

**ANNUAL ROCK SLOPE INSPECTION -
JUNE 2009**

The Highland Council
A890 Stromeferry Bypass

454.1-090519-R1.2-Annual09
August 2009

Tuesday, 25 August 2009

The Highland Council
Technical Services
Council Offices
High Street
Dingwall
Ross-shire
IV15 3QN

Attention: Mr B Stout

Dear Bryan

RE: A890 Stromeferry Bypass Annual Rock Slope Inspection, June 2009

Please find enclosed two copies of the A890 Stromeferry Bypass Annual Rock Slope Inspection Report, June 2009.

The "I" beam wall between slopes AA19 and AA20 requires maintenance to treat existing corrosion and to protect the steel work from further corrosion. The principal recommendations from the Annual Inspection are summarised in Tables 2 and 3.

The natural slopes above the man-made (cut) slopes are increasingly demonstrating that they pose a significant hazard (due to trees, crags and soil slopes). A review of the practical management / treatment of these slopes should be considered.

If you have any queries or we can be of any further assistance, please do not hesitate to contact the undersigned or Ian Nettleton.

For and on behalf of Coffey Geotechnics Ltd



Richard Denney

Project Engineer

Coffey Geotechnics Limited

Atlantic House Atlas Business Park Simonsway Manchester M22 5PR United Kingdom
T (+44) (0) 161 499 6800 F (+44) (0) 161 499 6802 www.coffey.com/geotechnics

Registered Office: 1 Northfield Road Reading Berkshire RG1 8AH United Kingdom
Registered in England No. 06328315 Vat Number: 638 923 407

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cc C. Howell
The Highland Council
TEC Services
Drummuie Offices
Golspie
Sutherland, KW10 6TA

CONTENTS

1	INTRODUCTION	1
2	ANNUAL ROCK SLOPE INSPECTION (APRIL 2008 TO JUNE 2009)	2
2.1	Significant Events	3
2.2	Findings of the 2008 - 2009 Annual Rock Slope Inspection	4
2.3	Additional Features Inspected	6
3	DISCUSSION	10
4	CONCLUSIONS	11

Tables

Table 1: Periodic Inspection Summary

Table 2: Principal Recommendations From The Annual Inspection of Rock Slopes – June 2009

Table 3: Principal Recommendations From The Annual Inspection of Additional Features – June 2009

Figures

Figure 1: Photomontage – March 2009 AA1 – Borrow Pit

Figure 2: Photomontage – March 2009 Borrow Pit – AA7

Figure 3: Photomontage – March 2009 AA7 – AA13

Figure 4: Photomontage – March 2009 AA11 – AA24

Appendices

Appendix A: Annual Rock Slope Inspection June 2009

Appendix B: Annual Rock Slope Inspection Photographs June 2009

Appendix C: Rock Slope Failure Mechanisms

1 INTRODUCTION

The Highland Council (THC) appointed Coffey Geotechnics Ltd (Coffey) as their Consultants for advice on and inspection of the A890 Strome ferry Bypass rock slopes, between Ardnarff and Attadale.

The maintenance management strategy developed in 2000, by the Transport Research Laboratory (TRL), for the A890 Strome ferry Bypass rock slopes requires the rock slopes to be inspected annually.

Mr Richard Denney and Mr Christian Houghton of Coffey undertook the annual inspection of the A890 Strome ferry Bypass Rock Slopes on the 11th and 12th of June 2009.

The 2009 Annual Inspection included the following:

- Reviewing the monthly inspection reports
- Ground level inspection of slopes AA1 to AA24
- Inspection of the landslide remedial works (September 2001) adjacent to rock slope AA20.
- Inspection of the debris flow scar and remedial works (October 2001) between rock slopes AA5 and AA6.
- Inspection of Frenchman's Burn.
- Inspection of the crest above slopes AA5 to AA10 and AA11 to AA22b.

This report presents the findings and recommendations coming from the inspections, and provides a timescale in which the recommendations should be implemented. In addition, record sheets are presented for each rock slope (Appendix A).

This report is the ninth of the annual Strome ferry Bypass rock slope inspection reports. It presents only the findings and required actions of the June 2009 inspection, as the full management strategy and re-processed Road Rock Slope Hazard Index (RRHI) for the Strome ferry Bypass have been previously reported (Ref 19. April 2007 Inspection). The re-processed RRHI and full management strategy will be reported with any required updates as part the 2012 inspection (5 year review), or in the event of any significant change, which requires amendments to the strategy.

The locations of the rock slopes and additional features are marked on figures 1 to 4.

