Taieri Gorge Rail Corridor Structures Condition Assessment

Report

Revision 2
25 November 2022
145138.31

Holmes
Australia Netherlands New Zealand USA

Report
Taieri Gorge Rail Corridor Structures Condition Assessment

Prepared For:
Vitruvius Ltd and Dunedin City Council

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25/11/2022	2	Final for Client Issue

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1 EXECUTIVE SUMMARY

Holmes have completed a high-level condition assessment of existing bridges and tunnels on the Taieri Gorge rail corridor. The inspections and condition assessments are to enable Dunedin City Council (DCC) to determine the level of investment required for the next 10 years, appropriate to the use of the line. The structures assessments are based on limited visual (non-intrusive) observations, review of available reports as well as engineering judgement, based on our experience with similar KiwiRail structures. A high-level review of the current 10-year maintenance/investment forecast has also been completed and commentary provided on asset management strategies with approaches which could be adopted to manage the existing structures on a whole-of-life basis. With reference to the current condition of bridges and tunnels, based on the inspections and review of available information provided, the following observations are provided:

- Bridges and tunnels are generally in satisfactory condition to fulfil their current functions and no critical defects were identified beyond what has already been identified in previous assessments and inspections.

- We concur with previous recommendations regarding replacement of **rail beams** and **corbels** in poor condition, requiring urgent attention. Excluding the track/sleepers on bridges, it appears that services can be extended over all bridges up to Middlemarch, conditional on continuation of regular inspections, monitoring and replacement of at-risk rail beams and corbels/sills.

- Given that painting constitutes a major portion of the investment required over the next 10 to 30 years and taking into account environmental impact and resource consent requirements, it is recommended that specialist coating assessments be undertaken on all large bridges in the short term (1 to 3 years). In addition, localised areas of paint deterioration and corrosion already identified should be treated and patch-painted during the first three years.

- As far as tunnels are concerned, we support the current approach of monitoring cracks for movement. It would be prudent to undertake more detailed investigation into remedial options to address the local bulging of the lining in Tunnel 9.

- The current 10-year forecast makes provision for the main areas of work, i.e., rail beam and corbel/sills replacement on selected bridges as well as assumptions regarding initiation of painting towards the end of the first 10 years. It is assumed that the priorities are based on previous condition assessments and the distribution of expenditure on the three sections appears realistic. It is noted that the basis of the estimates is not clear in terms of rates used nor has any cost escalation been included. It is recommended that DCC undertake a more detailed review of the basis for the current 10-year plan in conjunction with decisions on asset management strategies to be followed. Development of a more detailed schedule of works and costs in conjunction with Dunedin Rail staff is required to provide a more accurate and informed 10-year programme.

- It is recommended that individual asset management plans be developed for the major bridges which would provide the necessary evidence for developing a more accurate long-term investment programme.

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2 INTRODUCTION

Holmes NZ LP (Holmes) have been engaged by Vitruvius Ltd as subconsultant to undertake inspections and current condition assessments of rail structures, bridges and tunnels, on the Taieri Gorge Rail Corridor. The inspections and condition assessments are to enable Dunedin City Council (DCC) to determine the level of investment required for the next 10 years, appropriate to the use of the line.

2.1 Scope of Work

The Holmes scope of work consists of two distinct parts:

Assessment of the current condition

A visual condition assessment of the current condition of:

- approximately 35 bridges/viaducts with the longest viaduct being the Wingatui Viaduct spanning approximately 200m with height of 47m above the river.
- 10 tunnels, varying in length between 437m and 55m.

