

Toose Road Landslide

Geotechnical Review

October 2023

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Introduction

At the request of Transport for New South Wales (TfNSW) Disaster Recovery Team (North), an internal geotechnical review has been completed on six independent geotechnical reports prepared by GHD, Regional Geotechnical Solutions and Arup regarding a landslide at Toose Road, Bellbrook which is located in an area managed by Kempsey Shire Council. This review is based solely on the information provided in the reports.

We have been informed that the landslide was identified by Toose Road residents on 31 March 2022 and is located in an area where the road (constructed in the 1950's) has been cut into a steep natural river valley with slopes that extend above and below the road. The landslide is approximately 90m in length and has resulted in extensive damage to a section of Toose Road which is now impassable.

This internal geotechnical review has been undertaken by a TfNSW Engineering Geologist for each of the following reports with commentary provided under each of the report headings:

- 1) Toose Road, 2022 Landslide Emergency Advice – GHD, dated 6 April 2022
- 2) Toose Road Landslide – Bellbrook Geotechnical Assessment – Regional Geotechnical Solutions, dated 2 May 2022
- 3) Toose Road Geophysical Investigation – GHD, dated 29 June 2022
- 4) Toose Road Access Options Study – GHD, dated 8 September 2023
- 5) Toose Road Landslide Remedial Works – Arup, dated 8 February 2023
- 6) Temporary Remedial Preliminary Concept Design Development – Arup, dated 23 June 2023

We understand that the above reports were all commissioned by Kempsey Shire Council. We were not involved in the commissioning of these reports and are not aware of the agreed scope of works between the respective parties.

GHD – Toose Road, 2022 Landslide Emergency Advice, 6 April 2022

Brief Report Summary

A site walkover assessment was completed by GHD on 5 April 2022 which indicated that the landslide occurred within existing ancient landslide material already present on the slopes. Toose Road had been constructed by cutting into the colluvial material to form the roadway. Evidence of previous instability was observed with historical landslide debris extending down to the Macleay River below. The landslide occurred due to saturation of the colluvial soils during a significant rainfall event at the end of March 2022 following a prolonged wet and rainy period.

At road level extensive damage to the road was observed with tension cracks open to 500mm in width and steps up to 900mm high with other parts of the road fallen away. The landslide debris was estimated to be between 4m and 8m in thickness at road level with the majority of the road shifted downslope from its original position. Headscarps formed by the recent landslide were observed approximately 50m above the road resulting in open landslide affected ground with continued fretting of exposed soil and rock debris and general downward slope movement. GHD advised that these movements are “*expected to increase with future rainfall*” and the possibility that future movements could be rapid with a risk of road users being unable to evade the movements.

TfNSW Geotechnical Opinion

Given the nature of the landslide and the slope instability currently present, TfNSW is in agreeance with the emergency advice that GHD provided which included the following:

- 1) Maintaining the road closure – exclude all access across the landslide
- 2) Discourage people from travelling over the landslide in any way
- 3) Engagement with residents and knowledge sharing with regards to significant risk of injury and death if the landslide affected areas is crossed
- 4) Provision of emergency access via alternate routes to avoid the landslide affected area.

The GHD report also discussed remediation options and anticipated costs for repair. Repair of the landslide was estimated to include treatment of a 50m by 90m area of slope face which would include removal of up to 30,000 tonnes of rock and soil and then stabilising the remaining slope face with a combination of soil nails, rock bolts and shotcrete at an estimated cost of \$14 to \$17 million. The opinion of GHD was that this type of repair would be extremely challenging given the unstable nature of the slopes above and below the road which would present a risk to construction workers which could have “*catastrophic consequences*”.

Consideration was also given to permanent closure of the failed section of road and an alternate route. However, the lack of forest roads or bush tracks that could be formalised to provide an alternate route resulted in only one alternative – a bridge crossing the Macleay River upstream of the landslide area and approximately 6km of connecting road which was estimated to be in the order of about \$7 million.