2 ANNUAL ROCK SLOPE INSPECTION (APRIL 2008 TO JUNE 2009)

For the annual inspection, the Periodic Inspection reports filed during the year were reviewed to determine potentially active locations that should, in particular, be investigated during the rock slope inspection. Table 1 provides a summary of the significant observations noted during Periodic Inspections that were investigated during the Annual Inspection.

Table 1: Periodic Inspection Summary.

Slope	Chainage	THC Comment	Action / Comment
AA1	0023	<i>Minor fall from weathered rock outcrop at start of slope 1 – could do with scaling – opposite no parking sign. (8th July 2008).</i>	From mass at crest of slope with tree above. Contained by ditch. Clear out ditch during annual maintenance.
		<i>Additional stones in ditch by no parking sign. (18th February 2009).</i>	
AA4	0705	<i>Couple of small stones in verge. (18th February 2009).</i>	Block observed below recent deer track on slope above with two dead deer in ditch. Not a significant concern.
AA6	1390	<i>Four stones in ditch from low level on face. (18th February 2009).</i>	General raveling contained by ditch. Clear out ditch during annual maintenance.
AA7	1720	<i>Significant quantity of large cobble sized stones and some debris in lined cascade. (12th June 2008),</i>	Left over from Phase IV contract in January 2008. Noticed previously by Coffey. Not a significant concern.
Frenchman's Burn	2200	<i>Small amount of stones in each basin. (13th January 2009).</i>	Clear out during annual maintenance.
AA13	2404	<i>Small length of tree stump caught in bushes at top of slope at uplink end of slope – add to list of works for next contract. (13th January 2009).</i>	Observed from ground level, due to level of vegetation on upper slopes could not be seen during annual inspection. Coffey to inspect when next passing and level of vegetation is reduced.
AA15	2592	<i>Single stone in verge 5m before culvert. (12th June 2008).</i>	Stone has not come from netted rock face.
AA16	2770	<i>2nd tell tale broken. (8th May 2008).</i>	Replaced in June 2008.

Table 1: Periodic Inspection Summary (continued...).

Slope	Chainage	THC Comment	Action / Comment
AA17	2838	<i>Chainage – 2883m Large block fell onto road on Sunday afternoon (24/8/08) – moved by DLO to by passing place at slope AA20. Block 450mm thick, 0.7m high and split into two lengths 1.3m + 1.0m. Block fallen from slope above netted area though location not visible. (25th August 2008).</i>	Potential source area identified during Phase V works in October 2008 by Coffey.
AA18	2908	<i>Shackle missing. (12th June 2008).</i>	To be replaced when Coffey next in area.
AA19	2990	<i>Chainage 3006m – 4 small stones and one cobble sized contained by mesh. (12th June 2008). Chainage 3010m – 6 small stones contained by mesh. (12th June 2008).</i>	No significant concern.
		<i>Additional stones behind net at Ch 3012. (18th February 2009).</i>	Minor raveling to be expected, contained by netting.
AA22b	3386	<i>Rock debris. (16th December 2009).</i>	Appears to be from superficial reprofiling undertaken during Phase IV contract.
AA24	3627	<i>Rock debris on corner 2m from end of net. From deterioration of rock nose with bolts. Rock around 2nd last rock bolt looks quite fractured. Easily contained by net. (16th December 2008).</i>	Requires rope access inspection. 0.25m ³ of debris at the toe of the slope. If the fractured material failed it should be contained by the netting.

2.1 Significant Events

During the past year (April 2008 – June 2009) the mean temperature and mean rainfall were above the 1961 to 1990 and the 1971 to 2000 regional averages (Ref. 12).

A rockfall occurred on the afternoon of 24th August 2008 from an area above slope AA17 (Ref. 22). The rockfall is believed to have originated from a natural crag located on the upper slopes. The material from the rockfall landed on the road and was cleared from the road by THC. The potential source of the block was identified in October 2008 during the Phase V works. The path taken by the block on the upper slopes was observed during the annual inspection.

In September to December 2008 the Phase V works were undertaken (Ref. 23) on AA16, AA23N, AA23S, Frenchmans Burn and the "I" beam wall. Further remedial works have been undertaken in July of 2009 of slopes AA23N and AA23S (Ref. 23).

2.2 Findings of the 2008 - 2009 Annual Rock Slope Inspection

The rock slope inspections were initially undertaken from the base of the slopes to highlight areas of concern. These areas were then inspected from the most appropriate location. The observations and recommendations of the inspection are listed in the record sheet for each slope which can be found in Appendix A, along with a photograph of each slope (Appendix B).