Figure 1 - Location and extent of assessments

The condition assessment needs to be undertaken with the view of identifying:

- Immediate or urgent maintenance requirements (1 to 3 years)
- Maintenance from 3 to 5 years
- Maintenance from 5 to 10 years

Develop a Schedule of Works

Based on the outcome of the inspections and condition assessments of the bridges and tunnels, a schedule of works is required, broken down into the following sections of the rail corridor:

- 4km peg to Hindon
- Hindon to Pukerangi
- Pukerangi to the 64km peg at Middlemarch

2.2 Inspection methodology and approach

The inspections entailed a general visual condition assessment only. No provision was made for intrusive or destructive testing. Walking and High Rail Truck (HRT) access were used to complete the inspections from track level. The inspections were restricted to aspects which were visible from top surface walkways or adjacent embankments with safe access. Binoculars and zoom lenses were used to gain additional detail on elements which could not be accessed closely. A representative selection of photographs was taken to highlight the typical condition and defects encountered.

The DCC induction process and Safety plan fed into the inspection planning with key risks identified and mitigations put in place. Tunnel inspections were to be completed accompanied by trained personnel, utilising appropriate PPE, gas monitor, radio communications and lighting. Only bridges less than 5m span or with walkways could be crossed without the use of the HRT. As subconsultant to Vitruvius, Holmes prepared our own Health and Safety Plan which aligned with Vitruvius' Safety Plan.

The inspection plan was developed using a combination of the available information from previous inspections, track logs and topographical maps to identify the bridge and tunnel locations. Safe road access points (level crossings) were also identified for bridges which could be accessed and crossed without us of the HRT.

Prior to the inspections Holmes' personnel undertook training to ensure current certification for Working at Heights and the KiwiRail induction for working in a rail corridor.

2.3 Reference documents

The following documents provided by Vitruvius/DCC have been referenced:

- General and (selected) Detailed Inspection Reports for bridges and tunnels
- Taieri Corridor Track Log
- Extracts from DCC TGR Report (2020)
- Copy of Master 10-year Plan 3.5 to Middlemarch 01-11-2020
- Future Options for Dunedin Railways Ltd – Appendices 1 – 5 (Dunedin City Holdings Ltd)

2.4 Limitations

Findings presented as a part of this project are for the sole use of the client (Vitruvius and Dunedin City Council) and its service providers. The findings are not intended for use by other parties and may not contain sufficient information for the purposes of other parties or other uses.

Our inspections and observations have been visual only (not intrusive) and limited to safe access to structures and components from rail level and walkways. Observations were made using digital cameras and binoculars. Our observations have been restricted to visible structural aspects only and no assessments were made to determine structural performance or safety.

Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report.

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3 OBSERVATIONS

3.1 General commentary

Based on the asset information made available by DCC, engineering inspections undertaken, discussions with DR staff as well as our extensive experience with similar KiwiRail structures, our general observations are that the structures are currently in a satisfactory condition and able to deliver to the levels of service required to run passenger rail services between Dunedin and Middlemarch. (These comments exclude rails, sleepers, and drainage in tunnels, which are addressed separately by Vitruvius).

The inspections undertaken largely confirm the outcomes and conclusions of the recent General and Detailed Inspections undertaken by DR. It is noted that given the limitations of close access to below rail members, our observations are limited to what was visible from the top of rail areas and abutments.

No urgent/immediate major maintenance or remedial works have been identified that would impact on running services over bridges or through tunnels. Where practicable, crack meter readings have been photographically recorded and DR is commended for having these practical monitoring systems in place.

Holmes approached KiwiRail Engineering as well as KiwiRail regional staff to locate any relevant as-built records of the bridges on the line. A number of as-built drawings and an extract of structural data from the KiwiRail historic database system have been located. KiwiRail Engineering has no objections to information being made available to DCC on the basis that no guarantee can be provide as to the accuracy of the any information provided. (Contact: Jennifer Critchley <jennifer.critchley@kiwirail.co.nz>, Engineering Structures Team Leader, Wellington Railway Station).

