ScotlandTranServ
A Balfour Beatty Mouchel Joint Venture

A83 Tarbet – Lochgilphead – Kennacraig Trunk Road

Study into Potential Emergency Diversion Routes at the Rest and Be Thankful

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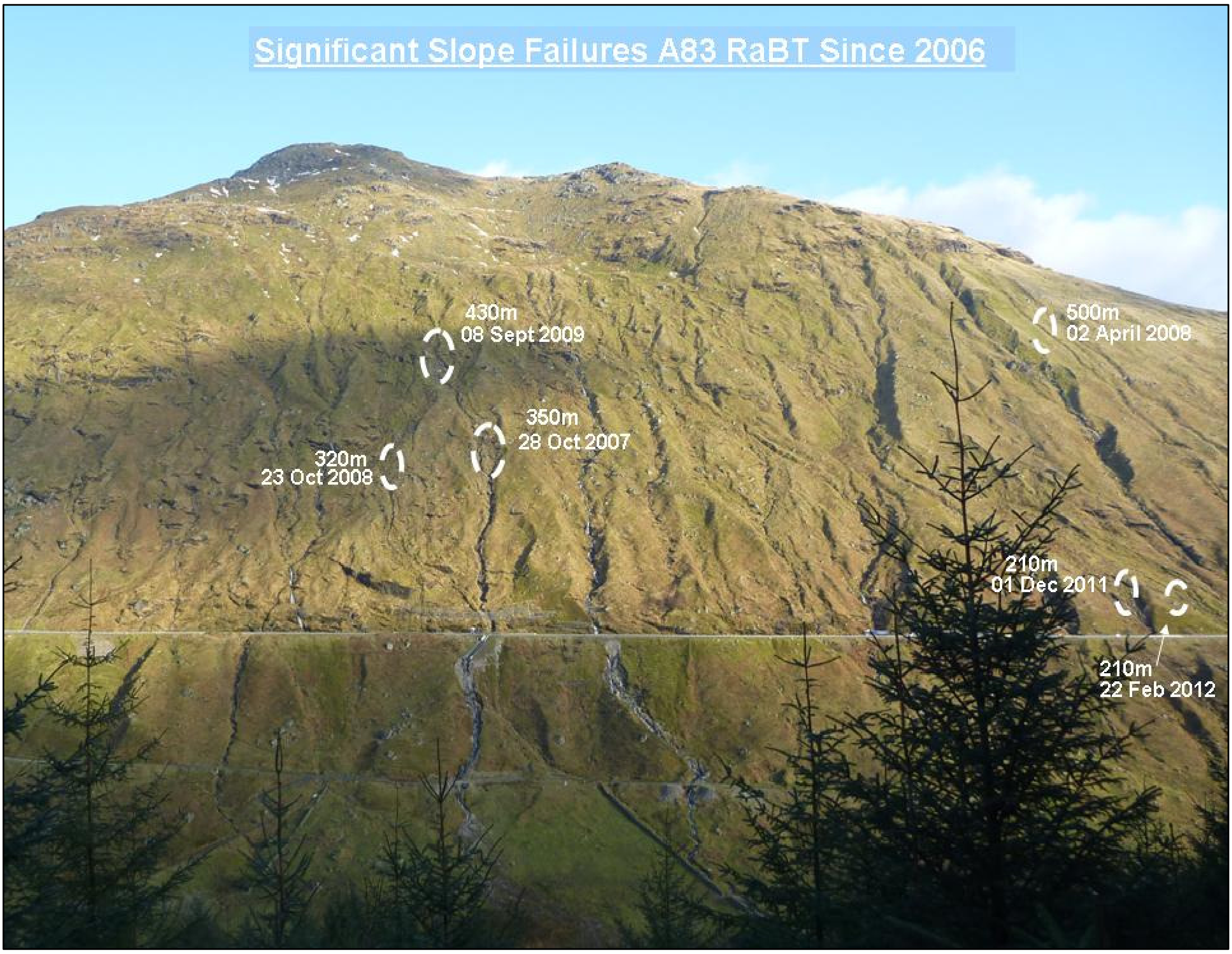


1 Background and Report Objectives

1.1 Background to Problem

Over the last five years the A83 trunk road at the Rest and Be Thankful has been affected by six debris flow events. Three of these events have led to the A83 being closed for a total of 34 days, due to debris landing on the road and subsequent concerns regarding possible further failures. When the A83 is closed all trunk road traffic is diverted around the incident via a pre-planned emergency diversion route, to ensure the safety of the travelling public.

The pre-planned diversion route for the A83 at the Rest and Be Thankful utilises sections of the A82 between Tarbet and Tyndrum, the A85 Tyndrum to Dalmally and finally the A819 between Dalmally and Inveraray before rejoining the A83. The typical journey time for this pre-planned route is 66* minutes to cover the 49 mile journey from Tarbet to Inveraray. To illustrate the length of the diversion an outline plan is provided in Figure 1.

* *Based on actual times taken to drive pre-planned diversion route*

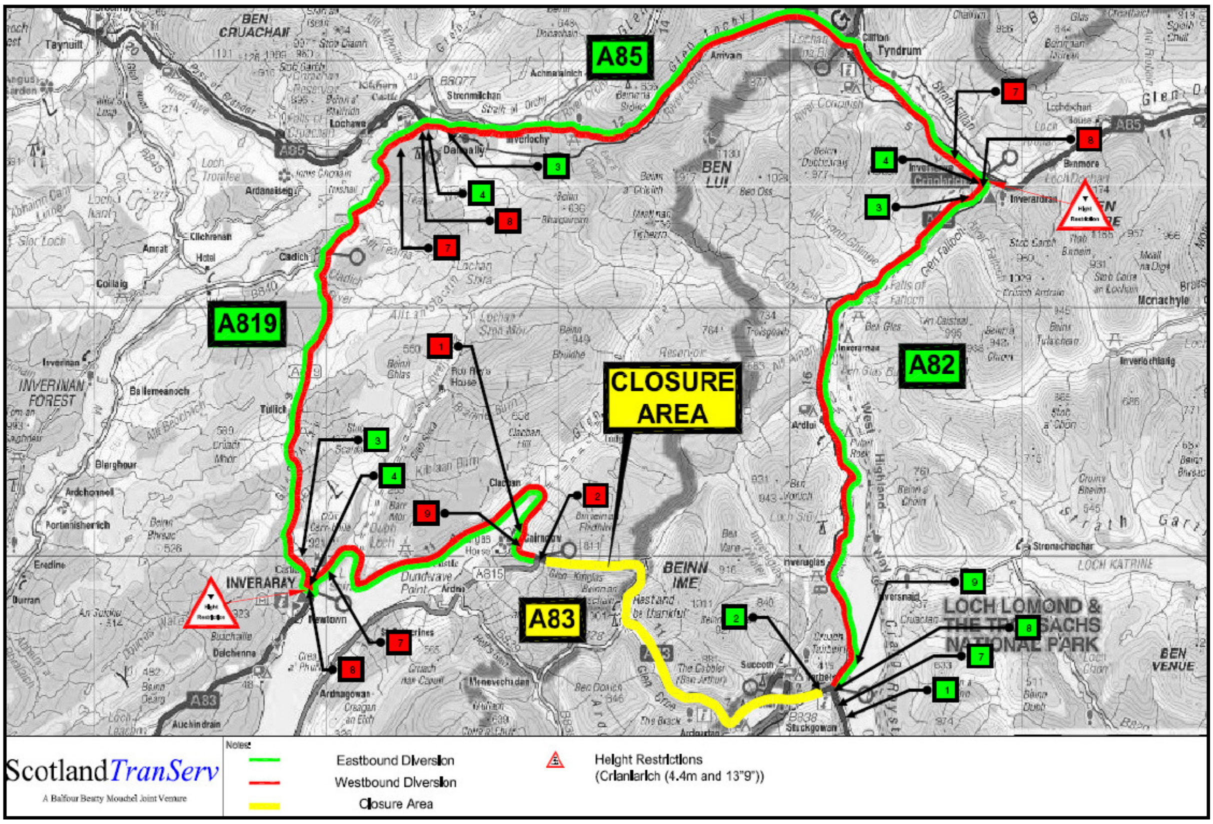


Figure 1: Pre-planned diversion route during closure of A83 at Rest and Be Thankful

There is an unavoidable impact on diverted traffic through increased journey distance and increased travel time. Table 1 below demonstrates the impacts upon diverted traffic.

	A83 between Tarbet and Inveraray (shown in yellow in Figure 1)	A82/A85/ A819 Pre-planned Diversion route (shown in red and green in Figure 1)	Impact
Journey in miles	24	49	**Increased distance = 25 miles**
Journey in minutes	35	66	**Increased travel time = 31 minutes**

Table 1: Impact of Emergency Diversion Route

Transport Scotland also plans to carry out extensive road improvements on the A82 at Pulpit Rock next year for 12 months, which will result in road closures to construct the works. The A83 trunk road will require to be utilised as part of a planned diversion route during this period. Should there be any events that impact on the A83, the only available diversion route from Inveraray would be A819 to Dalmally, A85 to Lochearnhead, A84 to Stirling and A811 to Balloch, a total of 108 miles taking 2 hours 31 minutes.

