GLJ774 A816 Millbrae Landslip

Inspection Report

December 2025

Draft Rev 0

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Report Details

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Executive Summary

There has been a large landslip (11m high x 12m wide) below the A816 at Carnasserie. On inspection the rock in the area is weak and the superficial deposits are mainly silts and clays. These are unfavourable ground conditions and are potentially extensive, leading to the conclusion that further failure is probable. Due to the low strength, it is possible that a slip plane may extend below the road and lead to the closure of the road if remedial works do not address the issue. This could also occur by multiple smaller failures. The highest hazard time for failures is during periods of inclement weather, particularly heavy rainfall, or snowmelt. Rapid evaluation of the options has been undertaken and the favoured solution is to install soil nails/anchors with a shotcrete facing. This is favoured due to:

- Adaptable: Suitable for mixed soil–rock slopes and variable ground conditions, including poor rock. Provides deep reinforcement and prevents slope movements. Gives slope reinforcement quickly.
- Fast to design and install: Can be installed quickly to reinstate the slope stability and prevent further failures. Allows the road to remain open during construction.
- Integration of drainage: Weep holes or inclined drains can be incorporated into the facing to reduce pore water pressure.
- Minimal space required: Unlike the gravity or post and beam wall the shotcrete wall can be stopped where rock is sound and requires less footprint/interaction with the riverbed.
- Design life: Durable solution, depending on materials used can be >60 years.
- Cost: Strong and robust measure for good value.

Locality

The site is located on the A816 just north of Kilmartin at Carnasserie (NGR 184391 701347, W3W ///unfilled.buzz.overpaid). The landslip has occurred on the westbound side of the A816 on the downslope, river (Abhainn Airdhcheodiuis) side of the road.

Scope

Geo-Rope were contracted to undertake an options report for the section of slope between the existing retaining wall at the south of the site and the concrete beam (installed 2009) to the north. This is a length of approximately 42.5m.

On arrival at site on Monday 1st December 2025 it was discovered that a large landslip had occurred below the road.

The scope of the report was altered to provide a reduced, rapid, overview of options, including proposed and considered repairs, associated costs and timescales.

Site constraints

The slope below the road is very steep (>80 degrees) and mostly covered with trees and vegetation. Trees have been recently cut but stumps remain 1-2m high and felled timber and branches remain on the slope.

There is access to a track on the other side of the river, this is a dirt track with a timber bridge at the south side and leads steeply uphill to a large flat area in trees. The area is owned by Mowi and is a salmon hatchery.

The site is located adjacent to the Abhainn Airdhcheodiuis and will need liaison with SEPA for any clearance and engineering works.

Desk study information

Geology

The British Geological Survey (BGS) interactive mapping[1] shows the bedrock in the area to comprise rocks from the Tayvallich Volcanic Formation (Figure 1). These are listed as quartzite, psammite and semipelite, metalimestone and metabasaltic-rock.

Superficial deposits are recorded to the south of the site as River Terrace Deposits (undifferentiated)-gravel, sand, silt and clay and alluvium-clay, silt, sand and gravel (Figure 2).

