural ☐ Other _____
29		☒ Decay ☒ Weathering ☐ Structural ☒ Non-structural ☐ Other _____
30		☐ Decay ☐ Weathering ☐ Structural ☒ Non-structural ☒ Other **Masonry pier concrete cap** _____

31		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Masonry pier**
32		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Masonry pier attachment points**
33		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Masonry pier attachment points**

34		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Pier settlement**

12. Bridge 10 - Steel Bridge 2



Bridge Number:	10
Description:	Steel Bridge 2
Length:	11 metres
Location:	38°28'05.5"S 145°31'58.2"E
Inspection Date:	03/07/24
Condition Notes:	Bridge was constructed from masonry piers, steel girders and timber decking. It appears the girders have been replaced post 1970's and are galvanised. Masonry piers and girders are in good condition.

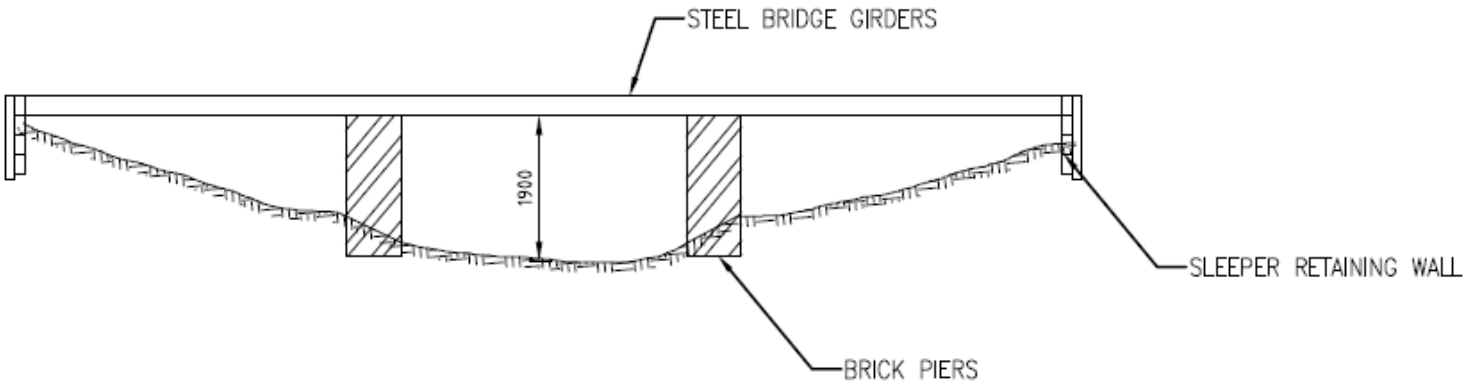
Observations

Bridge 10 comprises of masonry abutments/piers with galvanised bridge girders. The deck has completely decayed and collapsed over the years.

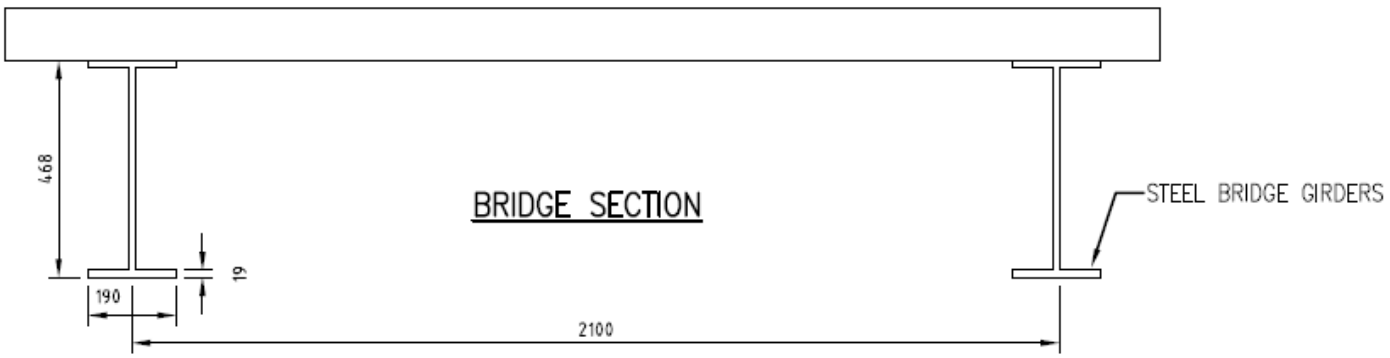
Remedial Action

The steel will require minor restoration with a new timber deck and timber headers.

The structural steel girders could be treated in-situ or dismantled and treated off site. Offsite, a new deck with hand rails could be installed.



BRIDGE ELEVATION



BRIDGE SECTION

No.	Photo	Description
1		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
2		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
3		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

4		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
5		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
6		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
7		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

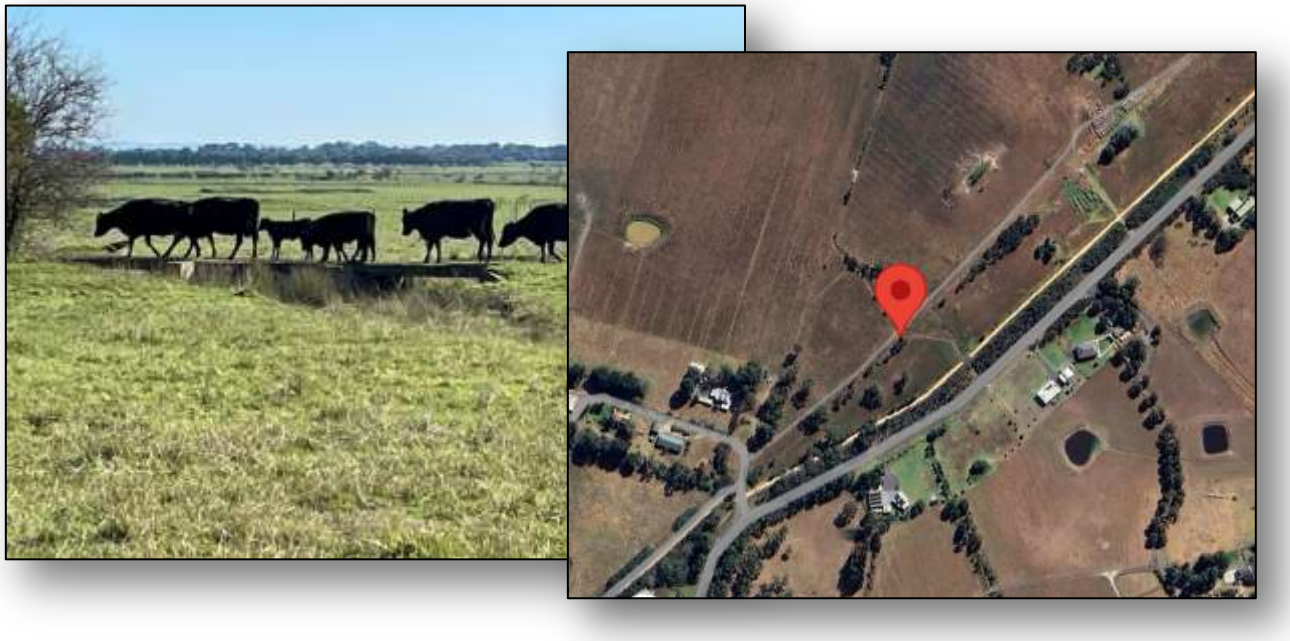
8		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
9		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
10		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

11		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
12		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
13		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

14		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
15		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
16		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

17		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
18		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____
19		☒ Decay ☒ Weathering ☐ Structural ☐ Non-structural ☐ Other _____

13. Bridge 11 - Concrete Bridge 3



Bridge Number:	11
Description:	Concrete Bridge 3
Length:	Unknown
Location:	38°29'59.2"S 145°30'12.1"E
Inspection Date:	03/07/24
Condition Notes:	Current bridge is a combination of concrete piers and planks. Currently it is in use on private property.