Information provided by DCC included a selection of general and detailed inspection reports as well as the current 10-year forecast. Limited information has been made available to Holmes as part of this review regarding prioritisation of works and basis of cost estimates included in the current forecast. ***It is noted that the cost estimates in the current 10-year forecast were done in 2020. As a minimum these estimates need to be adjusted to reflect significant cost escalation between 2020 and today.***

3.2 Bridges

Specifically, regarding bridges, it is evident that there are asset components now at a stage where programmed, proactive maintenance and/or replacement actions are needed over the next ten years to ensure that further deterioration is managed. Rail beam and corbel/sill replacements and steel span/pier painting are the main actions required. From a risk perspective, our view is that priority should be given to rail beams and corbels, as failure of these elements would have significant consequences. Painting, which would be a major cost, can be addressed on a risk basis to arrest current known corrosion and planning undertaken to prioritise other major painting projects. For example, the presence of red lead paint would require encapsulation and add considerable cost to any major bridge coating refurbishment exercise.

A summary of specific comments on the condition of individual bridges has been provided (refer Appendix A), supported by previous general bridge inspection reports. As far as possible, the reporting follows DR standard report formats and rating system. Based on our observations that the main defect areas on bridges are Rail Beams, Corbels and Painting, we include selected examples and comments in the following section.

3.2.1 Rail beams

Access to rail beams was limited to top sections between sleepers and where practicable, observations from abutments of the sides of beams. As expected, the tops of rail beams show typical hardwood deterioration in the form of splits and decay, specifically at beam ends and joints in continuous rail beam spans. In many instances, the ends of rail beams show more severe and deep splitting which impact on bolted connections. As far as longitudinal splitting is concerned, there are numerous beams which show splitting along the length of the beams, however we can't comment on the depth of these splits. DR records on boring would determine the extent of deterioration internally and the soundness of the members.

The reality is that the current condition will only get progressively worse which will require strengthening or replacement of the rail beams in due course. Remedial strengthening through clamping could be considered at the ends of rail beams, however these clamps become loose through dynamic loads and do require ongoing tightening.

Monitoring and recording, through video, of deflections and overall movement of rail beams under train loads is an effective method, in conjunction with boring data, to determine the structural risk of individual beams.

3.2.2 Corbels and bearing sills

Access to corbels and bearings/sills on spans was limited to what could be seen from abutments and between sleepers over piers. As expected, the tops and ends of some corbels show deterioration in the form of splits and decay to various levels of severity. It was noted that most corbels have been bored and it is also evident that corbel replacements have been undertaken in the past. While corbels mostly act in vertical compression, there are also cases where corbels act as beams, which would constitute increased risk depending on the soundness of the timber.

Similar to the comments above related to rail beams, the corbels will continue to deteriorate and given the challenges of replacement of corbels on viaducts, it may be cost-effective to consider replacement of all deteriorated corbels on particular bridges at the same time. Replacement of these timber elements on a like-for-like basis would depend on the availability of new/second-hand components. Alternatively, steel replacements can be considered.

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3.2.3 Coatings/paint condition

It is evident from previous inspection reports that deterioration of paint coatings has reached the point where intervention is needed to prevent corrosion from starting or progressing at specific locations. Coating deterioration varies from structure to structure and the most noticeable areas are on the steel trusses where welding has been done to connections and corrosion has initiated. There are also instances of corrosion in areas between steel plates/chords where moisture can get in or be trapped.

Based on the limited as-built information available at the time of the inspections regarding the paint systems and age of coatings, it can be assumed that some coatings would be coming to the end of their service lives. In most instances, painting/coatings require either spot paint repairs or total refurbishment. The benign exposure conditions on the line means that deterioration rates would be slower than normal and that it is possible to address the painting over more than 10 years without the risk of loss of section/strength having an impact on the service levels.

The viaduct iron/steel towers require attention as there is evidence of deterioration and general corrosion visible. This assessment is based limited to visual observations from walkways and abutments at rail level. Overall, with the exception of specific areas mentioned, the existing paint is providing protection to the steel components, and it would be prudent (as a minimum) to initiate a program of cleaning and spot painting areas where corrosion has initiated.

There is a build-up of lichen on the structures and undertaking regular washing down and water blasting to clean the steel members is recommended.

3.2.4 Other notable items / walkways

Whilst not required to run train services the upper walkway planks provide access across the bridges. Deterioration of walkway planks is approaching a point where safe access will be compromised. It appeared that areas of walkway were being replaced as required. This practice should be continued or accelerated to maintain safe access.