The principal recommendations from the Annual Inspection of the Rock Slopes are summarised in Table 2. Particular observations are discussed below:

- The tell tale on slope AA3 no longer requires monthly readings. The slope is performing satisfactorily. Rock fall is currently managed by the rock trap which needs to be kept clear of debris.
- At the base of the west end of slope AA20 the "I" beam post and reinforced concrete panel retaining wall has a significant deflection that appears to have been present for many years. The gap between the top of the 4th "I" beam post from the west and the concrete panel has continued to increase from the outside flange to the top of the concrete panel. Since the tell tale was installed in 13/11/2006 it has indicated that the gap has increased by 7mm and that the offset has increased by 2mm. The above measurements do not enable monitoring of the whole wall. Hence, as a minimum additional tell tales should be installed to monitor any additional movements that may be occurring. We would recommend that tell tales are installed on the either side (top and front) of the upper most concrete panel between the 3rd and 4th "I" beams.

The "I" beams require maintenance to treat existing corrosion and to protect the steel work from further corrosion.

- A recent isolated wild fire on and around slope AA26N has burnt the majority of the vegetation off. This has created the potential for minor ravelling failures to develop, although they should be contained by the adequate ditch at the toe.

Table 2. Principal Recommendations From The Annual Inspection of Rock Slopes – June 2009.

Slope	Recommendations	Action	Timescale
AA1	Remove trees on edge of crest above the rock slope.	THC	Outstanding Next Phase (VI) of works
	Clear out ditch	THC	Annual maintenance
AA2	Clear out ditch	THC	Annual maintenance
AA3	Abandon the tell tale. The slope is performing satisfactorily, whilst the rock trap remains functioning	None	None
AA4	#711 to 751 vegetation requires removal from slope.	THC	Next Phase (VI) of works
	Clear out ditch	THC	Annual maintenance
AA7	Clear Culverts	THC	Annual maintenance
AA9	# 1906 heavy scaled area – keep under observation.	THC & Coffey	All inspections
	Clear out ditch	THC	Annual maintenance
AA10	# 2053 large partially undercut block on small ridge – keep under observation - annual inspections.	Coffey	Annual Inspections
AA14 West	# 2543 rock fall (<0.125m ³) material lying on top of buttress. Keep under particular observation.	THC & Coffey	All inspections
AA17	# 2860, column of fractured rock under existing netting by “Hughie MacKenzy” graffiti – keep under specific observation during periodic and annual inspections.	THC & Coffey	All inspections
AA18	Clear out ditch.	THC	Annual Maintenance
AA20	# 3080 “I” beam post - the measurements do not enable monitoring of the whole wall. Hence, additional tell tales should be installed.	THC & Coffey	All inspections
	The “I” beams require maintenance to treat existing corrosion and to protect the steel work from further corrosion.	THC	Outstanding Next Phase (VI) of works
	Clear Culverts	THC	Annual maintenance

Table 2. Principal Recommendations From The Annual Inspection of Rock Slopes – June 2009 (continued...).

Slope	Recommendations	Action	Timescale
AA22b	# 3356, 3372 and 3382 – potential failures keep under particular observation during periodic and annual inspections.	THC & Coffey	All inspections
AA24	# 3672 rope access inspection of area of rock fall.	Coffey	Next Phase (VI) of works
AA25, AA26N and AA26S	Slopes not considered a significant hazard. Hence, removed from slope inspection list. Recommend a visual inspection during the Annual Inspections, with reporting only if significant features observed.	Coffey	Annual Inspections (ongoing)

2.3 Additional Features Inspected

The principal recommendations and timescales, from the Annual Inspection of the Additional Features are summarised in Table 3.

- **Debris flow scar and remedial works between rock slopes AA5 and AA6.**

The slope drainage and erosion prevention works all appeared to be functioning as designed. The erosion control matting is well vegetated (photograph 34). The top drainage catch pit / debris trap is full with sediment to the height of the pipe and will require cleaning out within the next 12 months (photograph 33).

The pipe extending from the drainage ditch down the slope has developed a leak in the upper most joint in the pipe (photograph 35). The restraining collar immediately below this joint is missing a galvanised eye for attaching to the ground anchorage. The cable has been temporarily looped around the collar until the eye can be replaced (photograph 36).

The area around the crest of the debris flow scar should be planted with appropriate trees to help further stabilise the area.

- **Frenchman's Gully.**

The lower and upper stilling basins were clear of significant debris (photograph 30) and the Phase V remedial works appeared to be performing satisfactorily.

Based on previous debris flows in Frenchman's Burn the enlarged stilling basins (Ref. 23) should be able to contain "normal" routine debris flows (50 to 200m³), but are likely to have their capacity exceeded by larger less frequent events with a return period of 5 to 15 years. The addition of a new source of approximately 100m³ is likely to lead to a larger than "normal" scale debris flow during. Hence, it is vital that the stilling basins are kept clear of debris accumulations.