Observations

As there was no access to the bridge, due to the bridge being located on private property, it was not inspected. Due to the existing track adjoining this bridge, it is understood this alignment is not required.

Remedial Action

Not applicable.

No.	Photo	Description
1		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Cows crossing bridge**
2		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Cows crossing bridge**
3		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Cows crossing bridge**

4		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Cows crossing bridge**
5		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Nearby existing trail**
6		☐ Decay ☐ Weathering ☐ Structural ☐ Non-structural ☒ Other **Nearby existing trail**

14. Timber Design for Durability

It is of vital importance to consider the durability of the timber selected for construction of the proposed replacement bridges for the Nyora to Woolamai Rail Trail, and the durability of the bridge design itself.

The majority of timber structures will perform their intended function for their service life with minimal maintenance, however it is important for the designer to consider the level of maintenance, repair or replacement that may be required within the design life of the structure.

To design a durable timber structure, it will be essential to assess the building material properties, the performance requirements of the structure, including its expected service life, and the factors or hazards that can influence the durability of specific timber members or the timber structure as a whole.

Timber Durability Contents:

1. Performance Requirements
    - 1.1 Design Life
    - 1.2 Reliability Required
    - 1.3 Initial buildings costs v maintenance costs

2. Hazard Classes, Conditions & Protection
    - 2.1 Weathering
    - 2.2 Insects
    - 2.3 Fungal Attack/Decay
    - 2.4 Corrosion
    - 2.5 Hazard Classes
    - 2.6 Natural Durability

3. Design
    - 3.1 Moisture Content & Moisture Traps
    - 3.2 Joint Detailing
    - 3.3 Shrinkage & Movement
    - 3.4 Corrosive Resistance
    - 3.5 Finishing
    - 3.6 Maintenance

1. Performance requirements

When designing a durable timber structure, the performance requirements will be determined by:

1.1 Design Life

The design life of a structure will vary considerably, depending upon the climate, uses for the structure and the cost of replacing a building or structure. See Table 1 below for a list of typical design life expectancies of various timber structures.

1.2 Reliability required

The degree of reliability required for a particular structure or component is directly related to the minimum level of safety that needs to be achieved, and the consequences of building product failure.

1.3 Initial building costs vs maintenance costs

Initial material and finishing costs must be balanced against long-term maintenance, and/ or repair and replacement costs. Where long-term performance with minimal maintenance is important, attention should be given to:

- good detailing (which eliminates water ingress, allows for shrinkage, etc.)
- quality fastenings (that may be hot dipped galvanising or non-corroding)
- timber with high natural durability
- the quality of the finishing systems.

Table 1[1] on the following page sets out the "typical" design life requirements appropriate for a number of applications. As can be seen in this table, bridges have an expected design life of 20-50 years, require high reliability for public safety and have high consequences of the structure failing.

[1] Source: *National Association of Forest Industries, Timber Design for Durability Manual, September 2003*

Table 1 Typical life expectancy and reliability considerations.

Application	Part	Life Expectancy (Years)	Reliability required		Remarks
			Safety	Cost of Failure	
Temporary Structures					
Bridges - road diversion, trench shoring, temporary construction-props and bracing	All	0.5 - 1	High	High	Very high degree of structural reliability required
Hoardings	Structural components	2 - 3	High	Low	Made up of 5-6 re-use applications
Formwork	Framework	2 - 3	High	Low	5-6 re-use applications
	Sheeting		Low	Low	
Classrooms (Transportable)	Structural Framework	10 - 20	Low	Low	Structural reliability probably based on 25 - 50 years
	Cladding	10 - 20	Low	Low	
Permanent Structures					
Farm Buildings	All	15 - 25	Low	Low	
Bridges - Roads and Rail and Wharves	All	20 - 50	High	High	Require a very high degree of reliability with respect to durability and structural integrity
Domestic Construction	Framework	50+	Low	Low	
	Cladding	25 - 50	Low	Low	
	Add-ons, Pergolas	20	Low	Low	
Industrial Buildings	Framework	50	High	High	Usually non-loadsharing
	Sheeting/ Cladding	25	Low	Low	
Commercial Buildings	Structural	50 - 100	High	High	
	Sheeting/ Cladding	50	High	High	
Public and Institutional Buildings - Civic Centres, Hospitals, etc.	Structural	100+	High	High	
	Sheeting/ Cladding	50 - 100+	High	High	

2. Hazard Classes, Conditions & Protection

Certain conditions and factors can affect timber's durability and its maintenance costs. The potential hazard conditions and the protective measures needed to minimise these hazards must be considered in the design of the bridges.

The following list contains the main hazards or environments that can affect the durability of timber structures:

- weathering
- insect attack
- fungal attack
- chemical degradation
- corrosion
- marine organisms
- fire
- mechanical degradation.

The factors that may influence the proposed bridges along the Nyora to Woolamai Rail Trail are summarised below. They are weathering, insects, fungus/mould decay, erosion and corrosion of fasteners.

2.1 Weathering

Protection from weathering can be obtained by the application and maintenance of finishes, including paints, stains, water repellents and preservatives. Without any treatment, timber exposed to the weather for extended periods of time will discolour, checks and cracks may form the structural integrity may be compromised.

2.2 Insects

Timber structures are best protected from damage by insects through proper design and construction procedures, accurate specification (including species selection) and where necessary, preservative treatment. The main insects that may cause damage to seasoned timber are:

- termites
- lyctine beetles (commonly referred to as Lyctus borers)
- anobiid borers (includes the furniture beetle)

The proposed bridges along the Nyora to Woolamai Rail Trail are not located in areas of prevalent termite activity, or areas of major concern for other insect attacks. It is still highly recommended however that the timber selected for use in the proposed bridges is termite-treated or naturally resistant to termite attack.

2.3 Fungal Attack/Decay

Fungi can be broken down into two sub-groups; moulds and stains which usually affect the timber's appearance, and rot fungi which can significantly affect strength properties, as they penetrate and break down the cellular components of wood.