The A83 at the Rest and Be Thankful is also an important lifeline to the village of Lochgoilhead whose route, the B828, joins the A83 just outside the western boundary of the slope failure area at the forestry car park. The impact of such a closure undoubtedly affects journeys from the community to the A83/B828 junction, as they must travel the full planned diversion, resulting in an 86 minute, 66 mile journey from Tarbet. Additionally, access to the village of Cairndow, which lies approximately midway between Inveraray and the A83/B828 junction, is only via the full planned diversion

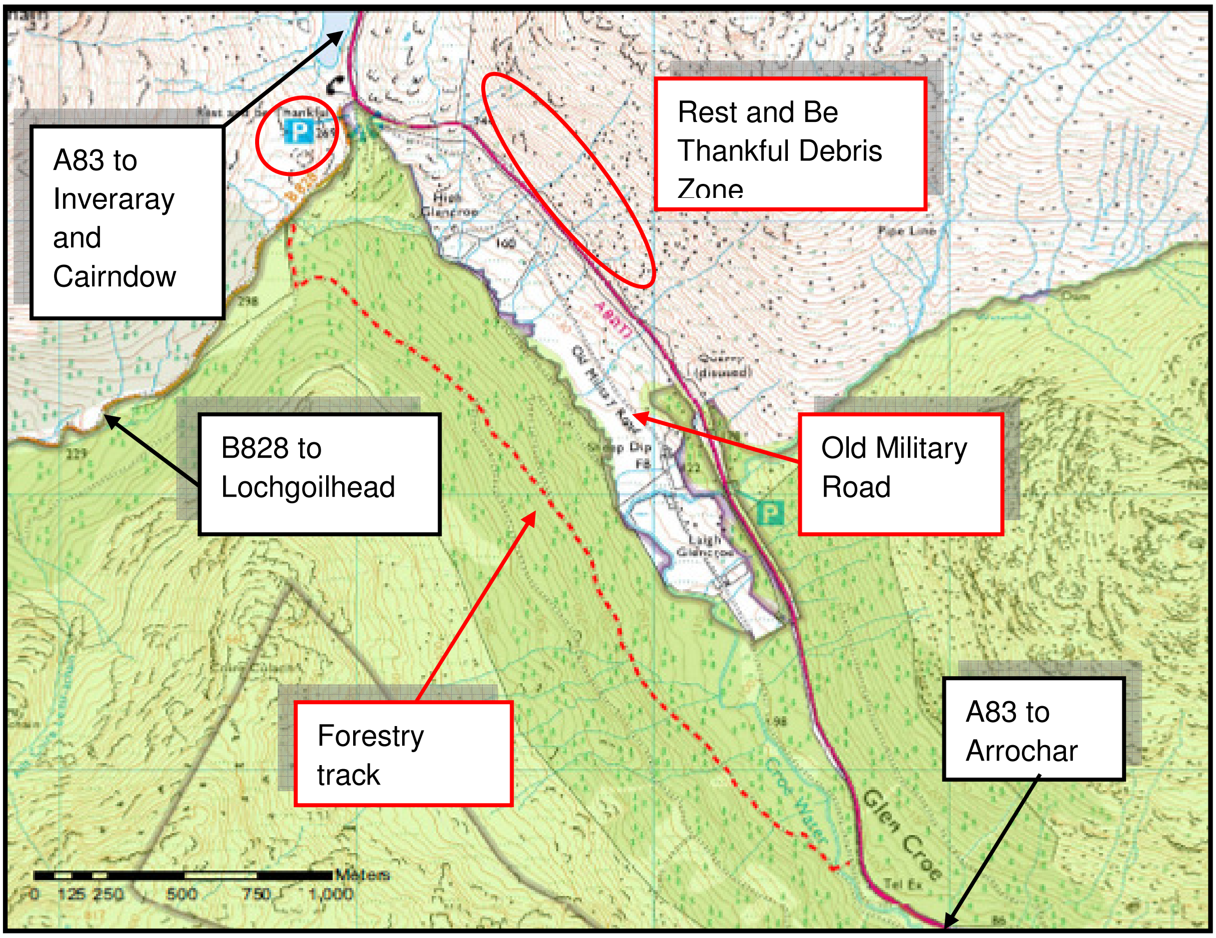


Figure 2: Location Plan Showing Primary Focal Points

In light of the impacts to both trunk road traffic and local communities, Transport Scotland instructed Scotland TranServ to investigate the feasibility of upgrading a nearby forestry track to an emergency route for trunk road traffic should the A83 be closed again. In addition Transport Scotland requested that the report also extend its scope to Major William Caulfeild's old military road. The military road, which was in operation until the late 1930's, sits predominately at the toe of the Rest and Be Thankful slope beneath the A83, and as a former route it was deemed to be worthy of further consideration.

1.2 Report Objective

The objective of this study is to investigate and assess both the forestry track and the old military road as a viable, but short term, emergency route in the event of any further debris events that close the A83 trunk road.

Each option will be assessed against a number of key factors. The purpose of this assessment is to measure the potential benefits and risks of both options to aid and inform Transport Scotland. The assessment framework is:

- Existing functionality,
- Journey times,
- Engineering required,
- Potential environmental Issues, and
- Mobilisation, Breakdown or Emergency Recovery

The study will conclude with a tabled summary of findings.

2 Forestry Track Assessment

2.1 Existing Functionality

The Forestry Track option would utilise the forestry track that crosses the slopes on the west side of Glen Croe and meets the A83 a few miles west of Ardgartan, in conjunction with the B828 Argyll and Bute Council local road, a total length of 4.1km. The forestry track is owned and managed by the Forestry Commission Scotland and is part of a network of forest tracks.

The forestry track has been formed into the very steep hillside of Glen Croe and is approximately 3.5km in length. The track rises from 91m above sea level at its eastern end to a height of 292m at its western end. The average gradient over the 3.5km distance rises at 6.7%*, although throughout the route there are short steep sections up to 18%* in gradient. Refer to Figure 11.

The existing track is unbound and believed to be made up of a 450mm – 600mm deep layer of road capping type material.

** Gradients derived form topographical survey information*

Alignment of the forestry track is changeable with no consistency in either horizontal or vertical geometry. Analysis of topographic information confirms an average track width of 3.2 metres. Nevertheless this average cannot be considered a constant value. Track width can occasionally dip to as narrow as 2.6 metres.

The forestry track is on sidelong ground with a steep lower slope below which presents a significant hazard along its full length. See Figure 3 below.

Figure 3: Image of forestry track and adjacent lower steep slope

The steep slope is separated from the forestry track by an existing soft verge. The width of the verge is changeable, ranging from 0.2 metres at its narrowest to 6.6 metres at its widest, but it generally measures 1.2 metres.

Numerous streams flow down the slope above the track which channel, in prolonged periods of rainfall, high volumes of water. Images of the streams in spate have been provided in Figure 4. Water from these streams is managed by a very effective open ditch system which runs most of the length of the western side of the track. The main benefit of an open ditch system is that it ensures that any new streams are fully captured and piped beneath the track, thus removing any potential risk of water reaching the track and saturating the unbound pavement. The existing culverts vary in size from 300mm up to 750mm. The majority appear to be of concrete construction although there are also upvc, stone and steel types. Some of the culverts are showing signs of damage or collapse at the inlet side and several were completely buried or blocked. There is no evidence of headwalls at either the inlet or outlet sides of any of the culverts.

Figure 4: Images of streams in spate after heavy rainfall

Numerous emergent stream beds have also been observed, suggesting that the hydrology of the upper slope is evolving and forming new channels, reinforcing the need for a drainage ditch along the length of the track.

The A83 between Ardgartan and the Rest and Be Thankful, Glen Croe has a long history of landslide events. Transport Scotland's "Scottish Road Network Landslide Study" categorised the area a priority one status in terms of high perceived hazard. To illustrate the potential debris susceptibility of this area Transport Scotland GIS susceptibility layer has been over laid on an aerial photograph to produce a debris susceptibility map. See Figure 5 below.

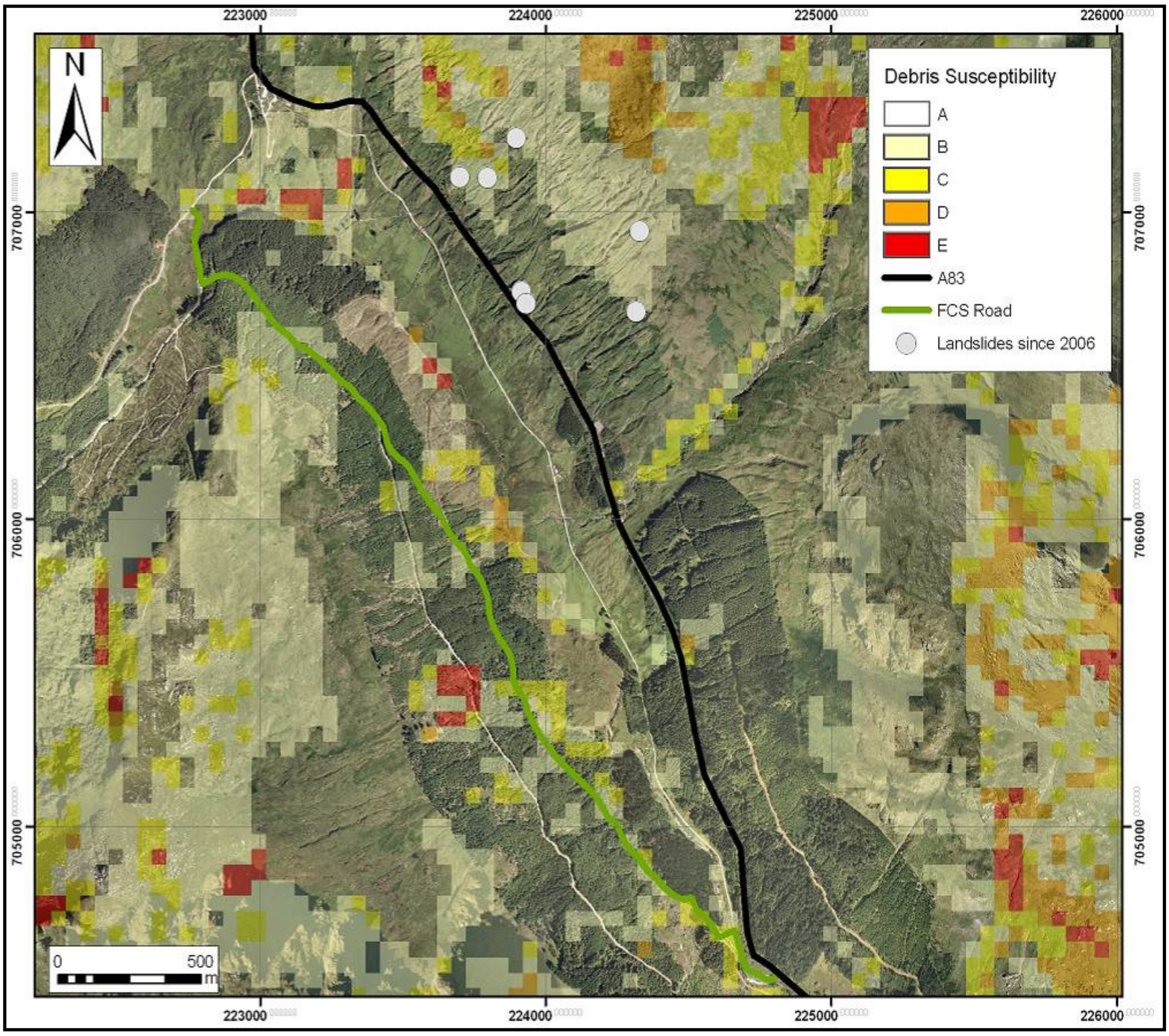


Figure 5: Debris susceptibility Map

The map shows, in red, a number of areas of debris flow susceptibility within the forestry track. The western slope of Glen Croe, on which the forestry track is formed, shares a lot of similarity with the neighbouring eastern slope, where the A83 is constructed, in terms of hydrology and geology. As a result they also share the same potential risk of landslide failure. Indeed, during the debris event in December 2011, when the A83 was closed, there was a lower slope failure on the forestry track at the same time. This required the Forestry Commission to carry out slope remediation measures, using rock infill to stabilize the failure and so protect the integrity of the forestry track. An image of the subsequent measures taken by the forestry commission to stabilize the failure is shown in Figure 6 below.