The handrail along Bridge 5 was noted to have a broken stanchion which should be replaced.

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3.3 Tunnels

Given the geology through which the tunnels have been constructed, cracking of tunnel lining (masonry/brick) is to be expected. In a number of tunnels there appears to be fines coming through weepholes and it is possible that cavities are present behind the linings. In the unlined tunnel sections, there is a build-up of fine materials at the base of the tunnel sides. Based on the number of crack meters in some tunnels, (notably Tunnel 7 and Tunnel 9) it is evident that a robust movement monitoring regime is in place.

A specific area of concern related to tunnels, is the localised movement in Tunnel 9. This is a known issue and is actively being monitored for movement. We cannot comment on any trends however it would be prudent to undertake a geotechnical investigation and design for stabilising the local area. This could include ground anchors for example. Having a design "in the drawer" which can be implemented should movements exceed agreed trigger points, would be a reasonable risk mitigation strategy.

Tunnel 3 appears to have a bulge in the brick lining in the ceiling (right hand side), however this observation is based on a visual assessment only.

Overall, regular monitoring of any movements through crack meters is an effective risk mitigation. While not deemed to be critical, the potential loss of material through weep holes in some tunnels, could indicate the presence of voids behind the linings and consideration can be given to investigating the extent.

Drainage in tunnels is typically an area of risk to track formation, sleepers, and rails. This did not form part of this report but will be covered separately by Vitruvius' reporting.

A summary of specific comments on condition of individual tunnels has been provided (refer Appendix A), supported by general tunnel inspection reports, following the DR standard template.

4 ASSET MANAGEMENT STRATEGY

4.1 Maintenance and prioritisation

There are different asset management strategies that can be adopted, ranging from do-absolute minimum and repair what is needed to maintain safe service levels, to time-based preventative maintenance which essentially replaces any member at a certain age regardless of condition or functionality. Given the age and current condition of the bridges on the line, a pragmatic approach is the Condition or Risk-based Preventative Maintenance. This requires regular inspections and assessments to be undertaken and works prioritised based on a condition-rating basis. Based on the information provided by DR, this is the asset management approach currently being followed.

In determining the 10-year investment programme, it is important to understand what the service life of the corridor is.