Four conditions determine the risk of fungal attack on timber. Removal of any one of these four conditions will reduce the risk of fungal attack, although in practice it is usually the exposure to high moisture levels that poses the greatest risk.

- The wood moisture content must be above the fibre saturation point (25% or higher) for prolonged periods
- Oxygen must be present
- Temperatures must generally be in the range of 5°C to 40°C
- Food in the form of unprotected nutrients (found in the wood itself), must be present

The Nyora to Woolamai Rail Trail is located in a Medium risk Hazard Zone, requiring H3 treatment for above ground applications and H5 treatment for in-ground applications for non-naturally durable timbers. It is recommended that a Durability Class 1 to 2 timber be adopted for replacement elements.

2.4 Corrosion

Most timbers are slightly acidic (ph 3 to 6). Therefore, when moisture is present and metals are in contact with the timber, the metals have a low resistance to corrosion. This can also cause chemical reactions that affect the strength of the surrounding timber.

To prevent deterioration of timber around metal objects, such as fasteners, particularly where moisture is present, the following is recommended:

- use non-corrosive or protected metals (i.e. hot dip galvanised)
- countersink and plug or stop fasteners (prevents moisture traps)
- avoid the use of dissimilar metals for fasteners
- grease, coat or sheath fasteners in contact with CCA treated timber (and preferably use hot-dipped galvanised fasteners)

2.5. Hazard Classes

To assist with selecting either naturally durable or preservative-treated timber products, the AS1604 series for 'Specification for preservative treatment' includes a 'Hazard Class selection guide'. There are five hazard classes, from H1 though to H5, defined in terms of specific

service exposures or hazards that the timber is expected to be exposed to during its service. The table below is extracted from AS1604.4 for Laminated Veneer Lumber (2004, page 11).

TABLE 1

HAZARD CLASS SELECTION GUIDE

Hazard class	Exposure	Specific service conditions	Biological hazard	Typical uses
H1	Inside, above ground	Completely protected from the weather and well ventilated, and protected from termites	Lyctid borers	Interior beams, staircases, stringers
H2	Inside, above ground	Protected from wetting. Nil leaching	Borers and termites	Interior beams, staircases, trusses, joists
H3	Outside, above ground	Subject to periodic moderate wetting and leaching	Moderate decay, borers and termites	Exterior beams
H4	Outside, in-ground	Subject to severe wetting and leaching	Severe decay, borers and termites	Bridges, foundation structures
H5	Outside, in-ground contact or in fresh water	Subject to extreme wetting and leaching and/or where the critical use requires a higher degree of protection	Very severe decay, borers and termites	Retaining wall structures, cooling tower structures

NOTES:

1 Examples shown in this Table are not exhaustive. Reference should be made to Table A1 in Appendix A.

2 It is recommended that specifiers nominate the minimum hazard class level appropriate to the specific exposure and service conditions.

2.6 Natural Durability

After determining the Hazard Class facing the timber elements, it is possible to specify the appropriate timber products based on their durability class and expected service life. The natural durability of timber refers to the inherent resistance of a particular species of timber to decay, insect or marine borer attack. For further information on this you can refer to Australian Standard AS5604 – 2005: Timber – Natural Durability Ratings.

Table A1 of AS5064-2005 can be found at Appendix A of this report and contains a full list of timber species and their natural resistance to certain insects, in-ground contact and marine borers.

The classification system is based on the average life expectancy (in years) for a species used in ground, above ground and in sea and estuarine waters. The table on the following page is extracted from AS5604 Timber – Natural Durability Ratings (2005, page 7)

TABLE 1

NATURAL DURABILITY—PROBABLE LIFE EXPECTANCY*

Class	Probable in-ground life expectancy (years)	Probable above-ground life expectancy (years)
1	Greater than 25	Greater than 40
2	15 to 25	15 to 40
3	5 to 15	7 to 15
4	0 to 5	0 to 7

* The ratings in this Table are based on expert opinions and the performance of the following test specimens:

(a) In-ground: 50 × 50 mm test specimens at four sites around Australia.

(b) Above-ground: 35 × 35 mm test specimens at eleven sites around Australia.

NOTES:

1 As further reliable evidence becomes available, these ratings may require amending.

2 The heartwood of an individual piece of timber may vary from the species' nominated classification.

3 Above-ground conditions equate to outside above-ground subject to periodic moderate wetting when ventilation and drainage are adequate.

3. Design

The last element to consider in the durable design of timber is ways to increase durability or eliminate weathering through design itself. The following are some key factors that should be considered in association with the geographical location and building orientation:

- Shielding
- Isolation
- Moisture traps
- Shrinkage allowance/movement
- Ventilation and condensation
- Joint detailing

Considering the nature of the timber bridges being proposed along the Nyora to Woolamai Rail Trail, the most pertinent design elements include moisture traps and joint detailing.

3.1 Moisture traps

Timber properties are greatly affected by the level of moisture content in the material. Seasoned timber kept dry (MC<15%), will not decay and similarly, fully immersed timber where

oxygen is excluded, will not decay. Moisture traps should be avoided particularly where connections and joints are exposed to the weather. In exposed situations, horizontal contact areas between members should be kept to a minimum and where possible, all joints should be free draining. If necessary, drainage holes should be included in the joint detail. It is necessary to divert water away from joints and other places where it can pool, and if water does reach a surface it needs to be able to drain away.

3.2 Joint Detailing

Good design of joint detailing includes the following factors:

- avoiding restraint due to shrinkage
- use of corrosive-resistant metals
- minimising moisture traps and contact areas
- allowing for shrinkage or differential movement
- using the correct fasteners and installation techniques (avoid splitting)
- easy replacement of elements

3.3 Shrinkage & Movement

It is important to make allowance for shrinkage and differential movement at connections in timber elements, particularly where unseasoned timber is used. Shrinkage restraint can cause splitting and subsequent moisture penetration or loss of structural integrity

The following options will help to avoid shrinkage restraint in timber:

- Minimise moisture content changes by using finishes and end-grain sealants
- Align fasteners along member axis
- Use single fasteners at the joints
- Use connections that allow for movement
- Use seasoned timber
- Drill holes 10% oversize in unseasoned timber

3.4 Corrosive Resistance

The interaction of moisture and chemicals on metals can cause a breakdown of the wood fibres around the metal fasteners. Where moisture is present, this breakdown can lead to additional moisture traps and loosening of joints, resulting in a greater chance of decay.

To avoid this problem, it is important to select the correct fasteners; metal fasteners made of material with the required resistance to corrosion and appropriate for the life of the structure.

Choosing the correct fastener is also important to provide restraint against shrinkage and swelling, and to minimise the loosening of joints due to vibration or impact loads.

3.5 Finishing

Timber is hygroscopic. That is, it absorbs and releases moisture in sympathy with its environment. Generally, the denser the species, the less reactive it is to rapid moisture changes. However, denser species tend to have greater overall shrinkage percentages. Therefore permanent moisture changes in denser species will lead to greater movement than occurs with less dense species.