TfNSW considers that the proposed remediation options and recommendation of an alternative bridge crossing proposed by GHD appears reasonable based on the information provided with consideration to the size and complexity of the landslide and the risk of further movements in the future. The estimated costs provided also favour a new bridge crossing. GHD also discussed the significant safety risks of construction workers working on an active landslide which we also agree with and consider to be a very difficult issue to manage.

Regional Geotechnical Solutions – Toose Road Landslide Geotechnical Assessment, 2 May 2022

Brief Report Summary

The purpose of this report was to provide a summary of site observations and make comment on the geotechnical advice provided by GHD and discuss the possibility for alternative emergency access measures. A representative of Regional Geotechnical Solutions (RGS) visited the site on 2 May 2022 and concurred with the previous GHD assessment that the existing landslide forms part of “*an ancient landslide with the toe reaching the Macleay River*”. Site conditions observed and the failure mechanisms described by RGS were consistent with those of GHD, with additional movement of debris observed. Similar to GHD, RGS advised that further failure of the landslide could be expected to occur with heavy rainfall (<1 year event) and may have a rapid to very rapid rate of movement. RGS was in agreeance with previous advice provided by GHD with

respect to remediation of the landslide itself by combination of soil nails, rock anchors and steel mesh (instead of shotcrete) and excavation of the slide debris.

If remediation of the landslide was an option, RGS recommended that extensive geotechnical investigations would first be required to understand the depth to the slide plane and assess the volume of failed material that would require removal as well as to obtain geotechnical data to enable design of the support structures.

TfNSW Geotechnical Opinion

TfNSW agree with the RGS recommendation and are of the opinion that given the size of the landslide, instability both above and below the road would be very challenging to manage from a site investigation perspective and that significant access requirements and ongoing monitoring would likely be needed. Specialist equipment and modified investigation techniques would also be costly and time consuming and the safety risk to personnel involved in the site investigation very difficult to manage.

RGS shared this view on safety also raising concerns about working on the surface of an active landslide from both hazards above and below the road. No comment was made on alternative routes other than they are “possible” and that access across the Macleay River using a natural gravel point bar could be utilized during periods of low river flow. No commentary was provided regarding an alternative route that involved construction of a bridge.

GHD – Toose Road Geophysical Investigation, 29 June 2022

Brief Report Summary

GHD’s previous advice as discussed in the 6 April 2022 report provided commentary of two main options. Either remediation of the landslide or abandon this section of road altogether and provide an alternative access via a bridge across the Macleay River. Following this initial advice GHD completed a geophysical investigation to assess the depth to competent rock below the landslide. We understand this assessment would help inform the feasibility of remediation versus the bridge option. Passive seismic methods to locate the interface between the colluvial landslide material and the underlying bedrock was completed in early June 2022. Traditional drilling techniques were considered unsuitable due to safety concerns around drilling into an active landslide. Instead, a passive seismometer was deployed due to its non-disruptive nature which was considered safer than active source seismic techniques given the steep slopes and significant landslide risk.

The purpose of the investigation was to assess the nature and thickness of the landslide material and provide a depth estimate to “competent” rock. This would inform design of suitable remediation treatments if deemed feasible. The profile of material across the valley slopes consisted of the recent landslide material that had mobilised within the existing ancient landslide deposits that mantle the in-situ bedrock. GHD reported that the depth to the underside of the recent landslide was estimated to generally be within 4m to 8m. Beneath the recent landslide zone, the depth to the interface of the ancient landslide/fractured rock and contact with competent rock below was estimated to vary between 17m and 34m. This data was used to inform the options study presented in the 8 September 2022 report as discussed below.

GHD – Toose Road Access Options Study, 8 September 2022

Brief Report Summary

We understand that GHD were engaged by Kempsey Shire Council to explore and outline long-term options for reconnecting Toose Road residents. The options considered included remediation of the landslide area, construction of a new overland road without a bridge, in addition to a variety of new bridge options. The new bridge options focused mainly on utilising existing road infrastructure in addition to the construction of a new bridge crossing at various potential locations over the Macleay River. For all bridge options a section of new

road would be required to connect Toose Road to the bridge, which in turn then connects to each of the existing road options on the other side of the river.