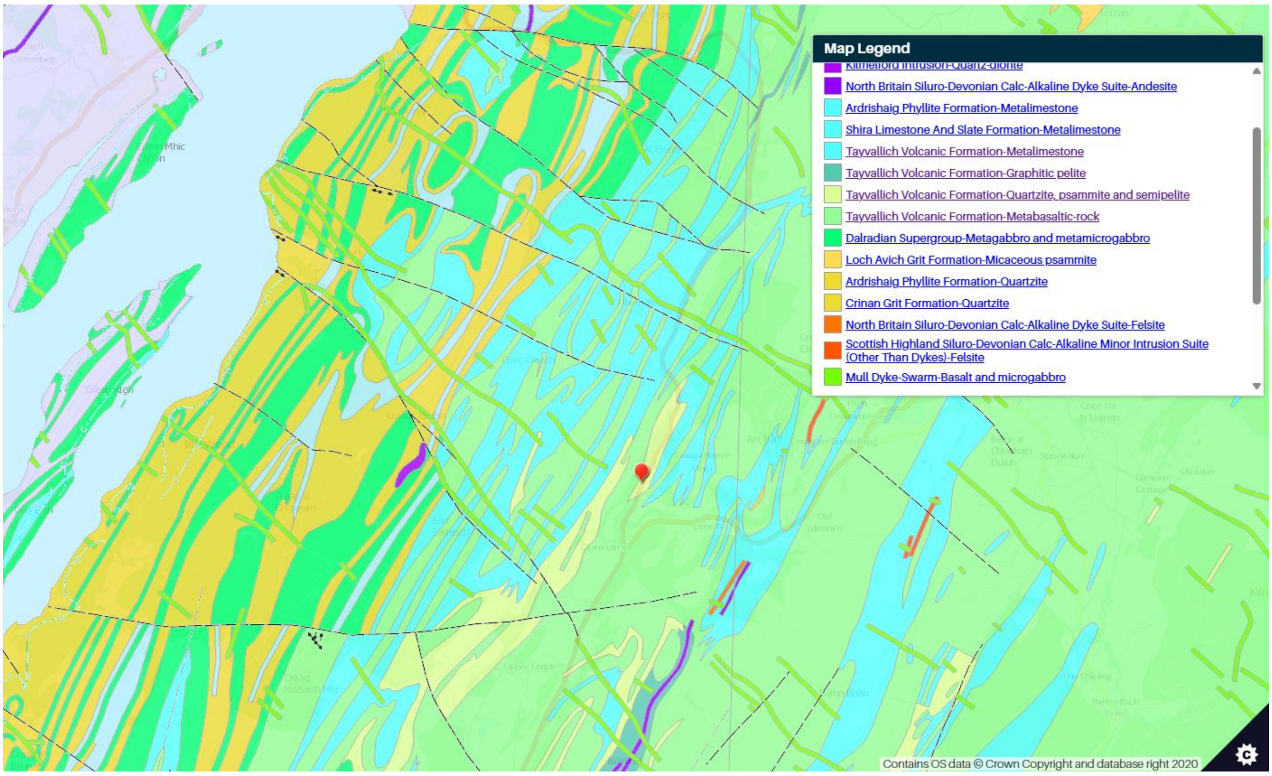

Figure 1 Extract from the BGS interactive geology mapping showing the bedrock in the area. Note the site is indicated by the red location pin.