Movement in timber can be greatly reduced by providing protective vapour barriers. The most economical of these is attained through the application of suitable paints, stains or water repellents. These must be maintained during the service life. If they do not provide a total seal, then given sufficient time, the timber will reach a moisture content which is in equilibrium with its surrounding service environment

3.6 Maintenance

The purpose of maintenance is to ensure that the original condition of a material will be retained intact so that it can continue to effectively perform its intended function. Maintenance must, therefore, be considered at the design stage, as the level and frequency of maintenance is a function of the original design and materials specification. It is at this point where initial costs must be weighed up against future maintenance or repair costs.

15. Remedial Action

REMEDIAL ACTION	ESTIMATE ON PROBABLE COSTS
Bridge 1	
▪ Remove timber header and replace with concrete ▪ Treat corrosion to underside with sand blast and coat with paint system ▪ (No scaffold required – treatment above ground level) ▪ Handrails and kick rails	$45,000
Bridge 2 – BASS RIVER	
▪ Remove timber platform ▪ Treat steel corrosion to top of steel beam and coat with non-paint system ▪ Fall protection system ▪ New deck from hardwood sleeper 100x200 ▪ Handrails and kick rails	$338,000
Bridge 3	
▪ Cranage ▪ Demolition with crane and EWP ▪ Fall protection/scaffold ▪ Handrails and kick rails	$910,000
Bridge 6 – WATTLE CREEK	
▪ Removal of timber elements that require replacement ▪ New bridge beams/piers @ 8 locations ▪ Fall protection/scaffold ▪ New deck 100x200 F14, Class 1 durability timber with clamp fixing ▪ Handrails and kick rails	$390,000
Bridge 7 – ADJACENT TO SCHIER ROAD	
▪ Cranage ▪ Demolition of entire timber structure and piers with footings ▪ Pre-fab full new bridge and assemble on site with crane and EWP ▪ Fall protection ▪ Deck ▪ Handrails and kick rails	$1,365,000
Bridge 8 – TENNANT CREEK	
▪ Demolition with crane and EWP ▪ Pre-fab full new bridge and assemble on site with crane and EWP ▪ Fall protection ▪ New deck, 100x200 F14, Class 1 durability timber	$1,235,000

▪ Handrails and kick rails	
Bridge 9 – AT GLEN FORBES	
▪ Make safe and secure old structure	$260,000
Bridge 9a	
▪ New steel bridge of FRP on existing brick abutments. Design and form to be confirmed.	$780,000
Bridge 10 – GORGE CREEK	
▪ Treat existing steel and repaint ▪ Replace timber abutment headers ▪ New deck timbers ▪ Handrails and kick rails	$130,000
Bridge 11	
No action required	$0

Note: The costings provided are only applicable at the time of the issue of this report. Cost may vary once full design and detailing has been completed.

Exclusions:
Cost estimation above does not include:

- Establishment fees
- Permits
- Design
- Inspections
- Environmental Protection
- Disposal
- Temporary Road Access
- Handrails and kick rails
- Employment Allowances
- Indigenous Supervision
- Geotechnical Investigation
- Accommodation & storage

16. Disclaimer

This report has been prepared for the client named and for the purposes stated herein. No party should apply this report for any purpose other than that originally contemplated without first contacting TGA Engineers. It makes no warranties regarding the structural adequacy of the building unless specifically set out in the report. The report is not to be used for the granting of warranty insurance. The report must be presented in full to any contractor who may be using it for pricing.

Yours faithfully



.....

Rob Nestic - B.Eng (Hons)
Director/Senior Engineer
TGA Engineers
Building Licensing Authority Registration No. PE0013419

17. Appendices

A. Table A1 from AS5064-2005: Timber – Natural Durability Ratings, pages 9 to 22
B. Rob Nestic CV 2024, 8 pages

A3.3 Column 3—Termite resistance of heartwood

Termite resistance of heartwood is classified as follows:

R — Resistant to termite.

NR — Not resistant to termite.

Other species not listed, or where there is no rating given (designated as '—'), should be assumed to be not resistant to termite unless evidence to the contrary is provided.

A3.4 Column 4—Natural durability class of heartwood

See Table 1, Clause 7.

A3.5 Column 5—Marine-borer resistance of heartwood

See Table 2, Clause 7.

TABLE A1

NATURAL DURABILITY RATINGS OF TIMBER SPECIES

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
alan *Shorea albida*	S	R	2	2	—
alder, blush *Sloanea australis*	S	—	4	—	4
alder, brown *Caldcluvia paniculosa*	S	NR	4	—	4
alder, pink *Gillbeea adenopetala*	NS	NR	4	—	4
alder, rose *Caldcluvia australiensis*	NS	NR	4	—	4
almond, rose *Owenia venosa*	NS	R	1	1	—
amberoi *Pterocymbium* spp.	S	NR	4	—	4
apple, rough-barked *Angophora floribunda*	S	—	3	—	—
apple, smooth-barked *Angophora costata*	S	—	3	—	4
ash, alpine *Eucalyptus delegatensis*	(See Note in Paragraph A3.2)	NR	4	3	4
ash, Blue Mountains *Eucalyptus oreades*	NS	—	4	—	4
ash, Crow's *Flindersia australis*	S	R	1	1	—
ash, hickory *Flindersia ifflaiana*	S	R	2	1	—
ash, mountain *Eucalyptus regnans*	NS	NR	4	3	4

(*continued*)

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TABLE A1 (*continued*)

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
ash, pink *Alphitonia petriei*	NS	NR	4	—	4
ash, red Alphitonia excelsa *Alphitonia whitei*	NS	NR	2	—	—
ash, silver *Flindersia bourjotiana* *Flindersia schottiana*	S	NR	3	—	4
ash, silvertop *Eucalyptus sieberi*	NS	NR	3	2	4
ash, white *Eucalyptus fraxinoides*	S	NR	4	—	4
backhousia, stony *Backhousia hughesii*	NS	NR	2	—	—
balau (selangan batu) *Shorea* spp.	S	NR	2	1	4
balau, red *Shorea* spp.	S	NR	4	—	—
baltic, red (pine, Scots) *Pinus sylvestris*	NS	—	4	—	4
baltic, white (spruce, Norway) *Picea abies*	NS	—	4	—	4
bamboo* (various species)	S	—	—	—	—
bean, black *Castanospermum australe*	S	—	2	—	—
beech, myrtle *Nothofagus cunninghamii*	S	NR	4	3	4
beech, negrohead *Nothofagus moorei*	S	NR	4	—	4
beech, silver *Nothofagus menziesii*	NS	NR	4	—	4
beech, white *Gmelina* spp.	S	—	—	—	—
beefwood *Grevillea striata*	S	NR	2	—	—
belah *Allocasuarina cristata*	NS	—	2	—	—
belian *Eusideroxylon zwageri*	—	R	1	1	1
birch, white *Betula pubescens*	—	—	4	—	4
birch, white, Australia *Schizomeria ovata*	S	—	4	4	4