Figure 6: Image of the slope remedial measures carried out. Note also fallen tree in background

There is one structure which crosses the Croe Water, at the eastern section of the forestry track. The structure is a narrow single lane 8m span bridge which is constructed from pre-stressed concrete beams with an insitu cast concrete deck, as shown in Figure 7 below. The operating limit of the bridge is 44 tonnes, which is suitable for trunk road traffic.

Figure 7: Images of the existing bridge over the River Croe.

2.1.1 Findings from Vehicle Trial of the Forestry Track

Based on the initial assessment of the functionality of the forestry track, there were concerns with the ability of large heavy goods vehicles to negotiate the narrow and winding alignment. In light of this, Scotland TranServ engaged a professional haulage firm for their expert views on whether it was feasible to drive the forestry track.

Following a detailed site inspection, the haulier's view was that it would be possible to carry out a trial run with a large vehicle. As a result a trial was carried out on Tuesday 15 May 2012, which was recorded via an HD hand cam. Weather conditions were dry. Both hill walkers and cyclists were encountered on the forestry track during the exercise showing the varied use made of the track.

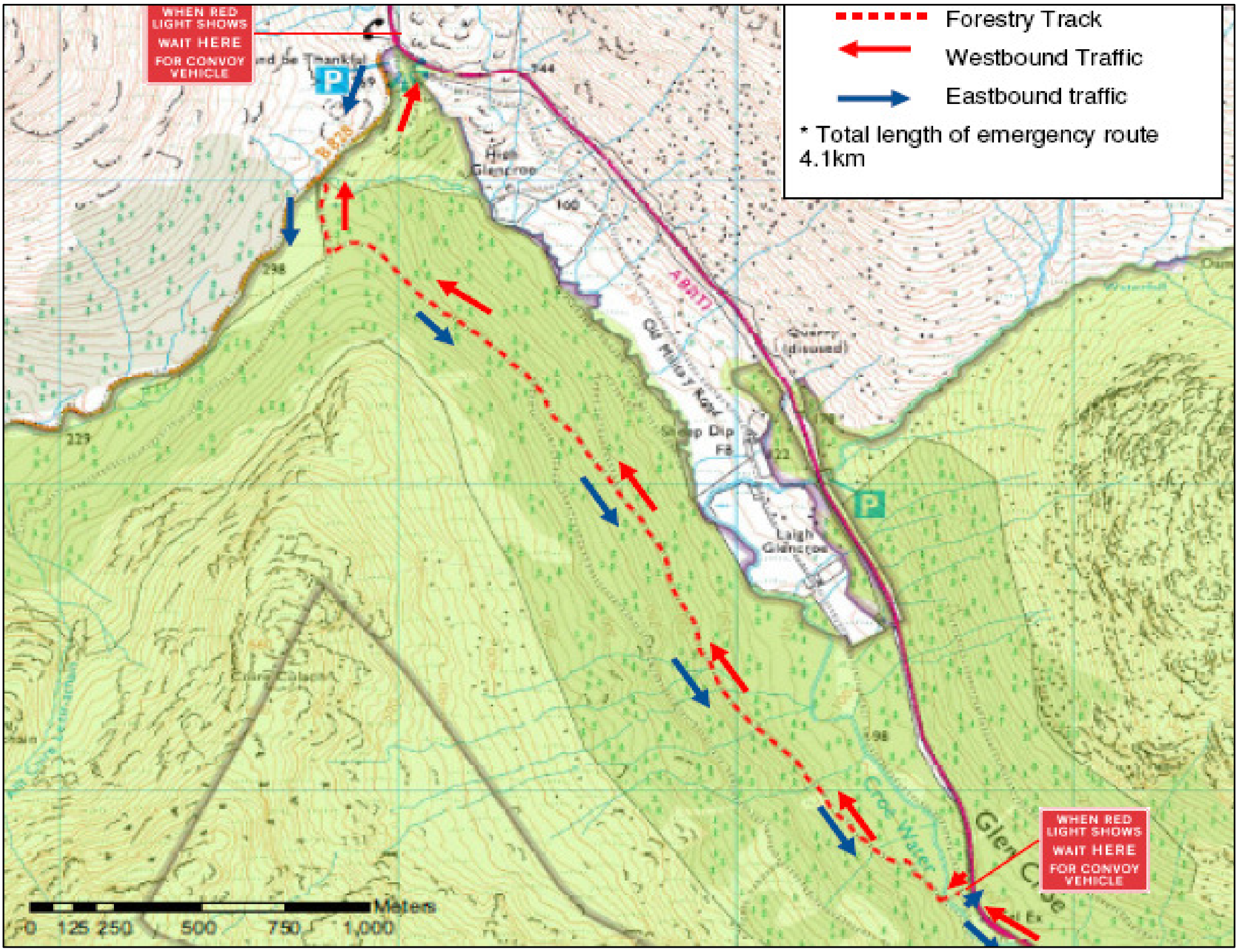
The trial involved using an unloaded 13.5 metre long articulated vehicle. Although not the longest articulated vehicle or the most onerous vehicle in terms of swept path, it was deemed sufficient to carry out this type of exercise. Refer to Figure 8 below.

Figure 8: Image of the 13.5m HGV negotiating a rock outcrop near the start of the east access

The outcome of the trial demonstrated that it is possible for heavy goods vehicles to negotiate the ascent and descent of the forestry track. However, there were times when the wheels of the vehicle swept uncomfortably close to the steep-sided lower slope raising concerns for driver safety. The alignment of the approaches to the existing bridge over the Croe Water on either side was also problematic because of sharp 90° bend at each side of the bridge, making it very difficult for heavy goods vehicles to negotiate without mounting over the low parapet.

Furthermore, whilst carrying out the descent the vehicle undertook significant braking to control speed. Both of these observations led to an overriding conclusion that, although feasible to manoeuvre a larger vehicle along the track, the likelihood of larger vehicles losing traction or mounting sections of narrow soft verge was high. This probability would increase further during periods of poor weather conditions, something to be anticipated regularly given the location and elevation of the site.

The trial also confirmed that the speed of the vehicle averaged between 5 and 6mph. There is further discussion on the journey time in section 2.2 of this report. The trial also raised concerns as to the ability to mount effective and timely emergency or breakdown operations. Initially in the event of a breakdown or emergency, part of the convoy would be temporarily cut off on the hillside whilst efforts were made to resolve the situation. Further discussion on this is covered in section 2.5 of this report.



2.2 Journey Time for Forestry Track

One of the key considerations of the emergency route is to deliver journey time savings over the current pre-planned diversion route, and reduce the impact to the local communities. As stated previously, to travel the pre-planned diversion route from Tarbet to Inveraray takes 66 minutes which results in an additional journey time of 31 minutes.

Using the heavy goods vehicle trial run it is possible to determine journey times along the emergency route. This calculation is complex due to the variable flows and behaviour of traffic in different circumstances at different times of day and year. The findings of our investigations are based upon a simple modelling technique without involving software analysis tools.

Because of the length of time taken to travel the emergency route, it becomes untenable to operate if all of the waiting traffic is not accommodated with each passing convoy, because the delays suffered by drivers rise exponentially if not let through in the first convoy they meet.

The length of the convoy required to accommodate peak flow throughout the wettest part of the year (September to April inclusive) has been calculated as follows:

Period (inclusive)	Peak Flow (vehicles/hour – one direction)	Number of Vehicles in Convoy *	Length of Convoy (m)	Time between first and last vehicle exiting route (mins)
December	70	83	**705**	5.3
January	135	186	**1581**	11.9
October to March	160	234	**1989**	14.9
September	200	333	**2830**	21.2
April	230	411	**3493**	26.2

Table 2: Length of convoy required to accommodate peak flow

** Iterative calculation multiplying the peak flow by the time that the lights in one direction are at red, which is a function of convoy speed and length.*

The risk of an incident involving the convoy and the severity of its impact increases with the length of the convoy. This is due not only to the quantity of vehicles and time on the route, but also to the reduction in control of the convoy by the lead vehicle. Under normal trunk road circumstances a convoy length of 300-400m would be acceptable. Again, due to the length of time to travel the route, the duration of an individual's journey depends mostly on when they join the queue. Using an assumed convoy length of 100 vehicles (850m) the journey times experienced by drivers varies as follows:

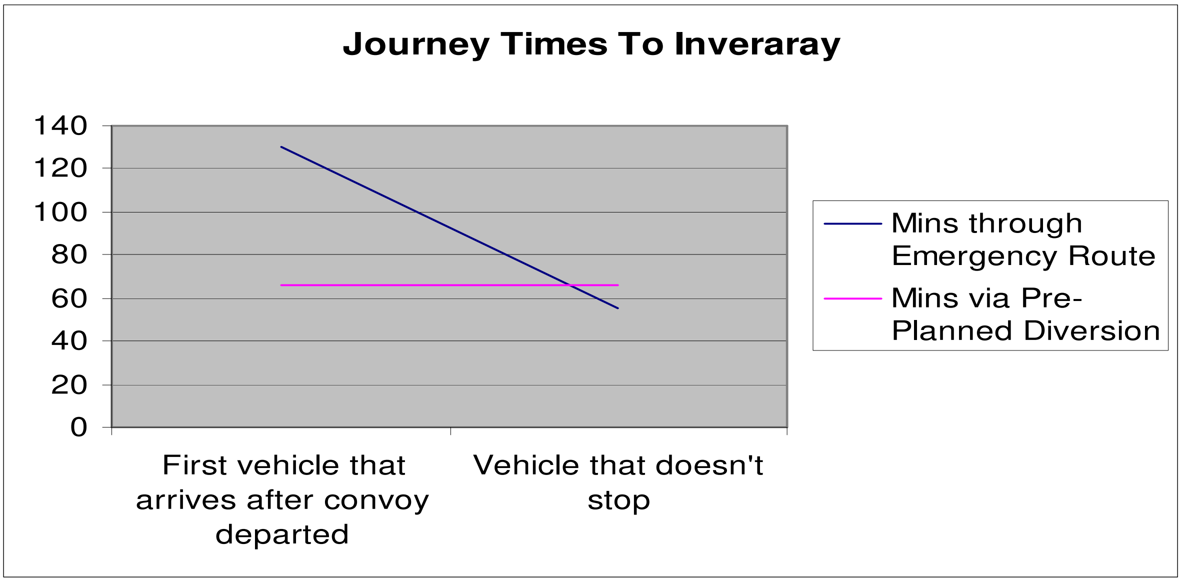


Figure 9: Potential journey times experienced by drivers

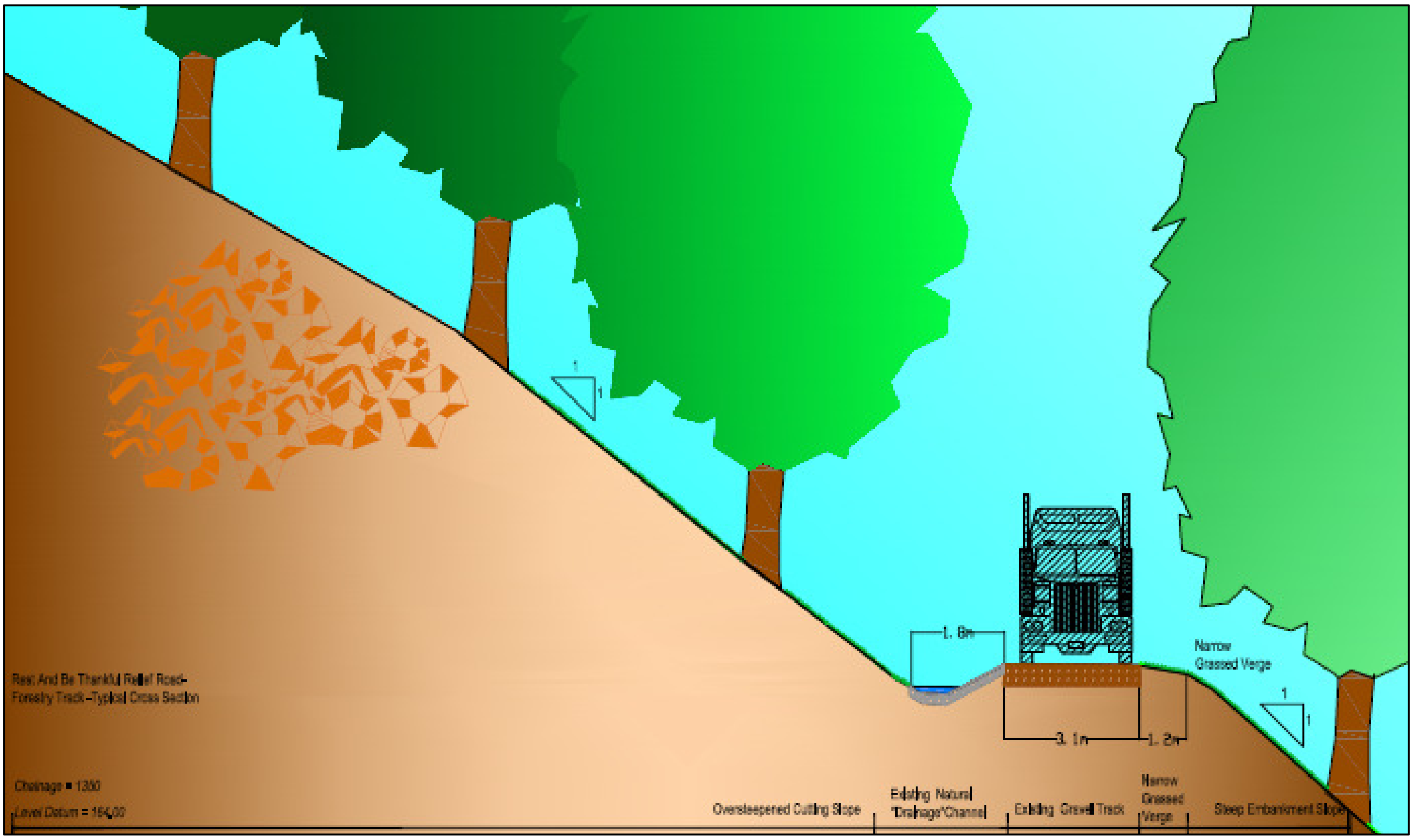
This shows that against the pre-planned diversion route, only a small number of drivers will benefit and have a reduced journey time. However, should there be a debris event when the A83 is being utilised to divert traffic from the improvement works at the A82 Pulpit Rock the maximum delay of 2 hours through the emergency route will be less than the 2 hours 31 minutes required to travel the A819, A85, A84, A811 to the A82 at Balloch.

Potential Solutions:

Operate emergency route only at times when traffic is below a certain flow.

Direct heavy goods vehicles around diversion.

Operate emergency route on a ‘tidal basis’



2.3 Engineering Required

2.3.1 Track Width

As previously discussed, and as highlighted in the trial run of the heavy goods vehicle, the existing cross section is narrow, steep and winding in alignment. Combining these factors with the ever present hazardous steep lower slope makes the likely severity, in the event of an incident, being ranked as high. The likelihood of an incident increases especially as history confirms that the emergency route would most probably be used during the months September to April where weather conditions will be at their worst.

Ideally, and to minimise risking driver safety, the track would be widened to form a standard trunk road lane width of 3.65 metres and include a 2.5 metres soft verge to separate traffic from the hazardous lower steep slope. However, to create an improved cross section would require cutting and filling both of the existing side slopes to form a new earthworks outline.

It was noted during our geotechnical walkover that the stability of the upper and lower slopes is questionable, with moderate to high risk for slope failure. One of key features that aids in minimising existing slope failure is the trees which grow on the upper and lower slopes. Their root system acts as a natural reinforcement to the slopes soils and therefore any removal of these trees will increase the probability of slope failure. To mitigate any risk of slope failure earth retaining measures, such as soil nailing or geotextiles would be required over the full length of cutting. This type of slope stabilising engineering would require extensive time to plan detailed ground investigations to define which areas required treatment. Without conducting a full ground investigation over the full length of the track, this type of solution is difficult to define. But considering the track is approximately 3.5km in length and would require work on both slopes, investment of both time and cost would be significant. As a result of all of these factors, conducting any form of improvement to track width is considered to be unfeasible under the terms of this study.

Figure 10: Image of tree and small slope failure noted during walkover surveys.

The open ditch that runs parallel at the toe of the upper slope could be utilised in order to maximise track width. However, as previously discussed, the hydrology of the upper slope is evolving and therefore the open ditch is an effective measure in ensuring water is kept off the track surface, protecting the integrity of the unbound track material.

2.3.2 Pavement Design

The existing track construction consists of a capping type material, probably a 6F2 granular sub-base, which is a frost susceptible material. Calculations have shown that this route would require a sub-base to a minimum thickness of 120mm to bring this track to a comparable strength to that of the old military road, before it could accept bituminous material to form a stable and robust pavement.

The depth of bituminous material required over the sub-base can vary depending upon the desired design life and number of heavy good vehicles that travel over the new pavement.

Taking these factors into account, we have calculated, using local traffic count information and working on the basis that the A83 could be closed for 6 days each year, a total of 1400 commercial vehicles could be expected to use the emergency route in a single year. Adopting a single layer of 75mm modern, high strength asphalt Base/Binder, the design life of the new pavement could be acceptable.

2.3.3 Structures Design

A new bridge is currently being designed by the Forestry Commission with the view to being incorporated within any final proposals to upgrade the forestry track. The new bridge would have a greater span and cross the river at a skew to remove the sharp 90° bends at either side of the bridge approaches.

2.3.4 Vehicle Restraint Design

As discussed, because of the narrow and winding nature of the forestry track there is potential for vehicles straying towards the narrow, soft verge and subsequently over the hazardous lower slope. Although speeds will probably be low when the road is used, at less than 10mph, examination of the video footage of the trial run highlighted that larger vehicle drivers margins of error were very small when driving past the very narrow sections of soft verge and adjacent steep lower slope. As it would be expected loads of up to 44 tonnes could be hauled by these vehicles, even at lower speeds, the movement of load could be problematic and influence the vehicle.

To effectively implement a vehicle restraint system that would provide some form of containment requires good verge width and stable ground to ensure the system operates at its optimum capacity. Without both factors the effectiveness of the system will be compromised. As discussed, the existing verge is generally narrow at 1.2 metres and typically, for a vehicle restraint system, 1.6 metres is the desirable minimum verge width to allow cars doors to be opened in the event of a breakdown, and allow sufficient width for a typical system to deform. Forming any improvement to the existing cross section will be problematic and costly as ground conditions are very soft and unstable under foot. As a result, experience suggests that it is highly probable that concrete strip foundations would be needed to support any new vehicle restraint system.