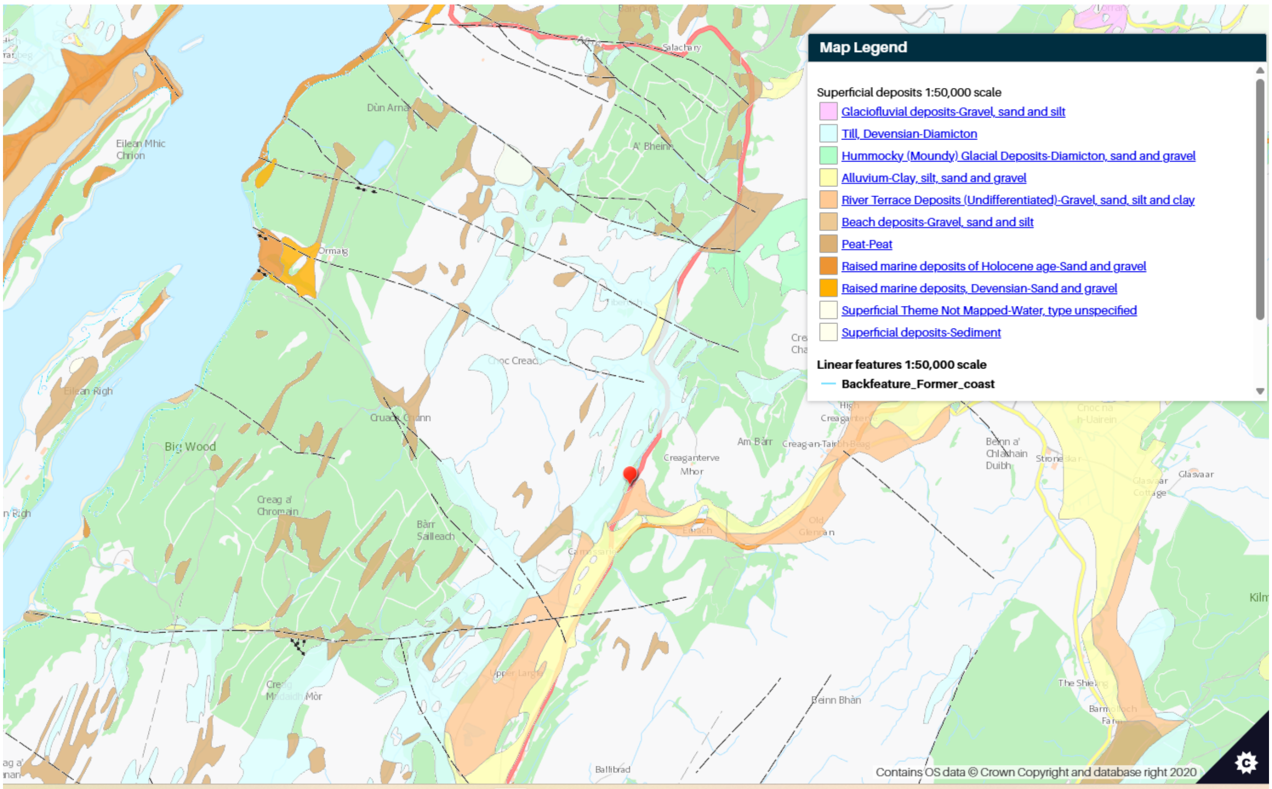

Figure 2 Extract from the BGS interactive geology mapping showing the superficial deposits in the area. Note the site is indicated by the red location pin.

Special protections or designations

The only designated listing for the area was found on Historic Environment Scotland(2) for Carnasserie Farm, cup-marked rock (360m ENE of Carnasserie Castle), covering an area of approximately 40x50m (Figure 3). The site is located to the east side of A816 opposite the bellmouth for the fish farm track.

No listings were found for the area with Nature Scotland (Sitelink) (3).

The trees to the west of the Abhainn Airdhcheodiuis are subject to Tree Preservation Order (TPO) (4), see Figure 4.

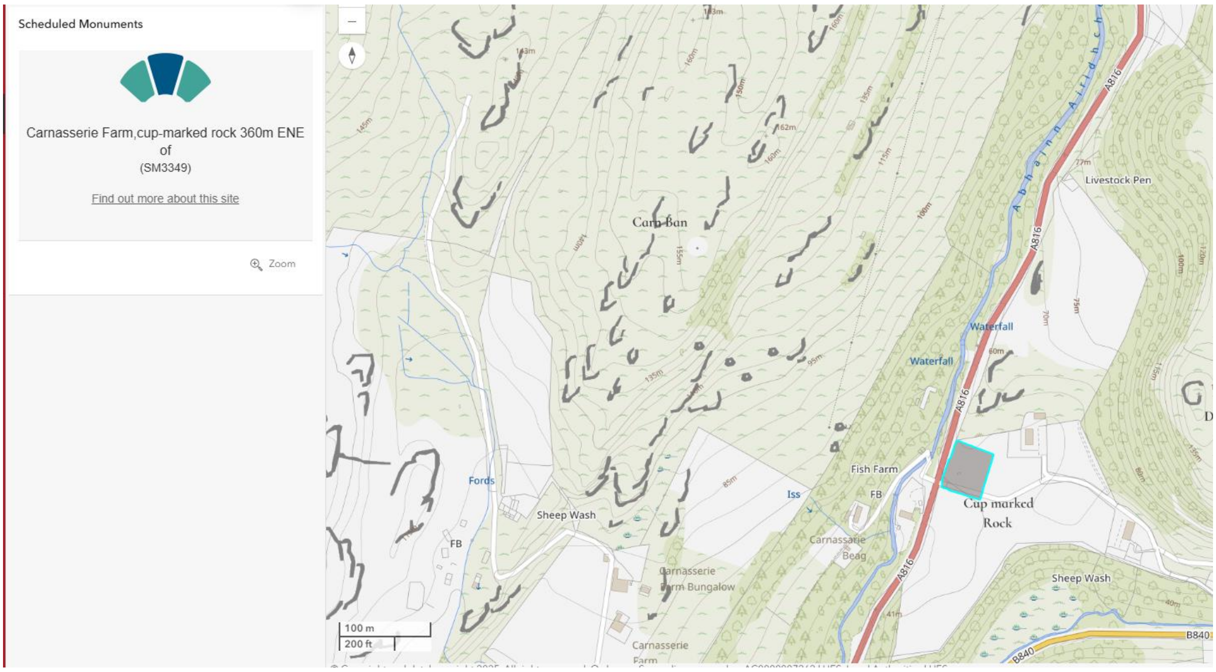

Figure 3 Extract from the Historic Environment Scotland portal showing the location of the cup marked rock, Scheduled Monument.