* Bamboo is not strictly a timber species although it may be used in building applications. (*continued*)

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TABLE A1 (*continued*)

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
blackbutt *Eucalyptus pilularis*	NS	R	2	1	3
blackbutt, New England *Eucalyptus andrewsii* *Eucalyptus campanulata*	S	R	2	2	2
blackbutt, Western Australian *Eucalyptus patens*	S	R	2	1	3
blackwood *Acacia melanoxylon*	S	—	3	3	4
bloodwood, brown *Corymbia trachyphloia*	S	R	1	1	—
bloodwood, Island, Melville *Corymbia nesophila*	S	—	—	—	—
bloodwood, red *Corymbia gummifera* *Eucalyptus intermedia* *Eucalyptus polycarpa*	S	R	1	1	3
bloodwood, yellow Corymbia eximia	S	NR	2	—	—
bollywood *Cinnamomum baileyanum* *Litsea* spp.	S	NR	3	3	4
box, black *Eucalyptus largiflorens*	S	—	1	1	—
box, brush *Lophostemon confertus*	NS	R	3	3	2
box, grey *Eucalyptus microcarpa* *Eucalyptus moluccana* *Eucalyptus woollsiana*	S	R	1	1	2
box, grey, coast *Eucalyptus bosistoana*	S	R	1	1	3
box, ironwood *Choricarpia leptopetala* *Choricarpia subargentea*	NS	NR	3	—	4
box, kanuka *Tristania exiliflora* *Tristania laurina*	NS	NR	3	—	4
box, long-leaved *Eucalyptus goniocalyx*	S	R	3	2	—
box, red *Eucalyptus polyanthemos*	S	R	1	1	—
box, steel *Eucalyptus rummeryi*	NS	R	1	1	—

(*continued*)

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TABLE A1 (*continued*)

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
box, swamp *Lophostemon suaveolens*	NS	R	2	1	2
box, white *Eucalyptus albens*	NS	R	2	1	—
box, white-topped *Eucalyptus quadrangulata*	NS	R	2	2	—
box, yellow *Eucalyptus melliodora*	NS	R	1	1	—
brigalow *Acacia harpophylla*	S	R	1	1	—
brownbarrel *Eucalyptus fastigata*	S	NR	4	3	4
bullich *Eucalyptus megacarpa*	S	NR	3	2	4
cadaga *Eucalyptus torelliana*	S	NR	2	—	—
calantas *Toona calantas*	S	—	2	1	—
calophyllum *Calophyllum* spp.	S	NR	4	—	4
candlebark *Eucalyptus rubida*	S	NR	4	3	4
carabeen, yellow *Sloanea woolsii*	S	NR	4	—	4
carbeen *Corymbia tessellaris* *Eucalyptus tessellaris*	S	R	1	1	—
cedar, red *Toona australis*	S	—	2	—	4
cedar, western red *Thuja plicata*	NS	R	3	2	—
cedar, yellow (Alaska) *Chamaecyparis nootkatensis*	NS	R	1	1	—
cheesewood, white *Alstonia scholaris*	S	—	4	—	4
chengal *Balanocarpus heimii*	NS	R	1	1	—
coachwood *Ceratopetalum apetalum*	NS	NR	4	—	4
cypress, black *Callitris endlicheri*	NS	R	2	1	3
cypress, white *Callitris glaucophylla*	NS	R	2	1	2

(*continued*)

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TABLE A1 (*continued*)

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
dabarima *Planchonia* spp.	NS	—	—	—	—
fir, amabilis *Abies amabilis*	NS	—	4	—	4
fir, Douglas (oregon) *Pseudotsuga menziesii*	NS	NR	4	4	4
gaboon *Aucoumea klaineana*	NS	NR	—	—	—
geronggang *Cratoxylon arborescens*	NS	NR	4	—	4
giam *Hopea* spp.	S	NR	2	—	—
gidgee *Acacia cambagei*	NS	NR	1	1	—
gum, blue, southern *Eucalyptus globulus*	S	NR	3	2	4
gum, blue, Sydney *Eucalyptus saligna*	S	NR	3	2	3
gum, grey *Eucalyptus canaliculata* *Eucalyptus major* *Eucalyptus propinqua* *Eucalyptus punctata*	NS	R	1	1	2
gum, grey, mountain *Eucalyptus cypellocarpa*	S	NR	3	2	4
gum, Maiden's *Eucalyptus maidenii*	S	NR	3	2	4
gum, manna Eucalyptus viminalis	S	NR	4	3	4
gum, mountain *Eucalyptus dalrympleana*	S	NR	4	3	4
gum, pink *Eucalyptus fasciculosa*	S	NR	3	—	4
gum, poplar *Eucalyptus alba*	—	NR	3	3	4
gum, red, forest *Eucalyptus blakelyi* *Eucalyptus tereticornis*	NS	R	1	1	2
gum, red, narrow-leaved *Eucalyptus seeana*	S	R	2	—	—
gum, red, river *Eucalyptus camaldulensis*	S	R	2	1	2
gum, rose *Eucalyptus grandis*	NS	NR	3	2	4

(*continued*)

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TABLE A1 (*continued*)

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
gum, round-leaved *Eucalyptus deanei*	S	—	3	—	—
gum, salmon *Eucalyptus salmonophloia*	NS	R	2	1	—
gum, scribbly *Eucalyptus haemastoma* *Eucalyptus micrantha* *Eucalyptus racemosa* *Eucalyptus rossii* *Eucalyptus sign*ata	NS	R	3	2	—
gum, shining *Eucalyptus nitens*	S	NR	4	3	4
gum, spotted *Corymbia maculata* *Corymbia citriodora* *Eucalyptus henryi*	S	R	2	1	4
gum, sugar *Eucalyptus cladocalyx*	S	R	1	1	—
gum, swamp *Eucalyptus camphora*	S	NR	4	—	4
gum, white, Dunn's *Eucalyptus dunnii*	S	—	4	—	4
gum, yellow *Eucalyptus leucoxylon*	S	R	2	2	—
hardwood, Johnston River *Backhousia bancroftii*	S	NR	3	2	4
hemlock, western *Tsuga heterophylla*	NS	NR	4	4	4
hollywood, yellow *Premna lignum-vitae*	NS	—	1	1	—
ironbark, Caley's *Eucalyptus caleyi*	S	R	—	1	—
ironbark, grey *Eucalyptus drepanophylla* *Eucalyptus paniculata* *Eucalyptus siderophloia*	NS	R	1	1	3
ironbark, gum-topped *Eucalyptus decorticans*	NS	R	1	1	—
ironbark, red *Eucalyptus sideroxylon*	S	R	1	1	2
ironbark, red, broad-leaved *Eucalyptus fibrosa* subsp. *fibrosa*	NS	R	1	1	—
ironbark, red, narrow-leaved *Eucalyptus crebra*	NS	R	1	1	—

(*continued*)

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TABLE A1 (*continued*)