2.3.5 Buildability

Early discussion with the Scotland TranServ supply chain confirmed that surfacing the forestry track would be problematic but not impossible. The key issue is a lack of track width to allow room for passing surfacing wagons. To overcome this it is possible that temporary infilling of the side long ditch, at particularly wider sections, could create sufficient width to stack wagons. Once surfaced the infilled ditches would have to be excavated and restored to their original condition.

2.3.6 Timescales

Currently it is envisaged the works would take 10 to 12 weeks to construct.

Potential Solutions:

There is a very little scope to widen the track to negate any errant vehicle reaching the lower slope hazard and to improve the swept path of larger vehicles. Nevertheless, risks could be reduced by limiting emergency use to within daylight hours only and restricting access to cars and light goods vehicles only whilst being managed by a convoy system at 10mph. Post and wire fencing could be used to delineate the narrow soft verge but would not contain vehicles. Ribbed road markings would also aid informing and deterring drivers away from both the lower slope and the open drainage ditch.

As the track will only be operational for a short duration there is no benefit in radically improving the condition of all the existing culverts and therefore they could be left in their current condition. However, inspections should be carried out daily whilst the track is in use.

The track pavement should be strengthened using type 1 sub-base before laying new EME2 asphalt materials.

2.4 Potential Environmental Issues

2.4.1 Ecology

The forestry track is within the Loch Lomond and Trossachs National Park and on the southern border of Beinn Lochain, a Site of Specific Scientific Interest (SSSI). A SSSI is a conservation designation denoting a protected area in the United Kingdom and as such bound by nature conservation legislation.

Preliminary environmental investigations of the forestry track noted that the area is rich and ecologically diverse, in particular for protected species such as badger, otters, red squirrel and a variety of bird species. The Croe Water, which flows at the bottom of the valley, and its tributaries also form part of the Loch Long and Loch Fyne groundwater body, currently classified by SEPA as good status. The groundwater body forms part of a drinking water protection zone. The ground towards the lower section of the forestry track, nearest the Croe

Water is also identified as at risk for flooding using information from the Scottish Environment Protection Agency (SEPA)

Part of the existing forestry track is marked on the OS 1:50,000 map as a cycle route; it is also signed as a Forestry Commission cycle path, but does not form part of the National Cycle Network. The same part of the forestry track is also designated as a core path for approximately 1km. The path is also used by walkers. The surrounding area is rich in a number of communities of mosses.

Overall, operations and measures to upgrade the forestry track therefore have the potential for a considerable environmental impact.

2.5 Mobilisation, Breakdown and Emergency Recovery

2.5.1 Mobilisation

The minimum time expected to mobilise the emergency route would be around 2 hours, however, should there be fallen trees, landslide or adverse weather then mobilisation could take significantly longer. To mitigate against these potential issues, the existing trunk road landslide patrols and winter maintenance operations could be adapted to incorporate the forestry track emergency route. Furthermore a winter maintenance vehicle, with salting and ploughing capability, could be used as a convoy vehicle to prevent any snow becoming hard packed through trafficking. However, a detailed procedure/protocol will need to be considered and agreed in advance in conjunction between all emergency services, Traffic Scotland and Scotland TranServ.

2.5.2 Breakdown and Recovery Service

One of the primary concerns with the operation of the emergency route is how to implement an effective breakdown and emergency service. The lack of available passing or turning places would result in any breakdown or emergency fleet having to be situated at the start and end of the route so as to be as resilient as possible, since there is no scope for a landing area for an air ambulance. Breakdown and emergency vehicles would subsequently have to wait until the convoy completed its journey before any rescue could be carried out.

Additionally, and particularly relevant for the breakdown vehicle, the limited space on the track essentially precludes any opportunity to turn directly at the exact incident location. As a result any recovery or emergency vehicle will have to perform a reversing manoeuvre in order to reach the vehicle in need of assistance. This type of operation places a significant risk to the driver of the recovery or emergency vehicle.

Taking into account all these factors it is considered that response times to an incident will be lengthy. Should an emergency occur on the route, then the planned diversion route would need to be utilised whilst the emergency was dealt with, and an appropriate assessment has been carried out to ensure the emergency route is safe for further use.

Another important factor to consider is that should there be a breakdown involving a heavier vehicle, there are concerns with how a recovery vehicle will accommodate the weight of the heavy vehicle and still maintain sufficient traction to pull potential loads of 44 tonnes on a gradient of up to 12 %, whilst negotiating the narrow and winding track alignment. Given the narrow carriageway width and narrow soft verges, there is little margin for error on the forestry track, and an HGV jack-knifing or becoming stuck in snow would put the emergency route out of commission for a prolonged period of time.

Potential Solutions:

To mitigate against debris obstructing the emergency diversion route the existing trunk road landslide patrols and winter maintenance operations could be adapted to incorporate the emergency diversion route. The length of time to conclude the check and make the track operational would vary depending on the issues found.

To ensure a rapid response, it is advised that a tail vehicle is used behind the convoy to notify breakdown or emergency teams and provide any immediate support if required.

During snow conditions it would be recommended to have a dedicated winter maintenance vehicle on the diversion route, travelling in front of the convoy.

3 Old Military Road Assessment

3.1 Existing functionality

Of the 4.0km long Major William Caulfeild military road, 2.6km is owned by a private landowner. The remaining 1.4km is the property of the Forestry Commission.

The old military road, which was the original road to link Dumbarton with Inveraray was in operation until the late 1930's until improvements were carried out to form what is the A83 today. The road also has a rich history with Scottish motorsport because of its steep gradient and hairpin bends at the far west end of the road and was used for hill climb events up until 1969. Today the road is still a popular choice for classic car clubs.

The total length of the bituminous bound old military road is slightly shorter than the forestry track at 4.0km. Road width generally ranges between 3.0m to 3.5m apart from where it widens to 6-8 metres towards the hill climb at the far west of the route. See Figure 11.

Figure 11: Image taken from the Rest and Be Thankful car park overlooking the hill climb of the old military road

The gradient and alignment of the road is different to that of the forestry track. Travelling east to west the road sits for the majority of its length relatively level and straight beneath the A83. To illustrate this, a comparative long section of both the forestry track and military road has been provided in Figure 12 below.

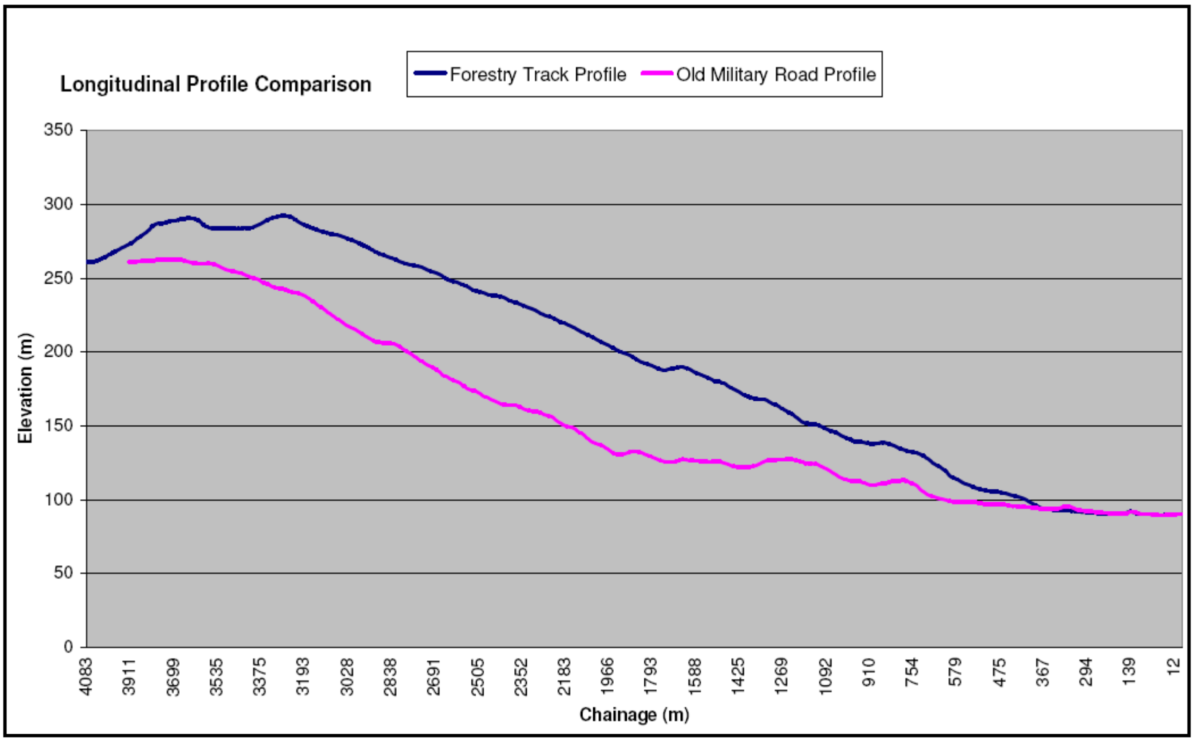


Figure 12: Comparative long sections

Towards the final third of the military road, the hill climb section, the road rises steeply at approximately 13% and twists and turns before finishing at the Rest and Be Thankful car park. This section is similar, in terms of alignment and gradient with the A9 at Berriedale Braes. See Figure 13 below.

Figure13: Image taken overlooking the hairpin at A9 Berriedale Bends

One clear advantage of the old military road is that it does not contain any existing hazards of notable concern in comparison to the ever-present steep lower slope that runs adjacent to the forestry track. However, as with the forestry road, water flowing off the hillside is an issue. Generally, where streams are formed, there are various bridges, pipe culverts and old stone built systems which allow water to pass under the military road. All of these would need repairs or to be replaced. Additionally, there are sections where new streams have been formed and discharged over the existing paved surface which, ideally, need to be managed with new cut ditches and piped culverts.

Figure 14: Image taken of a typical piped inlet.

With the exception of the hill climb section, the military road is located at or near the base of Glen Croe and therefore the potential for disruption due to slope failures on the down slope side of the A83 trunk road is negligible over much of its length. However, on the up slope side of the A83 trunk road there remains the risk of potential further debris flow events.