A viability ranking was assigned to each option that considers constructability, environmental impact and high-level construction costs. The options presented in the GHD options study are:

- 1) Remediate the landslide
- 2) New connection to the Kempsey to Armidale Road
- 3) Heightened Bridge connection to the Kempsey to Armidale Road
- 4) Towel Creek Road alignment
- 5) Gap Creek Road alignment
- 6) Pee Dee Road alignment
- 7) Wilsons to Jimmys Gully Track alignment

Option 1: Toose Road remediation – remediation of Toose Road was discussed previously in the GHD report of 6 April 2022 and at that time it was suggested that a remedial treatment would likely be in the region of up to \$17 million and consist of a combination of extensive material removal and stabilization of the remaining slope faces using a combination of soil nails, rock bolts and shotcrete. Due to the significant depth to competent bedrock identified from the geophysical survey, the original remediation treatment was then modified with inclusion of bored piles to support the lower slope.

Due to the significant depth to competent rock, together with the expected number of rock boulders within the landslide material, GHD regarded the piled solution as unlikely to be feasibly economically unless a significant volume of material from the upper slopes could be removed first, allowing the piles to be shorter. Following removal of this material above the road, pinning the in-situ slope face with soil nails would be required prior to the piling. The piles supporting the lower slope would also require restraining back with anchors, both of which still only provided marginal stability for the slope below the road. GHD reported that a top-down construction sequence would be required to install the 39 rows of 24m long soil nails totaling 37km of soil nails to support the upper slope alone. The lower slope would consist of 4 rows of 250mm micro-piles that comprise a contiguous piled wall formed into a concrete pile cap in turn supported by lateral anchors installed 20m into the slope. Initial cost for this system was estimated at **\$44 million**.

Viability ranking = Very Low

TfNSW Geotechnical Opinion

TfNSW considers that this option is not likely to be feasible given the very significant cost and the risks involved as discussed in the report. Extensive geotechnical investigations would likely be required to confirm the indicative depths to competent rock inferred from the seismic survey which could significantly influence the overall design if these were different. Geotechnical investigations within this terrain presents the same challenges as listed above in the RGS report review. Safety of workers during investigation and construction presents significant risk as well as a final remedial solution that may only provide marginal stability in the long term. TfNSW agree with the GHD viability ranking of Very Low and are not supportive of this option.

Option 2: Kempsey to Armidale Road connection – according to GHD this presents the optimal bridge and realignment option. A short length of new access road would be required to link Toose Road with a new bridge across the Macleay River and then on the opposite side of the river linking directly with the existing and sealed Kempsey to Armidale Road. The benefit of this option is the location which is mostly green-field and favorable

topographic conditions plus a short length of new road to be constructed. No upgrades to the Kempsey to Armidale Road would be required. Initial cost for this option was estimated at **\$8.9 million**.

Viability ranking = High

Option 3: Heightened Bridge connection – this option is similar to above with a bridge that links directly to the Kempsey to Armidale Road. The bridge would be launched directly from a cliff resulting in a higher bridge deck to withstand flooding conditions. An elevated bridge connection would result in the new access road to the bridge being shorter than the previous option, however specific methodologies would be required to be developed to construct the bridge safely and economically. Initial cost for this option was estimated at **\$12.8 million**.

Viability ranking = Medium

Option 4: Towel Creek Road alignment – this option would involve construction of a new access road to the bridge which then connects directly with the existing Towel Creek Road. The area for this option is generally flat which provides good construction options and lower height bridge. Initial cost for this option was estimated at **\$11.3 million**.