1	2	3	4		5
Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
ironbark, silver-leaved *Eucalyptus melanophloia*	NS	R	1	1	—
ironwood, Cooktown *Erythrophloeum chlorostachys*	S	R	1	1	—
jam, raspberry *Acacia acuminata*	NS	R	1	1	2
jarrah *Eucalyptus marginata*	S	R	2	2	3
jelutong *Dyera costulata*	S	—	4	—	4
kamarere *Eucalyptus deglupta*	S	NR	4	—	4
kapur *Dryobalanops* spp.	NS	NR	3	2	4
karri *Eucalyptus diversicolor*	NS	NR	3	2	4
kauri, New Zealand *Agathis australis*	NS	—	2	—	4
kauri, Queensland *Agathis atropurpurea* *Agathis microstachya* *Agathis robusta*	NS	NR	4	4	4
kempas *Koompassia malaccensis*	S	NR	3	—	4
keruing *Dipterocarpus* spp.	S	NR	3	3	4
kwila (merbau) *Intsia bijuga*	S	R	3	1	3
laurel, camphor *Cinnamonum camphora*	S	—	—	—	—
lumbayau (mengkulang) *Heritiera* spp.	S	NR	4	—	4
mahogany, African *Khaya* spp.	S	—	3	—	—
mahogany, American *Swietenia mahogani*	S	—	3	—	—
mahogany, brush *Geissois benthamii*	S	NR	4	—	4
mahogany, red *Eucalyptus pellita* *Eucalyptus resinifera*	S	R	2	1	2
mahogany, red, Philippine, *Shorea* spp.	S	NR	4	3	4

(*continued*)

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Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
mahogany, southern *Eucalyptus botryoides*	NS	R	3	2	—
mahogany, white *Eucalyptus acmenoides* *Eucalyptus tenuipes* *Eucalyptus umbra* subsp. *Carnea*	NS	R	1	1	2
malas *Homalium foetidum*	NS	NR	3	—	4
mallet, brown *Eucalyptus astringens*	NS	R	2	1	—
malletwood *Rhodamnia argentea* *Rhodamnia costata*	NS	NR	3	—	4
malletwood, brown *Rhodamnia rubescens*	NS	NR	3	—	4
malletwood, silver *Rhodamnia acuminata*	NS	NR	3	—	4
mangrove, grey *Avicennia marina*	NS	NR	4	—	4
maple, Queensland *Flindersia brayleyana*	NS	NR	4	—	4
maple, rose *Cryptocarya erythroxylon*	S	NR	4	—	4
maple, scented *Flindersia laevicarpa*	NS	NR	3	—	4
maple, sugar (rock) *Acer saccharum*	S	—	4	—	4
marri *Corymbia calophylla* *Eucalyptus calophylla*	S	NR	3	3	4
medang tabak *Dactylocladus stenostachys*	NS	NR	—	—	—
meranti, bakau *Shorea* spp.	S	NR	4	—	4
meranti, dark-red *Shorea* spp.	S	NR	4	3	4
meranti, light-red *Shorea* spp.	S	NR	4	4	4
meranti, white *Shorea* spp.	S	NR	4	—	4
meranti, yellow *Shorea* spp.	S	R	4	—	4
mersawa *Anisoptera* spp.	S	NR	4	3	4

(*continued*)

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			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
messmate *Eucalyptus obliqua*	S	NR	3	3	4
messmate, Gympie *Eucalyptus cloeziana*	NS	R	1	1	—
mulga *Acacia aneura*	—	—	2	—	—
myall *Acacia pendula*	NS	NR	2	—	—
nyatoh *Palaquium* and *Payena* spp.	NS	—	4	—	4
oak, bull *Allocasuarina luehmannii*	NS	R	1	1	—
oak, European *Quercus* spp.	S	—	2	—	—
oak, silky, northern *Cardwellia sublimis*	S	NR	4	—	4
oak, silky, southern *Grevillea robusta*	S	—	—	—	—
oak, tulip, blush *Argyrodendron actinophyllum*	S	NR	4	—	4
oak, tulip, brown *Argyrodendron polyandrum* *Argyrodendron trifoliolatum*	S	NR	4	—	4
oak, tulip, red *Argyrodendron peralatum*,	S	NR	4	—	4
oak, white, American *Quercus alba*	S	NR	4	—	4
Paulownia *Paulownia* spp.	S	NR	4	4	4
penda, brown *Xanthostemon chrysanthus*	NS	R	2	1	2
penda, red *Xanthostemon whitei*	NS	R	2	1	2
penda, southern *Xanthostemon, oppositifolius*	NS	NR	2	1	2
penda, yellow *Ristantia pachysperma*	NS	NR	3	—	2
peppermint, black *Eucalyptus amygdalina*	S	NR	4	3	4
peppermint, broad-leaved *Eucalyptus dives*	S	NR	3	2	4

(*continued*)

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Standard common name and scientific/botanical name	**Lyctid susceptibility of sapwood**	**Termite resistance of heartwood (inside above ground—applicable to H2 in AS 1604 series)**	**Natural durability class of heartwood**		**Marine-borer resistance of heartwood**
			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
peppermint, narrow-leaved *Eucalyptus australiana* *Eucalyptus radiata* *Eucalyptus robertsonii*	S	NR	3	3	4
peppermint, Queensland *Eucalyptus exserta*	S	R	1	1	—
peppermint, river *Eucalyptus elata*	S	NR	4	3	4
peppermint, white *Eucalyptus pulchella*	S	NR	3	—	4
pine, black *Prumnopitys amara*	NS	—	4	—	—
pine, brown *Podocarpus elatus*	NS	—	—	—	3
pine, bunya *Araucaria bidwillii*	NS	NR	4	4	4
pine, Canary Island *Pinus canariensis*	NS	NR	4	4	4
pine, Caribbean *Pinus caribaea*	NS	R	4	4	4
pine, celery-top *Phyllocladus asplenifolius*	NS	R	3	2	—
pine, Corsican *Pinus nigra*	NS	—	4	4	4
pine, hoop *Araucaria cunninghamii*	NS	NR	4	4	4
pine, Huon *Lagarostrobos franklinii*	NS	R	3	3	4
pine, King William *Athrotaxis selaginoides*	NS	R	2	2	4
pine, klinki *Araucaria hunsteinii*	NS	NR	4	—	4
pine, loblolly *Pinus taeda*	NS	NR	4	4	4
pine, longleaf *Pinus palustris*	NS	NR	4	4	4
pine, maritime *Pinus pinaster*	NS	R	4	4	4
pine, NZ white (kahikatea) *Dacrycarpus dacrydioides*	NS	—	4	—	4
pine, patula *Pinus patula*	NS	—	4	4	4
pine, ponderosa *Pinus ponderosa*	NS	—	4	4	4

(*continued*)