The south west wall of the gully above the upper and lower stilling basin has been subject to erosion. This has resulted in over steep superficial material. This should be kept under observation during the monthly and annual inspections.

- **Gully between rock slopes AA19 and AA20.**

Material at the toe of the gully (behind the "I" Beam wall) has been replaced since the previous annual inspection, this should reach an "equilibrium". Although the eastern face of the gully is subject to scour during periods of heavy rainfall. The hillside above the bank has previously undergone remedial works due to movement.

No significant debris dams were observed in the gully.

- **Landslide remedial works adjacent to rock slope AA20.**

Concrete beam, cables and temporary catch fence all appeared to be functioning satisfactorily. Above the erosion control matting there has been a failure of the superficial material in to the gully – this has not deteriorated further over the last three years. This eroded face should be kept under observation and monitored for any further signs of erosion.

- **Natural Features**

The natural crags and trees above the man made rock slopes AA11 to AA22 (Fig. 4) are representing a growing hazard to the road and railway, recent examples of this are listed below:

1. The rockfall from a natural crag above and between AA18 and AA19 which occurred on the 4th of May 2007. The material from which reached the road and the railway.
2. On the afternoon of the 24th of August 2008 two blocks were found on the road beneath slope AA17. Upon inspection of the upper slopes, the blocks were found to have come from a natural crag, travelled down the upper vegetated slope and over the crest of the netted slope. The initial cause of the rockfall has not been identified, but may have been caused by the root action of the trees.
3. During the annual inspection, a block (0.5m X 0.5m X 0.3m) from the upper slopes was observed to have been retained by the netting at the crest of slope AA18 (photograph 21). The block appeared to have been funnelled in to a small gully feature, which the netting spans across.

Above slopes AA11 to AA22 there are a large number of Larch trees that have fallen over and are lying across the slope. This is starting to act as a slide system for any new tree that falls over, sending the tree down slope towards the road. This is highlighted by the tree trunk leaning against the rock slope at AA14 east and the tree that landed on the road between slopes AA15 and AA16 during the Phase V remedial works contract. The trees are now presenting a growing significant hazard to the road and the railway.

In addition, the root balls of several upturned trees contain blocks of rock which have the potential to become dislodged and roll down the slopes and over the crests of the slopes AA11 to AA22.

The management of the standing and fallen trees is an issue that has been brought to the attention of Attadale Estate (Ref. 17).

To manage these natural features they must first be identified and assessed to determine what hazard they present, i.e. directly above the road, on steep slopes. To be able to do this a set of

stereo aerial oblique photographs of the rock slopes and natural features above them has been acquired as part of the Phase V works (Figures 1 to 4). Using the photographs as a new baseline to the condition of the slopes, the natural features can be identified and inspected. Following which they should be prioritised and remedial works undertaken to reduce the level of risk.

- **Rockfall Signage**

The rockfall signage between Ardnarff to Attadale covers the section slopes between AA1 to AA24. The first rockfall sign is between Ardnarff House and the car park above Ardnarff House, this sign is labelled to cover a distance of 2 miles. Two miles from this point is Frenchman's Burn. The second sign is at Frenchman's Burn and is for 1 mile, this covers the distance to the road closure gate after slope AA24.

The rockfall signage from Attadale to Ardnarff covers the slopes between AA24 to AA1. The first rockfall sign is prior to the road closure gate and states a distance of 1 mile, from this point it extends to the western side of slope AA11. The following sign is between AA8 and AA7 with no distance marked. This sign should be moved towards Frenchman's Burn and should have a two mile distance sign included on it.

Table 3. Principal Recommendations From The Annual Inspection of Additional Features – June 2009.

Feature	Recommendations	Action	Timescale
Debris flow scar between rock slopes AA5 and AA6	Top drainage catch pit / debris trap requires clearing.	THC	Annual maintenance.
	The area around the crest of the debris flow scar requires planting with appropriate trees.	THC	Outstanding Next Phase (VI) of works
	1 st elbow joint down from the catch pit requires the leak fixing. 1 st collar below the 1 st elbow joint requires the missing galvanised eye replacing and the anchorage re-attaching.	THC	Next Phase (VI) of works
Slopes between AA6 and AA7	No excavation or works on or in the slopes between AA6 and AA7 without appropriate geotechnical advice.	THC	Immediate and continuous
Rockfall signage	The rockfall warning sign between AA7 and AA8 should be moved towards Frenchman's Burn and a two mile distance sign included on it.	THC	Annual maintenance.
Frenchman's Burn	Remove debris from culvert beneath road.	THC	Annual maintenance.
Upper slopes above AA11 to AA22b	Require inspection to identify features that could potentially affect the road and railway below.	Coffey	Prior to next annual inspection
	Devise management and remedial works strategy based on the above.	THC & Coffey	
	Removal of block above AA17 (Ref. 22)	THC	Next Phase (VI) of works
Natural Crag above and between slopes AA18 and AA19	Keep under particular observation during periodic and annual inspections.	THC & Coffey	All inspections
	Remove tree rootball that is currently strapped.	THC	Next Phase (VI) of works
Gully between Slope AA19 and AA20	<u>No excavation within 3m of northeast bank of the gully.</u>	THC	During any future clearance work.
Landslide remedial works adjacent to Rock slope AA20	Monitor and observe erosion of superficial materials within gully. Observe and monitor for signs of further erosion.	THC & Coffey	All inspections.