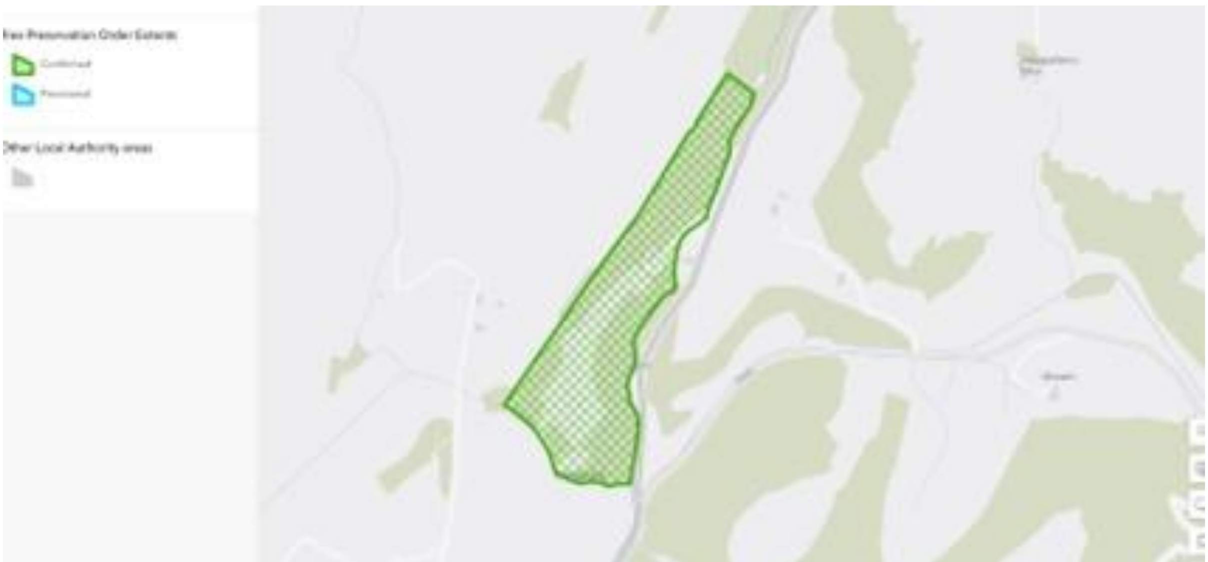

Figure 4 Extract from the Argyll and Bute TPO Portal showing the location of the trees at Carnasserie covered by the TPO.

Site Inspection

The landslip was noted to have likely occurred very recently, within the previous few days of the 1st December insepction. This is confirmed by Argyll and Bute Council, the last visit to the site was on the 27th November 2025 and the large slip had not yet occurred. There was a small slip towards the toe of the slope with an incised drainage channel evident in the mid-section of the slip with at further drainage feature close to the northern boundary evident on photographs from that day (Figure 5).

Heavy rain was experienced locally on 28th November 2025, followed by very cold weather and milder conditions by the Sunday (30th Nov) evening. It is thought that the slip had occurred sometime over the weekend 28-30th November.

The landslip is approximately 12m wide and 11m high, with the material depth ranging from 1-3m. Some of the slipped debris can be seen in the river below (Figure 6). There are several large tree stumps within the debris that should be removed to prevent water from eroding the toe and undermining the slope, leading to further collapse/landslips. The headscarp of the failure is in front and below an existing retaining wall, this can be seen in the top, right-hand corner of the scarp.

The retaining wall is present along the site from the existing retaining wall to the top corner of the straight. The wall is noted to be leaning downslope and is observed to be voided and unstable. A section was removed to allow rope access inspection of the slope below (just north of the retaining wall).

Figure 5 Site photograph provided by Argyll and Bute Council, taken on the 27th November 2025 from the track at the opposite bank.

Figure 6 Site photograph taken by Geo-Rope, taken on the 1st December 2025, the large photo at the top is taken from the track on the opposite bank. The two lower are taken from the A816.

The bedrock exposed in the upper slope rock cut (from road widening in 2009), shows medium strong to strong (breaks with one to more than one blow with hanmmer), grey, fine-grained rock (Figure 7). This is present in the north end of the cut, approximately in line with the concrete beam, likely part of the Tayvallich Volcanic Formation metabasites. From the south end of the concrete beam to the south of the section, the exposure of competent rock deteriorates and only soils are exposed with no distinguishable bedrock observed.