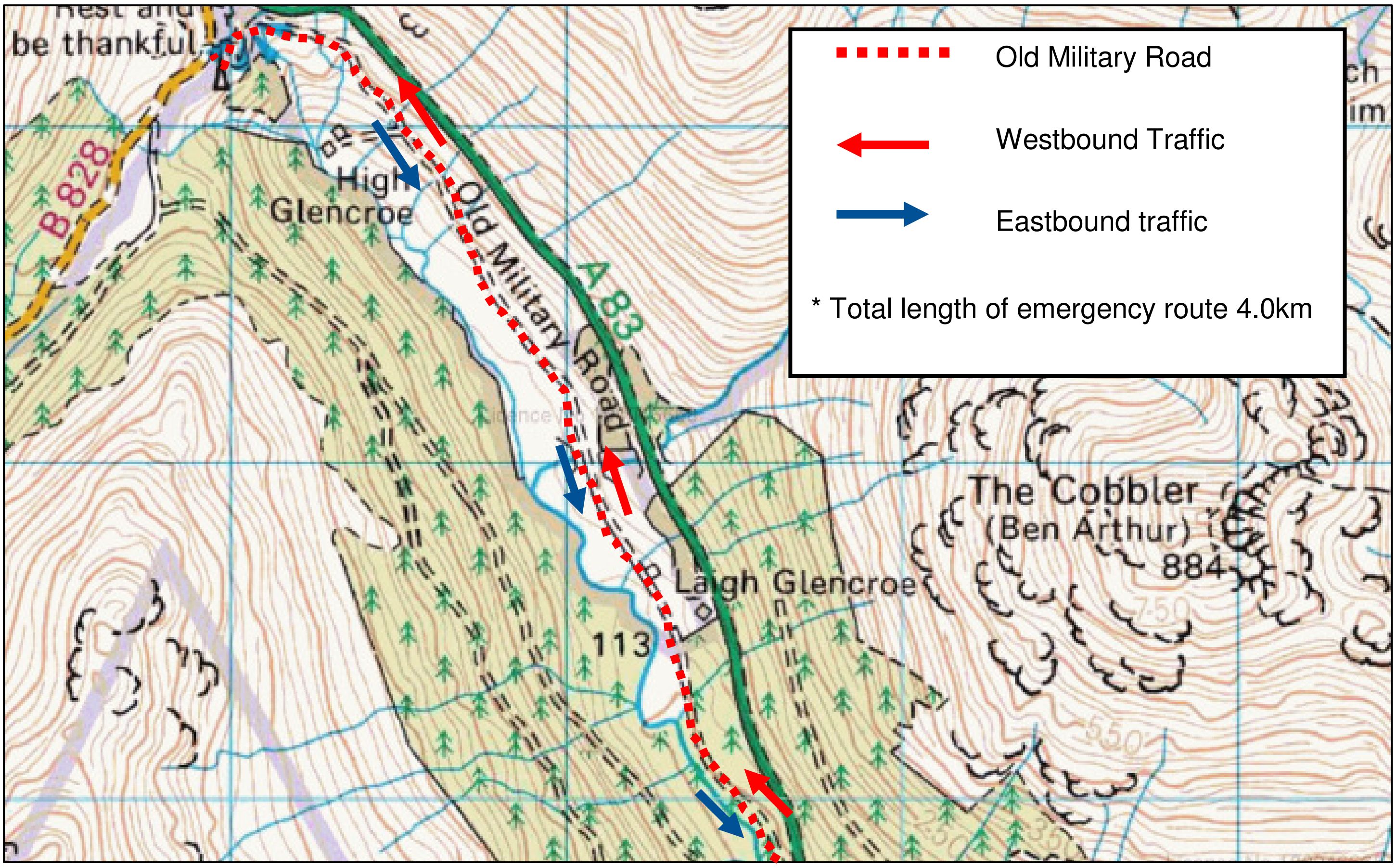
However, the position of the military road along the base of Glen Croe is such that the slacker slope angles near the valley floor present a run out area for failure debris before it reaches the military road. Examination of the three historic debris flow events that resulted in closure of the A83 highlighted that only one of the three failures impacted on the old military road. Additionally, the momentum of failure debris is likely to be dissipated by the A83 and, where applicable, the existing debris catch fences above the A83. Consequently therefore, the likelihood of debris reaching the old military road is considered relatively low risk and any debris that does reach the road is likely to consist of fine graded material only.

Using a combination of suitable engineering together with operational procedures, it is considered that this risk could be reduced to such a level that it could be discounted. This is discussed further in Section 3.3.3.

On the hill climb section, the old military road takes advantage of a series of natural shelves and berms to hairpin its way up to the top of the valley. Over this length, numerous bedrock outcrops are visible indicating that bedrock is at or near surface. Consequently, the risk of instability along this section is considered low, although consideration should be given to making drainage improvements to further reduce the risk.

Visual inspection of the road condition suggests quite a lot of age related failures such as pot holes and edge deterioration. A full pavement investigation has therefore been undertaken using Ground Penetration Radar, Falling Weight Deflectometer (FWD), pavement cores, trial pits and Dynamic Cone Penetrometer. Further discussion on the potential pavement design is in section 3.3.2 of this report.

There are three structures within the old military road, all under the ownership of the private landowner. They consist of two arched bridges and one reinforced concrete structure. Preliminary assessment has been carried out on each of the structures and found that the two arched bridges are in need of extensive pointing, grouting and masonry repairs. The reinforced concrete structure is also in very poor condition.



3.2 Journey Time for the Old Military Road

A heavy goods vehicle trial run could not be carried out on this route at the same time as that on the forestry track without first widening certain corners on the hill climb section. Nevertheless, the military road was driven using a 4x4 vehicle and recorded a time of 8 minutes to complete the 4.0km journey from the forestry access to the Rest and Be Thankful car park. The average speed was approximately 18mph. An identical calculation on the forestry track has also been carried out to determine the convoy length to accommodate peak flow based on a slower convoy speed of 13mph which represents the impact of a hill climb on heavy goods vehicles.

Period (inclusive)	Peak Flow (veh/hour – one direction)	Vehicles in Convoy (no.)*	Length of Convoy (m)	Time between first & last vehicle exiting route (mins)
December	70	30	**255**	0.8
January	135	61	**518**	1.6
October to March	160	74	**629**	1.9
September	200	96	**816**	2.4
April	230	114	**969**	2.9

Table 3: Length of the convoy required to accommodate peak flow

** Iterative calculation multiplying the peak flow by the time that the lights in one direction are at red, which is a function of convoy speed and length.*

Again, due to the length of time to travel the route, the duration of an individual journey depends mostly on when the vehicle joins the queue. Using a convoy length of 100 vehicles (850m) the journey times experienced by drivers during December varies as follows:

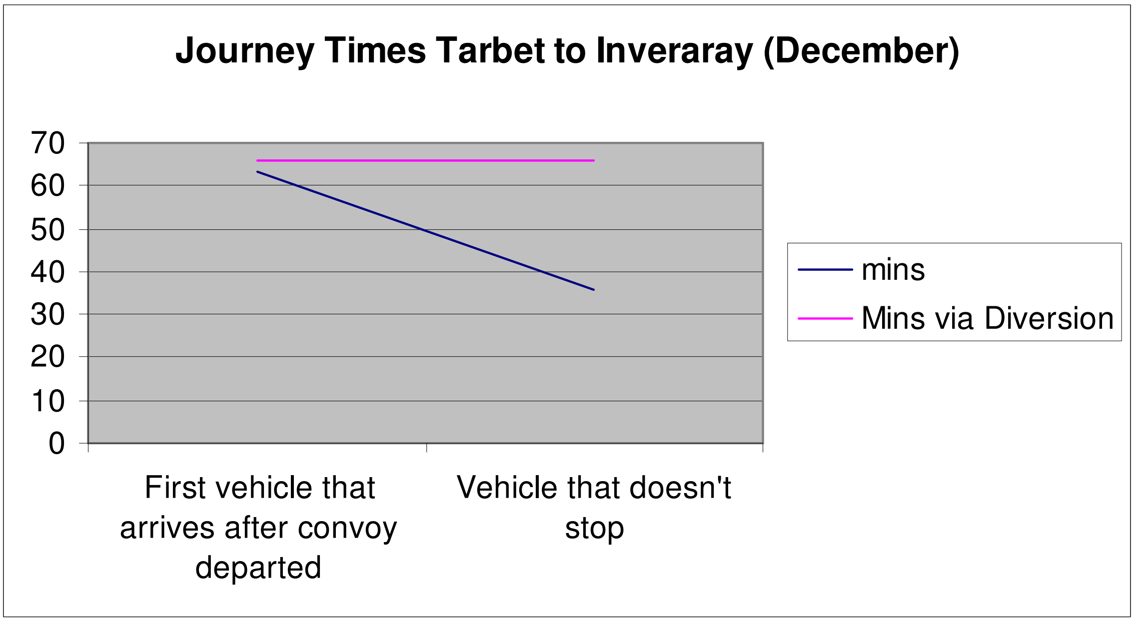


Figure 15: Potential journey times experienced by drivers in December

Even in April with its peak flows of three times that of December, the speed of the flow on the Military road means that journey times do not change greatly.