3 DISCUSSION

The recommendations from the Annual Inspection June 2009 are in Tables 2 and 3. The timescale categories are described below:

1. *Annual Maintenance (minor).*

The Annual Maintenance consists of work that can be carried out by the local roads maintenance unit, e.g. clearing ditches and culverts, etc.

2. *Next Phase (VI) of Works.*

The remedial works contract is for slopes and additional features that will require action in the next 2 to 5 years. For efficiency and effective use of budgets this should be carried out as a single contract (Phase VI).

3. *The Natural Slopes and Trees above the cut rock slopes.*

The slopes above the man-made (cut) slopes on the A890 Stromeferry Bypass are increasingly demonstrating that they pose a growing significant hazard to the road and the railway due to:

- Unstable trees and associated disturbance or crags and superficial deposits.
- Over-steep superficial deposits with localised drainage problems, e.g. debris flow AA5/6.
- Natural crags e.g. between slopes AA6 and AA7, above and between AA11 to AA22b.

A series of stereo oblique aerial photographs have been obtained for the A890 Stromeferry Bypass under the Phase V contract to enable events on these slopes to be recorded and assessed. These shall enable investigation and management of future failures to be undertaken once they have occurred, and could be used for a pro-active management strategy for the slopes.

4 CONCLUSIONS

From the findings and analyses of the annual rock slope inspection our conclusions are as follows:

1. The remedial / maintenance works in Tables 2 and 3 should be undertaken within the timescales given.
2. The natural slopes above the man-made (cut) slopes are increasingly demonstrating that they pose a significant hazard (due to trees, crags and soil slopes). A review of practical management / treatment of these slopes is considered to be timely.
3. Due to potential relict postglacial slope movements no excavation or works on or into the slopes between rock slopes AA6 and AA7 (Fig. 2) should be undertaken without appropriate geotechnical advice.
4. During the year (April 2008 to June 2009) there was one significant natural event (a rockfall originating from above slope AA17) that affected the road.
5. Phase V remedial works were undertaken between September to October 2008, with additional scaling work carried out in July 2009. All of the works appear to be functioning satisfactorily. Outstanding works that were not undertaken during the contract are highlighted in Tables 2 and 3.
6. The rockfall risks from the cut rock slopes on the A890 Stromeferry Bypass between Ardnarff and Attadale remain high but are suitably managed, as the traffic flow is relatively low (low exposure). If the traffic flows were to increase then the risk management of the Stromeferry Bypass would require proportionate future remedial works. The increase in mean peak traffic flow has increased the RHI values on all the slopes.
7. The risk reduction and maintenance management strategy has been implemented. The reduction in risk is largely due to remedial works that will require on-going maintenance. Despite this the possibility of unforeseeable events cannot be entirely ruled out.
8. The remedial works for the October 2001 landslide between slope AA5 and AA6 (at chainage 1335) and the August 2001 works adjacent to rock slope AA20 are functioning satisfactorily.
9. The 1999 sediment traps at the bases of Frenchman's Gully and the gully between rock slopes AA19 and AA20 have, as expected, functioned satisfactorily. The rock fall further up the gully has added to the supply of debris in Frenchman's Burn, hence it is vital that the stilling basins are kept clear of debris accumulations.
10. The 2010 Annual Inspection should be undertaken between the end of March and the end of June to enable any urgent remedial works required to be undertaken prior to the onset of the following winter.

For and on behalf of Coffey Geotechnics Ltd.

