A RISK MANAGEMENT FRAMEWORK TO ASSESS AND MITIGATE THE SCOUR AND EROSION RISK TO A SECTION OF THE MIDLAND RAILWAY LINE

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Aims

A section of the Midland Railway Line between the West Coast side of the Otira Tunnel and the Taramakau Bridge is known to be susceptible to scour and erosion from the Otira and Taramakau rivers. The aim of this KiwiRail project was to develop a risk management framework that could be used to prioritise expenditure to reduce the likelihood of an embankment failure occurring as well as manage residual risks through the use of a flood warning system.

Methods

A risk assessment framework was developed to enable specific reaches of this section of the Midland Line to be ranked in terms of their likelihood of failure due to river induced erosion or scour. This section of line was divided into 34 reaches with similar characteristics such as proximity to the river and type of bank/buffer protection. The risk assessment framework accounted for seven likelihood of scour/erosion factors and one consequence of failure factor to produce a single risk factor for each discrete reach of line.

The likelihood of scour/erosion factors were a combination of weighted quantitative and qualitative factors including; flood velocity, flood depth, distance from river to railway embankment, embankment protection type/condition, angle of flood attack relative to the embankment, historic failures and susceptibility due to morphological river changes. A number of these factors were quantified using a 2-D hydraulic model of the river based on a recent LiDAR topographic survey. The remaining likelihood factors were assessed in a more qualitative fashion based on visual observations from a site visit, examination of historical aerial photography and discussion with KiwiRail staff.

The consequences of a failure were represented by a single consequence factor defined in the overall KiwiRail Risk Rating Assessment Matrix. A catastrophic failure is defined as the inability to provide freight services for more than 48 hours and/or more than one fatality. There have been two historic failures from scour and erosion on this section of the Midland Line and both have been categorised as catastrophic failures. Further to this, an assessment of the time required to reinstate a failed section of line and the potential fatalities that would arise from a derailment confirm that any failure will have catastrophic consequences.

Each reach within this section of line was examined by calculating the likelihood of failure factor, multiplying by the weighting for each factor and then adding all the weighted factors together. The consequence of failure was assumed equal (catastrophic) for each reach of line so the overall risk was equal to the sum of the weighted likelihood factors.

Results

The 34 reaches within this section of the Midland Line were ranked in terms of risk of scour and erosion failure. Table 1 shows the risk ranking table for the three reaches of line most at risk to scour and erosion. Outline designs for physical erosion protection works were developed for these sections as well as the next three highest risk sections.

Table 1 also shows the approximate cost of the proposed physical protection works and the subsequent reduction in the risk as reassessed using the risk assessment framework.

Table 1: Highest scour and erosion risk sections of the Midland Railway Line

Risk ranking 20% AEP Flood event	Description	Start of section (km)	End of section (km)	Cost of physical works	Risk ranking after physical works
1	Upstream of Deception River	135.43	135.80	$160,000	17
2	Downstream Feb 2011 washout	134.38	135.00	$500,000	18
3	Deception River	135.80	136.03	$360,000	8

	Footbridge				

The proposed physical works consist of rock protection, either in the form of groynes or revetments. The potential use of groynes in this environment is limited to a few sites where the river is relatively stable.

In addition to the proposed physical works described above a flood warning system has been developed to manage the residual risks associated with a scour/erosion failure. The flood warning system has been based on examination of the nearby river and rain gauges to determine an event which is likely to cause erosion at the most vulnerable point on this section of the Midland Line. Once specified river level and rainfall triggers have been exceeded this section of the Midland Line is to be closed until the flood peak has passed and a full inspection has been completed.

Conclusions

A risk assessment framework was used to rank discrete reaches of the Midland Line in terms of their relative risk of failure due to scour and erosion. Outline designs for physical mitigation works were developed for the six highest risk sites to reduce the likelihood of failure. A flood warning system was also developed to minimise the residual risks linked with the consequences of a failure occurring.

The use of the risk management framework has provided an effective way to prioritise proposed protection works on this section of the Midland Line and the flood warning system has reduced the likelihood of a derailment occurring.

References

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