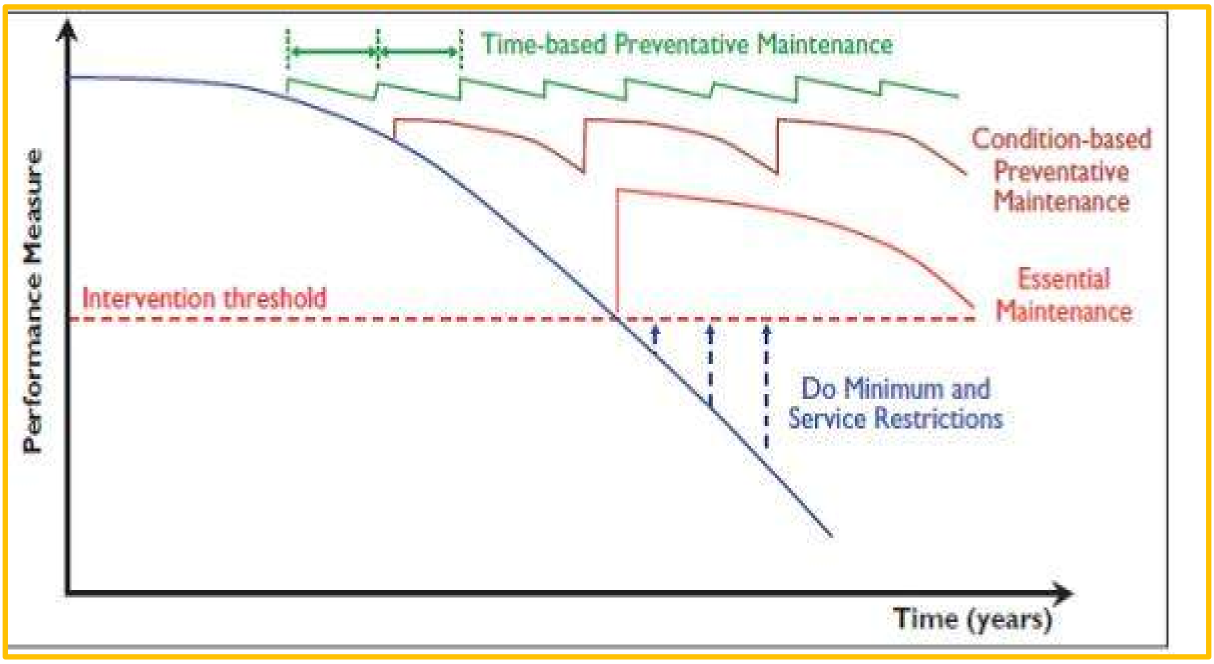

Figure 30 - Asset management strategies

Note: While condition is a key factor in developing a forward works programme, there are other risks which should be considered, i.e., seismic, scour, load rating and knowledge gap. A simple system based on these additional factors (to condition) can be developed for investment prioritisation and managing rail bridges. An example is the KiwiRail weighted "Structures Health Score" which is determined, and bridges ranked accordingly. A comprehensive condition assessment guide was developed to assist inspectors to making consistent condition assessments/ratings. Similar standards have also been put in place for tunnel condition assessment.

4.2 Asset maintenance and prioritisation

4.2.1 General

It is understood that DCC aims to extend the current rail service running between Dunedin to Hindon to the section from Hindon to Pukerangi and up to Middlemarch. From a bridge and tunnel perspective and based on our observations and review of available inspection reports, there are no specific high-risk immediate works to be undertaken to extend the rail service beyond Hindon.

However, we concur with the approach of completing rail beam and corbel replacements already identified in the DR inspection reports. This work would address structural risks which could have significant consequences should members fail. From a tunnel structural perspective, the approach of identifying and monitoring cracking and movement in tunnels is an appropriate mitigation. Specific recommendations regarding Tunnel 9 are provided below. Determining a strategy for undertaking structural maintenance on bridges must be done in conjunction with track renewals, which also include sleeper replacements on bridges.

4.2.2 Bridges

Table 1 provides a summary of observations in the field, combined with a review of information provided, i.e., inspection reports. In our view, from a risk and priority perspective, rail beams and corbels constitute the main areas of risk over the next 10 years and beyond. Dunedin Rail have replaced corbels/bearing sills and rail beams on specific bridges over recent years and have also identified members which should be replaced over short to medium term.

Table 1 - Summary of proposed works

	3 to 5 years			5 to 10 years		
Section	Rail beams	Corbels	Painting	Rail beams	Corbels	Painting
4km peg to Hindon	Bridges 4, 5, 6, 7, 8 Bridge 9	Bridge 5 Bridge 9			Bridge 4b	Bridge 5
Hindon to Pukerangi	Bridge 21	Bridge 14 Bridge 17 Bridge 21	Bridges 13,16	Bridges 13, 15, 16	Bridge 13 Bridge 18 Bridge 19	Bridges 10, 11, 14, 15, 17, 18, 19, 20
Pukerangi to Middlemarch	Bridge 22	Bridge 30 Bridge 33 Bridge 34a		Bridges 24, 26, 32, 33, 34a	Bridge 22 Bridge 27 Bridge 34	

Table 1 reflects the factual observations based on the current round of inspections undertaken as well as previous inspection reports done by DCC. With reference to the maintenance strategies in Figure 30, the forward works programme would depend on the preferred/chosen strategy.