C. HOUGHTON

Engineer

R.M. DENNEY

Project Engineer

I.M. NETTLETON

Principal

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Figures

Appendix A

Annual Rock Slope Inspection June 2009

AA1	Chainage: 0023 - 0178	Length: 155m	Height: 10 - 20m
	Grid Ref	Start: NG 89054 35683	Finish: NG 89161 35810
Description of Slope: Natural and excavated rock slope. Forest and forestry track above slope. Ditch (0.5m wide x 0.25m deep).			
Failure Characteristics: General ravelling.			
Existing Remedial Works: 2004: Ditch and culvert cleared.			
Inspection Findings: Ravelling continues, no significant potential failures observed. # 018 Tree at crest of slope with yellow spray paint on trunk on edge of crest. # 024 Tree at crest of slope with yellow spray paint on trunk on edge of crest. # 038 Area of ravelling on face, 4m up, not significant. # 042 2 No. trees on the edge of the crest with small pod of material 1m below. # 063 Small block 200mm x 200mm x 100mm, 8m up – fallen and contained by ditch. # 068 Tree at crest of slope with yellow spray paint on trunk on edge of crest. # 082 Heavy water flow – minor root mass (grass) stripped off face. Possibly due to movements (vehicle) on forestry track above. # 093 Tree at crest of slope with yellow spray paint on trunk on edge of crest. # 127 Tree on edge of crest above rock slope. # 130 Undercut at crest of slope, no signs of deterioration - not significant. # 165 Wedge of weathering schist – deteriorating, but would be contained by ditch. # 168 Culvert clear. Build up of debris in ditch along length of slope.			
Current Hazard Index Value: 4			
Remedial / Maintenance Works Required: Remove trees on edge of crest above the rock slope (# 018, 024, 042, 068, 093 and 124). Clear ditch (Annual Maintenance).			

AA2	Chainage: 0178 - 0297	Length: 119m	Height: 20 - 40m
	Grid Ref	Start: NG 89163 35809	Finish: NG 89277 35890
<p>Description of Slope: Natural and excavated rock slope. Forest and forestry track above slope. Ditch (0.5m wide x 0.3m deep).</p>			
<p>Failure Characteristics: General ravelling. Potential plane failures.</p>			
<p>Existing Remedial Works: Localised (# 178 to 199 and #230 to 277) draped chain link netting in poor condition, with some double twist rockfall netting patches. 2002: # 184 Potential failing column scaled (removed) by CAN. 2004: Ditch cleared. January 2006: # 199 to 228 Un-netted area, light scaled by TRAC. # 255 Potential failing column (2m high x 1.5m wide x 0.25m thick) - heavy scaled by TRAC. # 257 Potential blockfall (1.5m high x 1m wide x 0.25m thick) - heavy scaled by TRAC. # 178 to 199 and 228 to 277 slope re-netted by TRAC.</p>			
<p>Inspection Findings: Trees at crest appear to be generally in a satisfactory condition. # 197 Culvert is clear. # 220 Pod of material (0.25m³) scaled during inspection. # 259 Culvert clear. # 276 Build up of debris behind netting from ongoing ravelling. # 297 Culvert is one quarter silted – generally clear. Bottom cable on netting installed in 2006 is showing signs of corrosion. Ditch partially blocked in places.</p>			
<p>Current Hazard Index Value: 4</p>			
<p>Remedial / Maintenance Works Required: All shackles require threads smearing with adhesive resin (Annual Maintenance). Clear ditch (Annual Maintenance).</p>			

AA3	Chainage: 0516 - 0630	Length: 114m	Height: 20 - 40m
	Grid Ref	Start: NG 89054 35683	Finish: NG 89161 35810
<p>Description of Slope: # 516 is at northeast end of Armco barrier. Excavated slope set back from road. Shrubs and mixed forest above slope. From the toe of the rock slope a 40 to 45 talus slope leads down (3m to 5m) to a rock trap (see Existing Remedial Works). From this a talus slope with deer fencing, leads down (3m to 5m) to the ditch at the edge of the road. Ditch 0.5m wide x 0.3m deep at roadside.</p>			
<p>Failure Characteristics: General ravelling. Potential large plane and toppling failures.</p>			
<p>Existing Remedial Works: Rock trap created 3m wide with a 1.25m to 1.5m high 1m wide bund. January 2006: # 560 Potential toppling failures upper driving blocks removed by TRAC. No blocks escaped during removal. # 573 Undercut of blocks removed by TRAC. During removal no blocks escaped when the ditch was clear. 1 block escaped when ditch was full.</p>			
<p>Inspection Findings: Old track forms rock trap 2.5m wide x 1m deep at toe of rock slope with well-established shrubs and sapling trees on outer bund. Trap was still clear following January 2006 remedial works. Deer fencing installed from start of slope, running along whole length at road level. # 560 Tell tale installed 06/06/2006 by THC. Currently measuring +1.0mm horizontal, +0.5mm vertical (Appendix B - photograph 4). # 573 Back of scar is eroding back releasing small blocks (100mm X 50mm X 50mm). Area of erosion currently not undercutting any other areas and material will be contained by the ditch. Several wooden crash barrier posts on railway side of road have failed and are rotten.</p>			
<p>Current Hazard Index Value: <1</p>			
<p>Remedial / Maintenance Works Required: Tell tale no longer requires monthly recording of measurement, due to satisfactory performance of slope.</p>			