There is an open drain running along the toe of the upper slope in the verge of the A816, this was observed to be clear and free flowing.

Figure 7 Site photograph taken by Geo-Rope, taken on the 1st December 2025, taken from the A816 looking south. The photograph shows the upper rock slope (east of the A816) and the competent grey fine-grained rock to the north side and the change to poor, weak mica schist, highlighted by the dotted line.

Figure 8 Site photograph taken by Geo-Rope, taken on the 1st December 2025, taken from the track opposite. The photograph shows the lower slope (from the north of the existing retaining wall to the south of the existing concrete beam). Note the exposures of weathered, weak schist in the slope (following removal of tree stumps and branches from the slope.

The scarp can be seen to comprise brown, very silty clay (Figure 6). With outcrops of sub-horizontal bedrock outcropping approximately 2-5m below road level. At the north side of the slip there is a bedrock observed within the edge, approximately 3m below road level. The area within the slip and exposed in the lower slope to the south (Figure 8) is comprised of mica rich schists (likely belonging to the Tayvallich Volcanic Formation psammite and semipelites). This corresponds with the weaker area of weather rock observed in the upper slope. Hand samples of this rock (Figure 9) obtained by rope access inspections show rock to be weathered extremely weak to very weak rock exposed at the surface (breaks easily between finger and thumb to break easily with firm hammer blow and can be peeled with a knife). The rock contains a high proportion of mica and shows this weathering to clays. There are some areas on the slope there is no rock remaining only weathered products, dominated by silts and clays.

Figure 9 Site photographs taken by Geo-Rope, taken on the 3rd December 2025. The photograph shows the typical weathered, weak to very weak mica schist found on the lower slope.

It is not possible to determine how pervasive/extensive the weathered and weak rock is within the slope without intrusive ground investigation. It is a concern that if the road is constructed on such weak and weathered material a further failure could extend a failure plane below the road and a large section of the slope may be lost. The presence of weak rock and poor ground conditions may also lead to more significant engineering solutions being required.

On site, the limit of the concrete beam installed in 2009 was determined, this starts around 42m north of the existing retaining wall and is approximately 30m long. This was installed following a similar failure on a section just to the north. On examination drainage for the concrete beam would appear to be draining into the failure area. This was investigated and found to be the case (Figure 10). The pipe was found within the retaining wall within the south side of the failure scarp (Figure 11). No water was noted to be issuing from the pipe but even if the pipe is blocked it is though likely that the drain combined with the dam effect of the solid concrete beam is directing water into the failure area. The drainage will need to be addressed as part of the permanent remedial works.

Figure 10 Site photographs provided by Argyll and Bute Council from the 2009 concrete beam works. Note the filter drain, highlighted by the dashed line, discharging into the recent failure area.

Figure 11 Site photographs taken by Geo-Rope, taken on the 2nd December 2025. The photograph shows the grey outflow pipe of the filter drain installed from the concrete beam. The pipe is located in the top south corner of the retaining wall within the scarp of the failure.

Recommendations

Immediate:

- Removal of the stumps from the river below to prevent undercutting of the toe.
- SEPA to be contacted to ensure that they are aware of the event and the potential for silt release during works. Contact the landowner for access consent.
- Precondition survey to be undertaken prior to any works.
- Removal of stumps to ground level and the removal from the slope of the cut timber and branches. Together with vegetation clearance in two strips on the slope for better ground assessment and location of bedrock.
- The site should be monitored very closely for any signs of further movement, tension cracks, longitudinal cracking of the carriageway, etc., A 24/7 presence is recommended to react to significant changes.
- The site should be prioritized for gritting as it is now considered a worksite.

Short term:

Felling and removal of the fallen trees leaning on the existing retaining wall and exposed slope to prevent damage and/or failures. These are subject to TPO and the Arboriculture Officer or planning department and landowner should be consulted prior to works being undertaken.

Locate where water is draining and mitigate to control water discharge.

Anchoring of the existing concrete beam to provide a stable platform for plant to work from and to increase the stability of this area.

The site should be monitored very closely for any signs of further movement, tension cracks, longitudinal cracking of the carriageway, etc,. A 24/7 presence is recommended to react to significant changes.