For Years 1 to 3, we recommend that DR:

- initiate a programme of addressing coating/corrosion areas already identified during the last round of inspections through cleaning, preparation and painting;
- evaluate and upgrade maintenance access walkways through the truss bridges to ensure the walkways are compliant under current WorkSafe requirements, and available for refurbishment of trusses
- engage specialists to undertake coating condition assessments, specifications and detailed cost estimates for each of the major bridges, which would include environmental/consenting requirements, i.e., encapsulation. An optimised whole-of-life strategy can then be developed to ensure that DCC get value for money.

The following approaches are included for consideration:

Approach 1: Specific attention on Hindon to Pukerangi section (no trains running)

Assuming that train services north of Hindon can only commence once critical track/formation renewals/repairs are complete, rail beam and corbel/sill replacements should be scheduled on all bridges between Hindon and Pukerangi. This work should be undertaken while track renewals are undertaken, i.e., within 1 to 3 years or aligned with the track work, if practicable. This approach would fundamentally be a "replace and walk-away" strategy.

As noted above, during this period, undertake specialist coating condition assessments on major bridges to confirm remaining service life of coatings, specific strategies and cost estimate for undertaking refurbishment. This needs to include assessment of consenting requirements relating to environmental impact mitigation, i.e., full containment for red lead removal. Note - where sleepers are removed from trusses, repaint all supporting steel coatings before sleepers are installed.

Approach 2: Risk-based attention on Hindon to Pukerangi (no trains running)

Undertake a condition risk-based replacement programme for rail-beams and corbel/sills, i.e., estimate remaining safe service life of critical members and replace accordingly during the period year 1 to 3.

Approach 3: Risk-based prioritisation Dunedin to Pukerangi/Middlemarch (trains running)

This approach applies to the whole corridor and is driven by planning for progressive improvement to bridges based on remaining service life, risk and available budget. Elements of this approach would be spot painting of most corroded elements, replacement of worse corbels/rail beams, when reaching a condition state of 4 or 5.

Note: A common recommendation for all of the approaches is to set up a programme of coating/paint condition assessment undertaken by specialist contractors to get a better understanding of future investment requirements for maintain major steel bridges and viaducts. This should be undertaken during year 1 to 3 period.

4.2.3 Structural investigations

The following structural investigations can be considered:

Bridge 5:

- Investigate the camber on the last two spans and potential historic slope movement and/or bridge shortening.

Bridge 9:

- Undertake structural assessment of the effects of off-centre loading on bridge piers.
- Investigate the pier/span movement which resulted in the shift in alignment of the spans.

4.2.4 Bridge as-built information

KiwiRail Engineering and KiwiRail regional offices were approached to determine the availability of as-built drawings and historical information. Some as-built type drawings for trusses and piers for bridges along the route were found, as well as an extract from a pre-Maximo structures database. There are "paint units" for all steel bridges and it can reasonably be assumed that the values are in m^2.

This information will be provided to DCC electronically, with approval from KiwiRail Structures Team Leader. KiwiRail does not take any responsibility for the accuracy of the information.

Refer to Appendix C.

4.2.5 Tunnels

Based on our observations, there are no critical/urgent maintenance work required in tunnels. Monitoring of movement and cracking (crack meters) through regular inspections is a pragmatic strategy. Where movements are detected, further investigations can be done.

Specifically, regarding Tunnel 9, the bulge on the left-hand wall is currently being monitored. However, it is recommended that repair options be investigated and designed to have in place should further movement take place. This could include anchors, shotcrete or combination of the two.

4.2.6 Asset management strategy

In addition to the strategy adopted, it is recommended that DCC consider developing individual asset management plans for the major bridges.

5 10-YEAR FORWARD WORKS PROGRAMME

The existing 10-year forecast requires updating to reflect cost escalation since 2020 as well including an allowance for projected escalation over the short to medium term. Details regarding unit rates have not been made available within the forecast, however it is recommended that rates for the key activities be reviewed and updated.

Allowance for upgrading of maintenance walkways on trusses should be incorporated in the first 3 years.