AA4	Chainage: 0705 -0800	Length: 95m	Height: 10 - 20m
	Grid Ref	Start: NG 89511 36265	Finish: NG 89567 36340
Description of Slope: Natural and excavated rock slope. Shrubs and mixed forest above slope. Ditch (0.5m to 1m wide x 0.5m to 1m deep).			
Failure Characteristics: General ravelling. Potential plane, wedge and toppling failures.			
Existing Remedial Works: 2002: # 728 Heavy scaling of a plane failure block, some material in ditch, small overhang of remaining material solid, keep under observation. January 2008: # 725 Vegetation removed and light scaling of small overhanging block by Skye Rope Access.			
Inspection Findings: # 711 to 751 Vegetation partially obscuring the slope. # 728 Small overhang no significant change, no significant deterioration - keep under observation. # 738 Overhanging superficial (2m long by 0.5m high by 0.5m deep) 5m above the road level (Appendix B - photograph 6). # 770 Culvert is clear. # 795 Superficials washed away during debris flow on 4/10/2004. Ditch is partially blocked in places.			
Current Hazard Index Value: 2			
Remedial / Maintenance Works Required: Remove vegetation between # 711 to 751. Clear ditch (Annual Maintenance).			

AA5	Chainage: 1310 - 1330	Length: 20m	Height: 10 - 20m
	Grid Ref	Start: NG 89839 36749	Finish: NG 89956 36756
Description of Slope: Natural bluff of rock in a grass, shrub and tree covered hillside. Ditch (0.5m wide x 0.3m deep). Deer fencing along toe of slope.			
Failure Characteristics: General ravelling.			
Existing Remedial Works: None.			
Inspection Findings: Ditch appears to adequately control the ravelling failures, some small ravelling failures in ditch. Slope has re-vegetated well with no apparent signs of ongoing erosion. Deer fencing installed from start of slope, running along whole length at road level. # 1330 Culvert clear. # 1333 Block (0.25m ³) 1m above road level has become dilated – keep under observation.			
Current Hazard Index Value: 5			
Remedial / Maintenance Works Required: None.			

AA6	Chainage: 1390 -1450	Length: 60m	Height: 20 - 40m
	Grid Ref	Start: NG 89903 36816	Finish: NG 89932 36865
Description of Slope:			
<p>Natural and excavated rock slope. Grass, shrub and tree covered hillside above slope. Ditch (0.5m to 1m wide x 0.5m to 0.75m deep). To the north east of the slope there is a natural gully with rock walls. Deer fencing along toe of slope.</p>			
Failure Characteristics:			
<p>General ravelling. Potential plane failures.</p>			
Existing Remedial Works:			
2002			
<p>300m² Scaling on slope. 5m³ Heavy scaling / controlled removal on slope. 700m² Reinforced netting (# 1390-1417). In the gully to the north east there are: New catch fence across gully. 2 No. Gabion walls with double twist rockfall netting and wooden posts acting as catch fences, repaired during Phase II remedial works.</p>			
Inspection Findings:			
<p># 1420 Large pine tree at crest of slope has fallen over but alive during inspection. # 1426 Rock scar on face from 2002 remedial works. Not significant. # 1448 Small rockfall scar on face (1m wide by 1m high). Fallen tree above crest, south west of gully, currently lodged on slope.</p>			
Current Hazard Index Value: 5			
Remedial Works Required:			
None			

AA7	Chainage: 1706 - 1810	Length: 104m	Height: 20 - 40m
	Grid Ref	Start: NG 90146 37002	Finish: NG 90242 37024
<p>Description of Slope: Natural rock slope. Grass, shrub and tree covered hillside above slope. Slope is heavily wooded. Deer fencing installed on talus slope below rock slope. Ditch: # 1706 – 1720 rock slope is set back >10m, with a ditch 2m wide by the road. Densely vegetated. # 1720 – 1810 French drain has replaced ditch.</p>			
<p>Failure Characteristics: General ravelling. Potential wedge failures.</p>			
<p>Existing Remedial Works: January 2006: # 1802 Tree toppled off the face pulling with it the root mat and some superficial materials. Removed by TRAC. February 2008: # 1706 – 1810 Vegetation removed, light scaling and targeted heavy scaling and tree removal by Skye Rope Access. # 1717 Trap and bench (4m wide) created at toe of slope from scaled material by Skye Rope Access. # 1810 Installation of 5 No. 4m long stainless steel dowels into potential plane failure near the crest by Skye Rope Access.</p>			
<p>Inspection Findings: # 1706 Culvert clear. # 1717 Mass to right of scar may deteriorate but will fail into the gully and debris cone at the toe. # 1755 Culvert clear. # 1766 Culvert partially blocked. # 1766 Rock buttress – fractured but above low angle slope covered in vegetation and tree stumps, should be retained on slope and is >20m from road. # 1796 Culvert clear. Ditch is no longer present, has been replaced by a French drain.</p>			
<p>Current Hazard Index Value: 12</p>			
<p>Remedial / Maintenance Works Required: Clear culverts (Annual Maintenance).</p>			