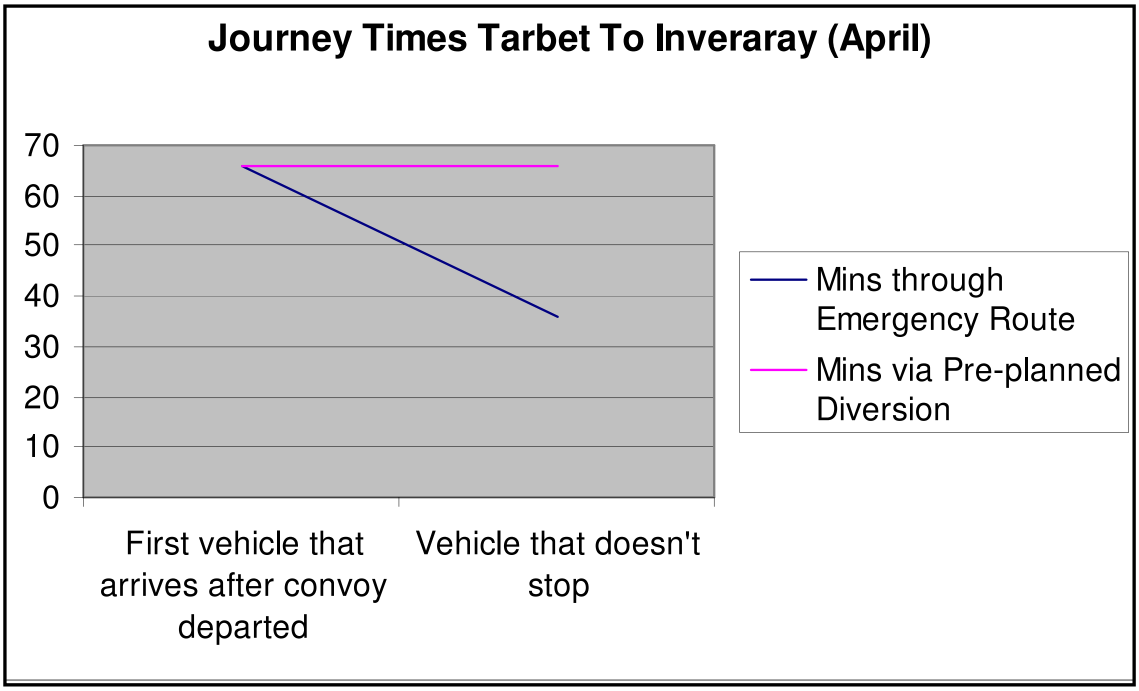
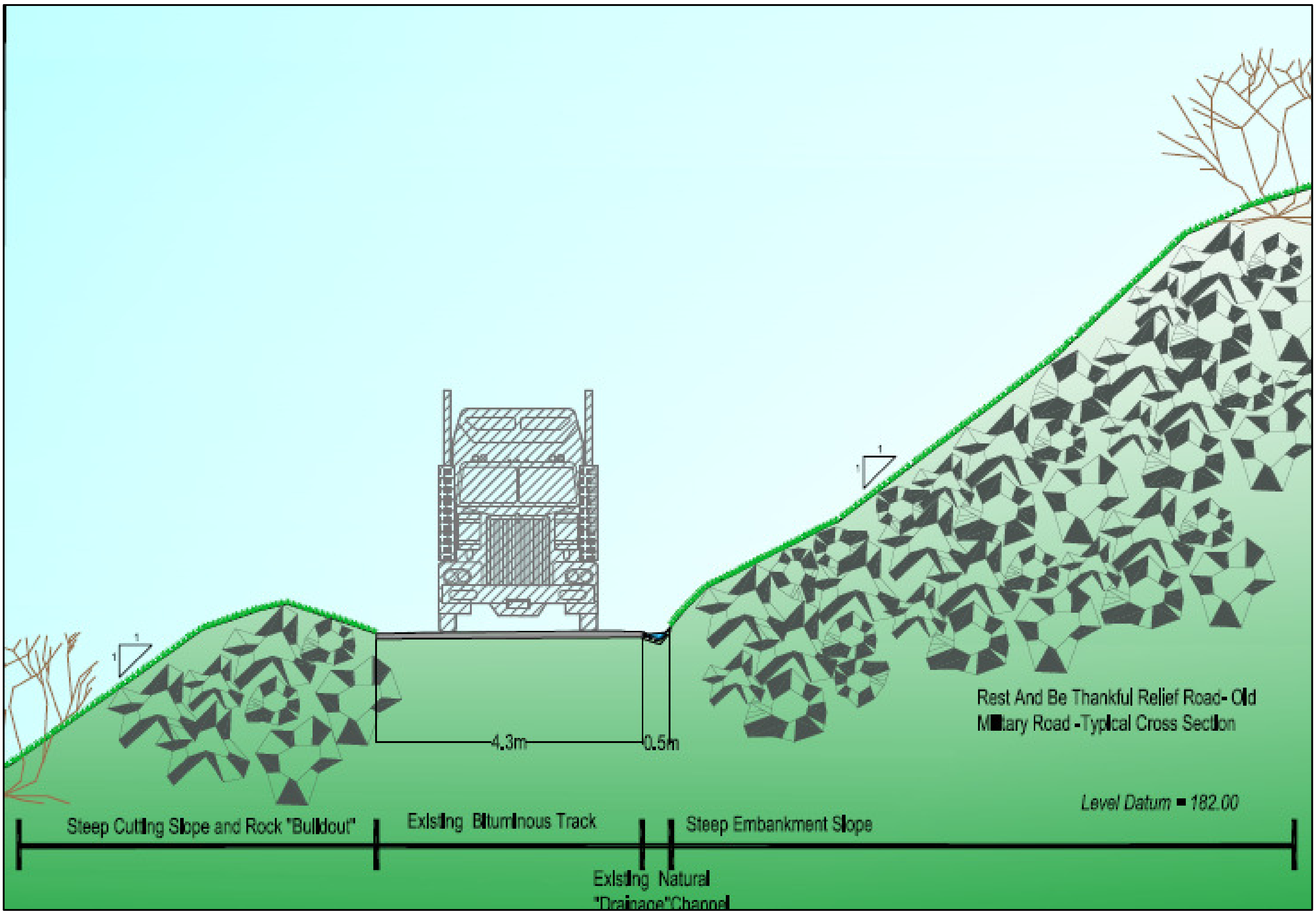


Figure 16: Potential journey times experienced by drivers in April



3.3 Engineering Required

3.3.1 Road Width

The old military road is, for the majority of its length, relatively straight, level and hazard free. As a result there is little need to carry out any operations to widen its existing width to accommodate diverted trunk road traffic. However, towards the final quarter, the hill climb section, the road alignment becomes significantly steeper and tighter. Although the landowner has confirmed vehicles up to 20 tonnes use the road to deliver livestock feed, there are concerns that larger heavy goods vehicles would not be able to negotiate the sharpness of the hairpin corners over this section.

Nevertheless, at each of the hairpin corners there is scope to utilise the existing wide verges as ‘over run’ areas and so provide larger vehicles with sufficient paved width to safely negotiate the hill climb.

There is one particular corner however which will need a new cutting to be formed within an existing steep embankment. The corner is located at the largest of the masonry structures and roughly within the initial third of the hill climb section. See Figure 17.

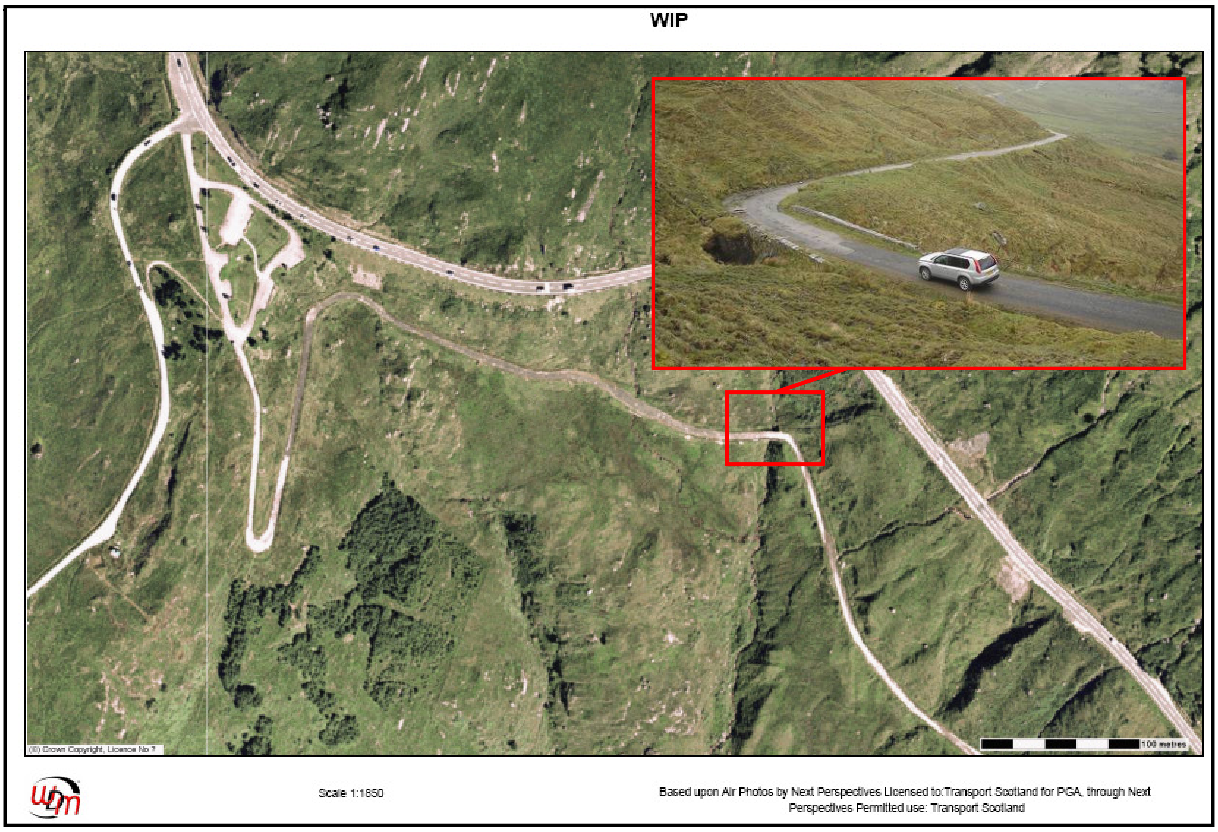


Figure 17: Image of area of concern requiring potential slope stabilisation

It is envisaged that a cutting up to 2 metres in width into the upper slope would be required to form sufficient room to accommodate the largest vehicle swept path. The formation of this cut will result in an overly steep slope and it will therefore require suitable sympathetically constructed reinforcement to ensure its stability.