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			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
pine, radiata *Pinus radiata*	NS	NR	4	4	4
pine, Scots *Pinus sylvestris*	NS	—	4	—	4
pine, slash *Pinus elliottii*	NS	R	4	4	4
pine, slash, Caribbean hybrid *Pinus elliottii, P. caribaea*	NS	R	4	4	4
pine, white, western *Pinus monticola*	NS	—	4	—	4
planchonella *Planchonella chartacea*	S	NR	4	—	4
planchonia *Planchonia* spp.	NS	NR	—	—	—
poplar, balsam *Populus* spp.	S	NR	4	—	4
poplar, pink *Euroschinus falcata*	S	NR	4	—	4
quandong, silver *Elaeocarpus angustifolius* *Elaeocarpus grandis*	S	NR	4	—	4
ramin *Gonystylus* spp.	S	NR	4	4	4
redwood *Sequoia sempervirens*	NS	R	2	1	4
rimu *Dacrydium cupressinum*	NS	—	4	—	4
rosewood, New Guinea *Pterocarpus indicus*	S	R	3	2	—
rustyjacket *Eucalyptus peltata*	S	NR	2	2	—
saffronheart *Halfordia kendack* *Halfordia scleroxyla*	NS	R	1	1	—
sandalbox *Eremophila, mitchellii*	NS	R	1	1	—
sassafras *Daphnandra dielsii* *Daphnandra micrantha* *Daphnandra repandula* *Doryphora aromatica* *Doryphora sassafras*	NS	NR	4	—	4
sassafras, grey *Dryadodaphne novoguineensis*	NS	NR	—	—	—

(*continued*)

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TABLE A1 (*continued*)

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			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
satinash, grey *Syzygium claviflorum* *Syzygium gustavioides*	S	NR	3	—	4
satinash, rose *Syzygium crebrinerve* *Eugenia francisii*	S	—	3	—	—
satinay *Syncarpia hillii*	NS	R	2	1	1
satinbox *Phebalium squameum*	NS	—	2	2	—
sepetir *Copaifera* spp. *Pseudosindora* spp. *Sindora* spp.	S	NR	4	—	4
sheoak, beach *Allocasuarina equisetifolia*	NS	—	3	—	—
sheoak, black *Allocasuarina littoralis*	NS	—	3	—	4
sheoak, river *Casuarina cunninghamiana*	NS	—	—	—	—
sheoak, rose *Allocasuarina torulosa*	NS	—	2	—	—
sheoak, swamp *Casuarina glauca*	NS	—	—	—	—
silkwood, maple *Flindersia pimenteliana*	NS	NR	4	—	4
spruce, Norway *Picea abies*	NS	—	4	—	4
spruce, Sitka *Picea sitchensis*	NS	—	4	—	4
stringybark, Blackdown *Eucalyptus sphaerocarpa*	NS	R	2	1	—
stringybark, blue-leaved *Eucalyptus agglomerata*	NS	NR	3	3	4
stringybark, brown *Eucalyptus baxteri* *Eucalyptus blaxlandii* *Eucalyptus capitellata*	NS	NR	3	2	4
stringybark, Darwin *Eucalyptus tetrodonta*	S	R	1	1	—
stringybark, diehard *Eucalyptus cameronii*	—	—	3	—	—
stringybark, red *Eucalyptus macrorhyncha*	S	R	3	2	3

(*continued*)

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			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
stringybark, silvertop *Eucalyptus laevopinea*	NS	NR	3	3	4
stringybark, white *Eucalyptus eugenioides* *Eucalyptus globoidea* *Eucalyptus phaeotricha*	NS	R — —	3 2 —	2 — —	3
stringybark, yellow *Eucalyptus muelleriana*	NS	R	3	2	3
sycamore, silver *Cryptocarya glaucescens*	NS	NR	4	—	4
tallowwood *Eucalyptus microcorys*	S	R	1	1	3
taun *Pometia* spp.	S	NR	3	2	4
teak, Burmese *Tectona grandis*	S	R	2	1	—
tea-tree, broad-leaved *Melaleuca leucadendron* *Melaleuca quinquenervia* *Melaleuca viridiflora*	S	—	3	—	3
tea-tree, river *Melaleuca bracteata*	NS	—	3	—	—
tingle, red *Eucalyptus jacksonii*	NS	—	3	3	4
tingle, yellow *Eucalyptus guilfoylei*	NS	—	2	1	—
touriga, red *Calophyllum costatum*	NS	NR	4	—	4
tuart *Eucalyptus gomphocephala*	S	R	2	1	4
turpentine *Syncarpia glomulifera*	NS	R	2	1	1
vitex *Vitex cofassus*	NS	NR	—	—	—
walnut, New South Wales *Endiandra virens*	NS	—	4	—	4
walnut, Queensland *Endiandra palmerstonii*	S	—	4	—	4
walnut, yellow *Beilschmiedia bancroftii*	S	NR	4	—	4
wandoo *Eucalyptus wandoo*	NS	R	1	1	3
wandoo, powderbark *Eucalyptus accedens*	NS	R	1	1	—

(*continued*)

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			In-ground contact, D_{ig}	**Outside above ground, D_{ag}**	
wattle, ironwood *Acacia estrophiolata* *Acacia excelsa*	NS	—	2	—	—
woollybutt *Eucalyptus longifolia*	S	R	1	1	—
woollybutt, northern *Eucalyptus miniata*	S	NR	2	—	—
yapunyah *Eucalyptus ochrophloia*	S	—	1	1	—
yapunyah, mountain *Eucalyptus thozetiana*	NS	R	1	1	—
yarran *Acacia homalophylla*	NS	—	—	—	—
yate *Eucalyptus cornuta*	NS	—	2	1	—
yate, swamp *Eucalyptus occidentalis*	—	—	—	—	4
yertchuk *Eucalyptus consideniana*	NS	R	2	1	—

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CURRICULUM VITAE

ROBERT ANTHONY NESTIC

Mr Robert Anthony Nestic (Director and Design Manager)

Timgib Pty Ltd trading as TGA Engineers
20 Sydney Road Bayswater Vic 3153
PO Box 301, Box Hill 3128
Phone: (03) 9780 4866
Email: rob@tgaengineers.com

PROFESSIONAL MEMBERSHIPS

- Past President of Association of Consulting Engineers Victoria
- Corporate Member of Association of Consulting Engineers Victoria
- Member of Engineers Australia

ACCREDITATIONS

- B.Eng. (Civil) Honours
- Building Licensing Authority Registration Number - PE0013419
- National Engineers register – NER.
- Building Service provider Tasmania.

STUDIES & POST GRADUATE STUDY

- Bachelor of Engineering (Honours) - Civil Engineering, Monash University, Clayton campus.
- Final yearbook prize for outstanding achievement in the study of structural engineering – The institution of Engineering Australia, Structural Branch, Victoria Division.

Ÿ Postgraduate - Research into Edge bonded glued laminated timber

- Literature search of relevant past and current research into glue laminated timber.
- Development of Finite element model to analyse stress levels at glue joints with varying grain orientation.
- Monte Carlo simulation of strength and stiffness characteristics of glue laminated timber.
- Finite Element Analysis of finger joints profiles to determine critical parameters governing strength.
- Destructive testing of various finger joint profiles to verify theoretical parameters using RF and PU adhesives.
- Fabrication of edge bonded glue laminated timber beams for destructive testing. Process involved study and development fabrication techniques
- Destructive testing of edge bonded glue laminated timber to determine characteristic strengths.