Viability ranking = High

Option 5: Gap Creek Road alignment – this option would also involve construction of a new access road linking a new bridge that can be accessed from Gap Creek Road. This option provides the shortest new road to be constructed, but the longest bridge span. In addition, due to the topographical conditions, substantial cuttings would be required for the new access road. Initial cost for this option was estimated at **\$17 million**.

Viability ranking = Low

Option 6: Pee Dee Road alignment – this option requires a new road to connect Toose Road to a new bridge which is positioned at a shallower location over the Macleay River. This new road would be located within steep terrain and would require excavation to acceptable grades for this to be a feasible option. The bridge would then link up with existing Pee Dee Road which also comprises steep grades, hillside cuttings and the likely replacement of existing culverts. Initial cost for this option was estimated at **\$13.3 million**.

Viability ranking = Medium

Option 7: Wilsons to Jimmys Gully Track alignment – the final option was suggested by the local community as an over land option without the requirement of a new bridge across the Macleay River. Utilising this alignment would require extensive vegetation clearing and construction of a new road over very steep grades up and over the ridgeline connecting Jimmys Gully and Wilsons Gully. GHD did not access this area and the commentary given in the report is from assessment of aerial imagery only. GHD concluded that this option would likely present significant safety risks to road uses because of the steep grade of the road as well as further landslip risks due to the generally steep topography. Initial cost for this option was estimated at **\$10.1 million**.

Viability ranking = Low

TfNSW Geotechnical Opinion

Based on the above, GHD recommended the following two options for further consideration for concept design which TfNSW is broadly supportive of for the reasons discussed in this report:

- Option 2 – New connection to the Kempsey to Armidale Road
- Option 4 – Towel Creek Road alignment

Arup – Toose Road Landslide Remedial Works, 8 February 2023

Arup were commissioned by Kempsey Shire Council to complete a geotechnical desktop study and peer review of the previous reports prepared by GHD and RGS and provide practical options for remediation of the landslide. Similar to the advice provided by GHD and RGS, Arup also concurred that *“It is unlikely that a practical, cost efficient and stable long-term remedial solution will be possible”* for the landslide affected area of Toose Road. *“Further slides in the future can be reasonably expected and a slide that permanently closes the road is likely”*. However, Arup were of the opinion that a temporary remedial solution that involved *“moving the road into the slope, controlling surface water and removing the active landslide material may be possible”*.

TfNSW Geotechnical Opinion

TfNSW would not recommend this type of temporary approach due to the significant risks involved. Given this option is proposed as a temporary interim measure until the permanent solution is developed, this option would still be a significant capital works project with little benefit. The total cost for this temporary works solution combined with the cost of the permanent works is considered likely to be cost prohibitive. In addition to the overall cost there are also safety and technical issues that do not support this approach. Excavating the toe of a compromised landslide is high risk and can lead to further movements or failures. Even with the proposed top-down construction methodology it introduces a lot of risk, particularly to construction workers. As this would be a significant construction project, extensive geotechnical investigation would also be required which would present the same challenges expressed earlier. Overall project time for this temporary solution would also be significant considering environmental approvals, geotechnical investigation, options analysis, concept through to detailed design of the preferred treatment, engagement of a contractor and then the actual construction. It is likely that the timeframe required to develop the temporary solution would be similar to that of the permanent solution so would therefore offer little benefit to the Toose Road residents as an interim measure.

Findings from the Arup peer review in general agreed with the Emergency Advice provided by GHD referencing agreeance that *“the slope is not stable and could move at any time”*. There was also agreeance that a top-down construction process would be required if the landslide was to be remediated. Whilst GHD had originally commented on the top-down requirement, they had also concluded that this was not possible due to the steep terrain and difficulties in accessing the upper slopes with excavation equipment. Arup disagreed with this view and although considered this to be *“challenging”* was reported to be *“possible”*.

Arup also disagreed with the GHD remedial concept of stabilising the remaining slopes with rock bolts, soil nails and shotcrete. Concluding *“Due to the expected depth and upslope extent of the colluvial debris and challenges with installing rock bolts / soil nails in the material, Arup consider that it is unlikely that rock bolts / soil nail would be practical or effective in stabilising the underlying slope”*.