Regarding painting, as an example, based on the KiwiRail Makatoti Viaduct refurbishment, a rate of approximately $750/m^2$ (including encapsulation) was established. Allowing for some escalation, an equivalent rate of say $900/m^2$ can be assumed for current costings. If the information in the historic database obtained from KiwiRail is accurate, an assumed painted area of 4000m^2 would result in $3.5M cost, vs the assumed $1.2M in the current 10-year forecast.

6 RECOMMENDATIONS

Our main recommendations for discussion are as follows:

- Agree on an overall asset management strategy/approach and update the 10-year forecast accordingly.
- Undertake a detailed review of unit cost rates and allowance for escalation to refresh the current 10-year forecast.
- Utilise the first three years to undertake routine local spot painting of all structures and complete specialist coating assessments and cost estimates on all major bridges.
- Upgrade lower walkways to current compliance during the first 3 years.
- Maximise the time available for track upgrades between Hindon and Pukerangi to undertake corbel/sill/rail beam replacements.
- Consider development of asset management plans for major structures.
- In conjunction with Dunedin Rail staff, develop a detailed prioritised work bank and cost estimates for rail beam and corbel replacements required. A comprehensive/accurate painting programme can only be developed with input from specialist coating experts.

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Appendix A Inspection assessment summary

Bridge Inspection Summary

	Span	Corbel Replacement	Sill Replacement	Rail beam replacement	Painting Required	Walkway replacement	Other
Start							
Bridge 4	4m			R			
Bridge 4a							
Bridge 4b	4 m		M				
Bridge 5	200 m	R	M	R	10yr	R - 3 spans	Handrail stanchion - R
Bridge 6	63 m			R			Handrail painting - R
Bridge 7	42 m			R		R	Handrail painting - R
Bridge 8	64 m			R			
Bridge 9	98 m	R	M				Decking plank decay
Bridge 9a	2 m						Clear drainage
Hindon							
Bridge 10	30 m				10 yr		Head wall undercut and slumping (M)
Bridge 11	4 m				10 yrs		Ballast over topping end wall (M)
Bridge 12	38 m						
Bridge 13	32 m	M		M	5yrs	R	Winwall slumping (M)
Bridge 14	83 m	R			5-10yr	Loose planks	Handrail painting - R Scour exposing foundations - M
Bridge 15	50 m			M	5-10yr	R	Handrail painting - R
Bridge 16	86 m			M	5-10yr	R	
Bridge 17	122 m	R			10 yrs		Pier painting required Paint handrail
Bridge 18	18 m		M		5-10yr		
Bridge 19	18 m		M		5-10yr		
Bridge 20	22 m				5-10yr		Paint handrail
Bridge 21	63 m	R		R			
Pukerangi							
Bridge 22	17 m		M	R			
Bridge 23	32 m						Tarmac approach Guard rail out of place Soil build up along track Heavily decayed decking planks limited repairs to top decking
Bridge 24	4 m			M			Winwall timber replacement
Bridge 25	4 m						Paint handrail Monitor deck beams
Bridge 26	4 m			M			
Bridge 27	7 m		M				
Bridge 28	15 m						
Bridge 29	14 m						
Bridge 30	14 m		R				
Bridge 31	3 m						Timber head wall balast guard splitting - replace
Bridge 32	3 m			M			
Bridge 33	3 m		R	M			
Bridge 34	6 m		M				
Bridge 34a	3 m		R	M			Timber head wall balast guard splitting - replace
Middlemarch		M=Monitor R=Replace					

Tunnel Inspection Summary

	Length	Potential voiding	Water ingress	End portal cracking	New cracking	Other
Start						
Tunnel 1	278 m	M	M			
Tunnel 2	440 m			M		
Tunnel 3	132 m					Bulging RHS roof?
Tunnel 4	121 m			M - previously anchored		
Tunnel 5	100 m			M - previously anchored		
Tunnel 6	67 m					
Hindon						
Tunnel 7	54 m					
Tunnel 8	94 m	M			LHS half way along tunnel	
Tunnel 9	102 m					
Tunnel 10	65 m	R				Cracking and voiding behind bulge on LHS
Pukerangi						
Middlemarch						

M=Monitor
R=Replace