Install permanent solution, the preferred solution to install soil nails/anchors with mesh and shotcrete facing combined with drainage improvements. This system has been discussed with Argyll and Bute Council at meetings on the 02/12/25 and 05/12/25 (Andrew Summers, Hugh O'Neill, Elsa Simoes, Jamie Salmon, Kris Hawkings, Callum Robertson, Adam Ross, Stuart Watson, Niall McLean, Calum McLean, Nicky Horsburgh) in response to the landslip emergency. The solution is preferred due to the following:

- Adaptable: Suitable for mixed soil–rock slopes and variable ground conditions, including poor rock. Provides deep reinforcement and prevents slope movements. Gives slope reinforcement quickly.
- Fast to design and install: Can be installed quickly to reinstate the slope stability and prevent further failures. Allows the road to remain open during construction.
- Integration of drainage: Weep holes or inclined drains can be incorporated into the facing to reduce pore water pressure.
- Minimal space required: Unlike the gravity or post and beam wall the shotcrete wall can be stopped where rock is sound and requires less footprint.
- Design life: Durable solution, depending on materials used can be >60 years.

- Cost: Strong and robust measure for good value.

Alternative solutions were considered but have been discounted. These are detailed below and further information including indicative costs and durations are included in Table 1.

Do nothing: No engineering works and move the traffic permanently to the inner lane under traffic lights. In time it is probable there will be a further large failure event, or multiple smaller events. Given the weak, poor rock and unfavourable ground conditions thought to be present a large failure plane extending below the road is a possibility. Once the road is unable to support the vehicle load the options will be to restrict vehicle weight or close the road. It will take many months for the road to be reopened if this were to happen.

Flexible facing with anchors: Initially considered as a temporary holding measure, deemed not strong enough for the poor rock conditions. May have potential if a temporary solution is warranted. Soil nails/anchors could be adopted into a shotcrete or retaining solution later.

Piles (secant/sheet piles/contiguous): Dismissed due to the risk of slope failure due to vibration though the slope at installation, particularly in the unfavourable ground conditions.

Post and beam concrete wall: Dismissed due to unknown rock conditions for keying in posts. Would also need to extend to the base of slope within the river, difficult to construct at this time of year and would require a CAR licence (or current equivalent).

Gravity-type solutions: Not feasible due to the width required due to the height of the slope and the location of the river at the toe. SEPA consents, environmental impacts, heavy temporary works and problematic geotechnical ground conditions increase the complexity of the solution. Cost and timescales would be increased compared to other options.

Counterfort/buttressed RC wall: Would reduce the concrete and footprint compared to a gravity type wall. Still requires wide footing/improved foundation and drainage improvement. SEPA consents, environmental impacts, heavy temporary works and problematic geotechnical ground conditions increase the complexity of the solution. Cost and timescales would be increased compared to other options.

Mechanically Stabilised Earth (MSE): Not feasible due to the large potential failure zone and the set back that would be required. Not enough space for excavation of the slope to install without road closure. Given the poor ground conditions and slope height it may not be strong enough. Also, not ideal with the river at the toe, would require significant scour protection.

Localized Realignment/Widening: Moving or widening the road is not feasible. Widening uphill would require a significant excavation (~10 meters) and would disrupt the only open lane. This is also prevented by archaeological constraints due to the presence of a Scheduled Monument (cup mark stones) within the required widening zone, and a nearby house. Widening to the west would require significant engineering project and infrastructure, e.g., a cantilevered road, viaduct. This would still require stabilisation of the lower slope.

Table 1: Summary of options, indicative costs and durations with key constraints and notes. Please note that the costs and durations are indicative only and do not constitute an offer, they are provided to allow comparison of potential option costs.