Ÿ Published Literature

- 'Shrinkage induced stresses in adhesive joints of glued laminated timber', R. Nestic and H. R. Milner – Journal of the institute of wood science, Volume 12. Number 4. Issue 70

Ÿ Academic Lecturing

- Monash University 2012, 2013, 2020
  Lectured and assessed Timber Engineering elective unit for third year civil engineering students on campus. Content included design, connections, material properties, species, major project, tutorial and exam paper.

ENGINEERING DESIGN EXPERIENCE

Senior Design Engineer : 2001 – 2018

Director / Senior Design Manager: 2018 to current

- Structural design of structural elements in steel, timber, concrete, glass, masonry and aluminum.
- Design of foundation systems.
- Structural and Finite Element Stress analysis of structural and mechanical systems.
- Investigation of distressed structures due to moisture movement in soils due to trees or other factors.
- Investigation of building and mechanical systems due to fatigue or structural failures.
- Design and detailing of Temporary works for earth retaining during basement excavation beneath existing buildings.
- Inspection and certification of amusement rides.
- Investigation and reporting of structural defects in residential and commercial and industrial structures and advice of required remedial work.

TIMBERBUILT PTY LTD
Design Engineer: 1993 to 2001

- Product support for Engineered timber products for Formwood Products manufacturer of Hyspan, Hybeam, Hyplank, and Truform. Engineering and technical support for engineers, builders, and architects.
- Investigation and reporting of structural problems with timber structures in residential construction. i.e. Lintels, floor joists, bearers etc.
- Design of structural support members for residential and commercial structures from Hyspan and Hybeam.

- Structural design of timber portal frames for residential, commercial and industrial buildings.
- Development of software for residential span tables for laminated timber products.
- Supervision of junior engineers
- Management of fabrication unit for engineered timber structures.

RESEARCH PROJECTS

- Development of Advanced Timber Concrete Composite system for floors acoustics, fire resistance, and strength with VicAsh, TPC Victoria, and FWPA.
- Development and testing of a reinforcing nail system for Timber Utility Transmission poles for Downer Pty Ltd, Australia.
- Development of Prorafter ™– composite timber plywood 'C' beam roof beams
- Development of Superply and its structural use.

SIGNIFICANT DESIGN AND/OR FABRICATION PROJECTS

1993 - 2001

- Design of glue laminated structure for sports stadium in Frankston, Victoria. 35m span x 50m in length.
- Design of Hyspan LVL portal frame for fertilizer storage facility, Keith, South Australia. 25m span
- Design and fabrication of composite Plywood and Hyspan LVL box beam structure for Mushroom compost storage facility, Mildura, Victoria. 30m span x 80m long.
- Design and fabrication of Hyspan LVL portal frame structure for residential building, Rockhampton, Queensland. 6m span.
- Design and fabrication of Hyspan LVL structure for new LVL production plant at Marsden Point, New Zealand. 96m span (2 centre props) x 219m long.
- Design of LVL bolted truss 50m span, Berwick, Victoria.

2001 to 2023

- Pro-Rafters for unit development at 74 Epping Road, Epping
- Carpark entry pergola - Living Carlton Stage 4, 950 Swanston St., Carlton
- Supply of fabricated LVL shed for Mortim at Wells Road, Mordialloc
- Roof structure for shed in West Launceston Tasmania
- Supply of fabricated timber truss and column for Wesley Learning in Residence

- Structural timber package – ProRafters for mixed use development at 276 – 280 Maroondah Hwy, Ringwood
- Arched roof structure at 15 Heal St., Ceres
- Timber truss fabrication and supply for Rockdale City Aquatic Centre - Preddys Road, Bexley North
- Design and construction of timber roof trusses for new Aldi store at 313 Doncaster Road, Balwyn North
- Design, manufacture and supply of ProRafter roof truss system for Child Care Centre in Bluff Road, Hampton
- Panelized residential dwelling, Surf Parade, Inverlock
- Fabrication and supply of TCC pedestrian bridge for Baw Baw Shire Council
- Panelized wall, roof & floor system at Yagura Place, Allambie Heights.
- Underpinning/retaining structure of 100-year-old six level build for the excavation of a basement, Lonsdale Steet, Melbourne CBD.
- Underpinning/retaining structure of 120-year-old five level Victorian State Parliament building for the excavation of a basement, Spring Street, Melbourne.
- Design and supervision of a Nine story precast residential complex with double basement, Mitcham, Melbourne.
- Large span timber box-beam portal frame for Meyer Timber's new 20,000m^2 warehouse in Penrith, NSW
- 3-storey timber concrete composite (TCC) structure for the RMIT Garden Building, City campus.
- Curved feature timber balustrade for the Monash University Chancellery Building, Clayton campus.
- Curved plywood dome structure for Swinburne University's 'Factory of the Future', Hawthorn campus.
- Glulam portal building for St Josephs college, Wagga Wagga, NSW.
- Masslam timber structure, Cowes Cultural Community Centre, Phillip

Island, Victoria.

- Design and supply Timber portal frames for proposed shopping centre complex, Oran Park, NSW.
- Structural Review of existing timber hanger built in the 1940's for structural integrity, Tocumwal, NSW.
- Structural review of existing timber floor framing and floor due to moisture ingress at Point Cook, RAAF base, Melbourne, Victoria.
- On going review of existing 100 year old rail trail bridges, Gippsland, Victoria.
- Design, detail and fabrication of horizontally curved mass plywood beams for proposed Advanced manufacturing research Facility, Badderys Creek, NSW.
- Review and report for residential timber structure exposed to prolong weather, Caulfield, Melbourne, Victoria.

- Design and fabrication of six story Mass LVL structure RMIT University, Bundoora, Melbourne, Victoria.
- Investigation and report on structural integrity of Glulam Truss at Collingwood Aquatic center, Melbourne.

CONFERENCES AND COURSES ATTENDED

- 24th Forest products research conference – 15-18 November 1993. (Paper presented). CSIRO division of forest products Clayton, Victoria, Australia.
- Structural design of industrial steel frames - 16-17 February 1993. Department of Civil Engineering, Monash University
- CSIRO/PAA Plywood products knowledge course – March 1995.
- International Timber Engineering Conference – 2000, Whistler, British Columbia, Canada.
- International Timber Engineering Conference – 2016 – Vienna.
- Presentation on design of SPAX screws, Sydney, 2017.
- Online presentation on Timber portal frames, Wood Solutions, 2021, Australia.

EXPERT WITNESS LEGAL REPORTS

- Investigation and Preparation of structural report on failed residential timber roof trusses for VCAT, Wodonga, Victoria.
- Investigation and Preparation of structural report on residential floor framing in relation to building movement in Class E soils, Hamilton, Victoria.