3.3.2 Pavement Design

Investigation of the old military road confirmed the condition of the road is variable. The road was built using tar bound materials, however over time, and due to subsequent lack of maintenance, the road is no longer operating as a consolidated pavement with some sections being dilapidated and now more indicative of an unbound material.

The surface condition is, as expected, cracked and deformed throughout which will require a regulating layer to remove undulations within the existing road. Dynamic Cone Penetration tests carried out on the existing road's foundation confirms variable California Bearing Ratio (CBR) values from poor (5%) up to excellent (100%). The lower areas of CBR are because of a combination of high ground water, poor drainage and aging construction.

From the initial analysis of the surface modulus analysis of the FWD data the following observations have been found:

- 0-200m (entrance to the forestry junction) the pavement has reasonable strength.
- 200-2300m is considered as the poorest section as it sits within a wetland area.
- 2300 – 3730 (car park at the top of the Rest) the pavement has reasonable strength.

Although lengths of the existing road have reasonable structural strength in general, our investigation concluded that any further traffic loading will lead to pavement failure. Therefore, if used as an emergency route it would need to be structurally improved, specifically from chainage 200 to 3100.

3.3.3 Structures Design

The preliminary assessments also found that the each of the arched structures have a low load bearing capacity. However, with remedial works and improvements, their condition could be improved and they would be capable of carrying highway loading of 40/44 tonnes.

The reinforced concrete structure is in a worse condition and it is thought that it would fail any assessment. As a result measures would have to be taken to either replace the bridge or temporarily bridge over the existing bridge with a ‘quick bridge’ type structure.

As discussed in Section 3.1, there is a potential risk of the old military road becoming blocked by failure debris sourced on its up slope side. To reduce this risk to a level where it could be discounted, consideration should be given to improving culverts using a combination of culvert enlargement and gully training works. These works would promote the free passage of mobilised failure debris material below the old military road. The scope of any such works would require agreement with the landowner and should also take cognisance of the cost against the likely limited operational periods of this diversionary route. As an alternative, procedures could be implemented to have plant available for clearing any debris, which is likely to be of limited volume, as part of the old military road operating procedure.

3.3.4 Buildability

As with the forestry track, road space is limited to carry out operations successfully. There are however areas which could be formed to make standing areas or turning points, predominately within the middle section of the road. The hill climb section will be challenging to conduct an effective surfacing operation and may need the use of tracked pavers to accommodate the steep gradient as well as anchoring plant from fixed points.

3.3.5 Timescales

Currently it is envisaged the works would take 10 to 12 weeks to construct.

Potential solutions:

Conclude a minute of agreement with landowner and provide suitable stock proof fencing.

Carry out localised widening of road at hairpin corners within the hill climb section. Resurface existing road, combined with mesh reinforcement grids within wet areas, to improve structural condition.

Carry out improvements to existing drainage and form new ditches and piped culverts where required.

Carry out remedial works to both masonry bridges with extensive pointing, grouting and masonry repairs. Replace or temporarily bridge over the existing reinforced concrete structure.

3.4 Potential Environmental Issues

As with the forestry track, the old military road also sits within the Loch Lomond and Trossachs National Park and on the periphery of the Beinn Lochain Site of Specific Scientific Interest.

As the old military road runs within rough grazing land, the land is not as rich in biodiversity in comparison with the forestry track. There are however numerous watercourses that flow under the old military road and into the Croe Water which could provide an attractive habitat for certain species such as water vole and otter.

While there is potential for some environmental effect it is probable that this would be lower than the environmental impact of the forestry track and there may be more scope to mitigate the impact through sensitive design.

3.5 Mobilisation, Breakdown and Recovery Services

3.5.1 Mobilisation

As with the forestry road the minimum time expected to mobilise the old military road to an emergency route would be approximately 2 hours.

There is potential that a debris event could overspill over the A83 trunk road. Should debris flows reach the old military road then they can be 'cleaned up' during the mobilisation period.

It is advised that existing trunk road landslide patrols and winter maintenance operations are adapted to incorporate the old military road emergency route. Again, a detailed procedure/protocol will need to be considered and agreed in advance between all emergency services, Traffic Scotland, Scotland TranServ and landowners.

3.5.2 Breakdown and Recovery Service

The military road has greater potential to create areas where breakdown and emergency service vehicles could sit in the event of a situation, or be utilised to move vehicles to the side whilst services respond. Nevertheless any improvement made would have to be agreed with the landowner. There is also ample area to co-ordinate a landing from a rescue or air ambulance helicopter.

Potential Solutions:

To mitigate against debris obstructing the emergency diversion route, the existing trunk road landslide patrols and winter maintenance operations could be adapted to incorporate the emergency diversion route. The length of time to conclude the check and make the track operational would vary depending on any issues found.

During snow conditions it would be recommended to have a dedicated winter maintenance vehicle on the diversion route, travelling in front of the convoy.

Provide a dedicated storage area for plant and materials in the event of any clear up operations required.

4 Design Risk Register

It is apparent that the design of either emergency route cannot be undertaken to modern trunk road design standards. To overcome issues arising from this, and to form the basis of a design 'decision' log, the following risk register has been prepared.

Design element	Risks of non standard design	Mitigation Measures
Geotechnical Assessment	Failure of upper or lower slope	• Walkover by geotechnical engineer during feasibility • Quarterly inspection by geotechnical engineer throughout the year • Landslide inspection prior to use by trained operatives • Risks compared to that on existing Scottish road network
	Trees falling onto road	• Inspection prior to use by trained operatives • Risks compared to that on existing Scottish road network
Pavement Assessment	Failure of sub-formation of carriageway	• FWD and deflectograph surveys undertaken • Sub-base blinding incorporated into forestry design • Pavement designed to 1400 commercial vehicles per year • Surface inspection prior to use by trained operatives
Environmental Assessment	Ecological harm to flora, fauna, drinking water	• Walkover by environmental engineer during feasibility • Liaison with FCS and LLTNP throughout • Otter mitigation measures included in structures design by FCS • Construction planned for out of nesting season
Buildability	Injury due to reversing vehicles, person or vehicle in contact with edge slopes, lack of traction due to gradient	• Buildability walkover by surfacing contractor, haulier and surfacing manager during feasibility • Turning bays incorporated into design where feasible • Reversing cameras to vehicles • Tracked paver • Non-standard compaction equipment (may reduce compaction achieved) • Verge marker posts installed • Temporary infill of drainage ditch
Verge Protection	Persons or vehicles in contact with edge slopes	• Edge lining installed • Verge marker posts installed • Convoy vehicle controlling speed • Risk compared to that on existing Scottish road network • Temporary lighting of lower section

Gradient	Loss of control, loss of traction, stranded vehicles blocking convoy	• Topographical survey during feasibility • Trial run by haulier during feasibility • Risk compared to that on existing Scottish road network • Surface gritting incorporated unto design to improve tyre contact • Trial vehicle in convoy to give assistance/control to stranded vehicles
Pavement	Surface deterioration	• Designed using standard tables to meet 6 days usage per year • Topography causes water run off
Structures	Structural failure	• Carry out repairs and improvements to existing masonry structures, replace/overbridge reinforced concrete structure
Drainage	Running water undermines pavement	• Walkover assessment of ditch capacity during feasibility • Upgrade of culverts included in design • Quarterly inspection by Geotechnical Engineer throughout the year
	Running or frozen water impairs surface condition	• Inspection prior to use by trained operatives • Convoy vehicle assessing condition on each pass • Surface condition sensors to be trialled • Winter maintenance vehicle to lead convoy
Segregation of traffic from casual users	Contact with cyclists, hikers, equestrians	• Signs included in design at entrances to FCS land • Side entrances to route identified during design and measures included
Maintenance	Failures within pavement	• Inspection prior by trained operatives

5 Summary of findings from the study

Our study shows that it is possible for a vehicle to travel both the forestry track and old military road and therefore each route provides a possible alternative route in the event of future closures on the A83 Trunk Road. Nevertheless, as highlighted within this study, both routes have their own issues and risks. These are summarised below.

Study Factors	Findings	
	Forestry Track	Old Military Road
Existing functionality	Narrow and winding geometry. Very prominent lower steep slope hazard.	Alignment generally less constrained with no obvious verge side hazards. Steep hill climb at west end.
	Forestry track shares similar geotechnical features as Rest and Be Thankful slope and therefore has similar risk of debris failure. When the A83 was blocked in December 2011 the forestry track suffered a similar debris failure and blocked access over the track.	The old military road lies at the toe of the Rest and Be Thankful slope. There have been on occasion fines from a debris event over spilling the A83 and onto the military road.
Journey times	Trial run confirms HGV can travel track, however there are concerns of driver safety due to narrow and winding alignment which risks potential conflict with lower steep slope.	Trial run using HGV could not be carried out because of a need to widen corners. However the road is used by 20 tonne vehicles by landowner for deliveries.
	High probability for long delays to motorists which will exceed the pre-planned diversion journey time during a debris event.	Delays unlikely to exceed journey time to carry out pre-planned diversion.
Engineering required	Limited scope to carry out track improvements without extensive investigation, planning and design. New bridge to be constructed over Croe Water.	Widening of hairpin corners, repairs to two existing masonry structures and possible replacement/overbridging of existing reinforced bridge and slope stabilisation measures required.
	Existing track requires excavation to accommodate sub-base layer and 75mm of bituminous material.	Existing old road condition varies, will require regulating and surfaced. Scope to reduce treatments at certain locations.
Environmental issues	Area is rich and ecologically diverse particularly in protected species such as badger, otters, red squirrel and a variety of bird species.	Area is less diverse the forestry track however still scope for potential protected species, in particular water voles and otters.
Mobilisation, Breakdown or emergency recovery	Surrounding topography and forest environment restricts and prevents resilient mobilisation of breakdown and emergency recovery. Very limited scope to provide passing places.	Area is open and traffic can be monitored constantly. Road is predominately single lane width, but with greater scope to implement passing places. Scope to accommodate an air rescue
Timescale	10 to 12 weeks.	10 to 12 weeks.

6 References

1. SEPA - http://www.sepa.org.uk/flooding/flood_extent_maps/view_the_map.aspx

2. Transport Scotland (2008) Scottish Road Network Landslide Study