Scheme	Typical use at 10-12 m	Indicative installed cost (£/m²)	Total indicative cost (£) if 550m²	Duration (weeks)	Key constraints	Notes
Do nothing	N/A	N/A	N/A	1-2	Keep traffic on the inside lane to the east of the site - run this section under traffic lights. No engineering measures.	No stabilisation of the lower slope, further failure of the lower slope is likely and may extend to below live lane. If there is a further failure this is likely to result in either the requirement for restricting vehicle weight (e.g., cars only) or road closure. In the event of a further significant failure the road would require to be closed for months to allow repair. Following further failure repair options could also be more extensive, increasing cost and programme.
Flexible facing with anchors	Yes	2,200-4,000	1.2 - 2.2M	16-28	Low footprint, fast to install. Initially considered as a temporary holding measure, deemed not strong enough for the poor rock conditions. May need additional mesh/soil retention for softer ground. Will require additional protection/reinforcement at the crest, e.g., concrete beam and anchoring of the existing.	May have potential if a temporary solution is warranted. Soil nails/anchors could be adopted into a shotcrete or retaining solution later. Requires dense, long soil nail grid, corrosion protection critical. Areas uncertain, may be required over less area if competent rock is found towards the lower slope. Cost is based on 550m² , this may be reduced on design.
Soil nails / anchors and shotcrete facing	Yes	2,400-5,000	1.3-2.75M	18-32	Low footprint and good for mixed ground. Fast to install. Additional beam or anchoring at the crest may be required. Needs to include	Requires less dense, long soil nail grid, corrosion protection critical. Can be stopped on the slope where competent rock is found. Areas uncertain, may be required over

					drainage (chimney drains, weep holes, etc.), to prevent pore pressure build up. Will require additional protection/reinforcement at the crest, e.g., concrete beam anchoring of the existing.	reduced area if competent rock is found towards the lower slope. Cost is based on 550m², this may be reduced on design.
Secant/contiguous bored pile wall with anchors	Yes (if drivability allows)	3,000–5,500	1.65-3M	22-34	Groundwater, complex temporary works. Vibration resulting in instability/failure. SEPA, environmental impacts.	Minimizes excavation footprint; anchors reduce bending and movement. Vibration in poor unsupported ground gives a high risk of slope failure, particularly in poor ground conditions.
Sheet pile wall with tiebacks and concrete cap	Yes (if drivability allows)	2,500–4,500	1.4-2.75M	16-26	Groundwater, complex temporary works. Vibration resulting in instability/failure. SEPA, environmental impacts.	Minimizes excavation footprint; anchors reduce bending and movement. Vibration in poor unsupported ground gives a high risk of slope failure, particularly in poor ground conditions.
Gravity-type retaining structure	yes (if base width allows)	3,500-7,000	1.925-3.85M	26-45	Large, battered faces and thick bases (space not available). Large and complex temporary works.	SEPA consents, environmental impacts and high cost/long timescales. Wide base with no space for construction, unlikely to get consent from SEPA.
Counterfort/buttressed RC wall	Possible	3,200–5,200	1.76-2.86m	26-40	Wide excavation footprint, dewatering, longer formwork cycles, complex temporary works.	Reduces concrete volumes and base vs. gravity; requires improved founding and robust drainage. Ground conditions at base would expect to require improvement to provide suitable footing. May need keying into base of slope which would not be advisable. Heavy temporary works required.
MSE/reinforced soil with staged excavation	If setback available	3,000–5,500	1.65-3M	24-46	Space for reinforced zone, drainage, river setback. Needs a competent zone behind, unknown if this is present; not ideal right on the river toe without cutoff/scour control.	Needs a competent zone behind, unknown if this is present; not ideal right on the river toe without cutoff/scour control. Would need road to be closed for approx. 8-12 weeks and unlikely to be strong enough for

						the height and poor ground conditions. Complex temporary works would be required.
Hybrid: embedded toe + mass concrete stem	Yes	3,500–6,000	1.925-3.3M	24-36	Sequencing toe works with stem pours, scour protection. SEPA, environmental impacts.	Piles or a shear key at toe to resist sliding/scour; complex temporary works. Excavation of toe of slope required, this is not advisable in the poor rock - inducement of failure is a big risk.
Localized Realignment/Widening	Possible if move to the east away from slope	N/A	7-10M	36-52	Widening uphill would require a significant excavation (10 meters +) and would disrupt the only open lane for some time. Moving the road a significant amount would ensure reduced risk from deterioration of the slope over time.	Moving east, most logical - Archaeological constraints with presence of scheduled monument. Nearby house. Land purchase. Moving west - space constraints would lead to heavy engineering works and still require the slope to be stabilised.

References

(1) BGS GeoIndex https://mapapps2.bgs.ac.uk/geoindex/home.html. Accessed 02/12/25
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(3) SNH Sitelink https://sitelink.nature.scot/map. Accessed 02/12/25
(4) Argyll and Bute TPO Webmap Argyll and Bute TPO Web Map accessed 04/12/25