Arup shared some common points of interest and were in general agreeance with the Regional Geotechnical Solutions report dated 2 May 2022.

In review of the GHD options study report, Arup only made reference to one of the seven options which was the first option of repair of the Toose Road landslide. No reference was made to any of the bridge linkage options to existing roads. Arup supported the GHD view that combination of soil nails and piled solution *“would be very*

challenging and costly to construct. It is not considered a long-term solution.....". Arup also made reference to whether a cutting option was explored by GHD or why this option might have been abandoned.

Section 4 of the Arup report discussed remedial solutions concluding that *"It is unlikely that a practical, cost effective and stable long-term remedial solution will be possible. Further slides in the future can be reasonably expected and a slide that permanently closes the road is likely".* TfNSW agree with this view.

Arup – Temporary Road Landslide Remedial Works, 23 June 2023

Brief Report Summary

We understand that this report was issued to progress the temporary works solution of moving the road into the slope to concept design. No geotechnical investigations were completed in preparation of the June 2023 report. The report was prepared based on observations collected from the original site walkover plus a subsequent site visit of March 2023 and a drone photogrammetry and LiDAR survey completed in April 2023.

Arup reiterated that *"rainfall is a significant factor driving instability"* and *"further shallow failures during significant rainfall are to be expected"*. Deeper failures were regarded as unlikely to occur, especially during dry periods. Arup states that the temporary remedial solution could be implemented with appropriate controls to reduce the risk to workers and to residents. Examples of controls provide in the report are:

- Restrict access to the area during period of wet weather
- Design slopes to be as flat as possible
- Improve drainage and control surface water to direct away from the affected area
- During construction additional precautions and controls required during wet spells with potential restrictions on work
- Following completion of the works additional precautions and controls required during wet spells

TfNSW Geotechnical Opinion

The opinion of TfNSW in regard to the temporary solution that Arup proposes remains same as for the Arup February 2023 report, we do not recommend this approach for the reasons previously discussed.

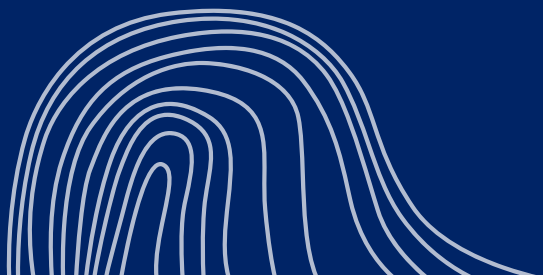
TfNSW concluding remarks

The purpose of this report was to review and give commentary on each of the geotechnical reports prepared to date by GHD, Regional Geotechnical Solutions and Arup and in doing so we have the final concluding comments:

- The GHD landslide emergency advice report of 6 April 2002 summarises very well the geotechnical issues and risks present at this site;
- Landsliding, both recent and historical is the dominant slope stability risk in this area and is characterised by steep slopes and infilled drainage gullies;
- The recent natural disaster events have reactivated these ancient landslides and have further compromised the slopes above and below Toose Road;
- In its current condition the landslide affected area at Toose Road is considered unsafe from above and below for vehicles and for foot traffic;

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- Permanent remediation of the landslide affected area is not considered feasible due to the significant costs involved, safety to workers and an overall consensus between all of the consultants that a practical, cost effective long-term remedial solution is unlikely to be possible for the Toose Road landslide
- Temporary remediation of the landslide affected area is not considered feasible due to the extensive geotechnical investigation required to design, overall timeframes involved, significant costs, safety to workers and overall effectiveness given the proposed is a “dry weather” solution only
- With remediation of the landslide affected area considered unfeasible, the most likely solution to regain access to Toose Road is by construction of a new bridge crossing the Macleay River and linking up with existing road infrastructure as detailed in the GHD options report of September 2022.



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