AA8	Chainage: 1810 - 1873	Length: 63m	Height: 20 - 40m
	Grid Ref	Start: NG 90242 37024	Finish: NG 90301 37052
Description of Slope:			
<p>Natural rock slope.</p> <p>Grass, shrub and tree covered hillside above slope.</p> <p>Slope is heavily wooded (vegetation cleared in area of Phase II remedial works has now re-established well).</p> <p>Ditch: # 1810 – 1846 (1.0m wide, 0.5 – 1.0m deep).</p> <p># 1860 – 1846 rock slope is set back 4.0 – 6.0m from the road.</p>			
Failure Characteristics:			
<p>General ravelling failures.</p> <p>Potential wedge and toppling failures.</p>			
Existing Remedial Works:			
2002:			
200m ² Scaling over top half of slope.			
10m ³ Heavy scaling / controlled removal at crest of slope.			
1400m ² Draped double twist rockfall netting (# 1823 – 1860).			
January 2006:			
# 1822 Toppled tree removed along with a tree it supported, by TRAC.			
Inspection Findings:			
# 1822 Tree trunk removed, stump and roots left to allow coppice to development as these hide rock slope remedial works and help to dissipate rockfall energy			
# 1848 Post shaped block at approx. 30m height behind rock fall netting, if fails should be contained by netting - keep under observation, now difficult / impossible to see in summer.			
# 1854 Culvert clear.			
# 1873 Column 4m above toe of slope, on gully side with tree growing out of area above. Should be retained on slope, >3m from road.			
Current Hazard Index Value: 7			
Remedial Works Required:			
None.			

AA9	Chainage: 1873 - 1953	Length: 80m	Height: >40m
	Grid Ref	Start: NG 90301 37052	Finish: NG 90368 37079
<p>Description of Slope: Natural rock slope. Grass, shrub and tree covered hillside above slope. Slope is heavily wooded. Deer fencing installed on talus slope below rock slope. Ditch: # 1873 – 1886 1.0m grass verge, no ditch. # 1886 – 1913 (2.0 - 4.0m wide, 0.5 – 1.0m deep) # 1913 – 1953 (4.0 – 6.0m wide, 0.5 – 1.0m deep)</p>			
<p>Failure Characteristics: General ravelling. Potential wedge failures.</p>			
<p>Existing Remedial Works: 2002: # 1886 Heavy scaling of two small blocks approximately 25m above the road on the rock slope and installation of 150m² of rock fall netting. January 2006: # 1899 Attempts to scale off block at north east of netting made – only some small blocks were removed. Netting extended across this area, by TRAC. EDGE Rope access inspection February 2006 (Ref. 15). February 2008: # 1873 – 1953 Vegetation removed, slope light scaled by Skye Rope Access. # 1930, 1970 & 2010 Targeted heavy scaling undertaken by Skye Rope Access. # 1906 Heavy scaled area 25m up – scaled rock contained in ditch / verge by Skye Rope Access. # 1970 Vegetation removed, 4 No. mature trees removed and light scaled by Skye Rope Access. # 1970 – 2000 Targeted removal of dense vegetation and mature trees along crest line by Skye Rope Access.</p>			
<p>Inspection Findings: # 1906 – Non change to heavy scaled area since contract. Ditch partially blocked. Deer fencing installed.</p>			
<p>Current Hazard Index Value: 10</p>			
<p>Remedial / Maintenance Works Required: Keep heavy scaled area (# 1906) under observation. Clear ditch (Annual Maintenance).</p>			

AA10	Chainage: 1953 - 2100	Length: 147m	Height: >40m
	Grid Ref	Start: NG 90368 37079	Finish: NG 90603 37205
Description of Slope:			
<p>Natural rock slope set >10m back from the road. Grass, shrub and tree covered hillside above slope. Slope is heavily wooded. Talus slope 10 m high 40° to 45° slope angle. Deer fencing installed on talus slope below rock slope. Ditch replaced by French drain.</p>			
Failure Characteristics:			
General ravelling.			
Existing Remedial Works:			
February 2008:			
<p># 2056 – 2137 Targeted tree removal, light scaling and heavy scaling by Skye Rope Access. # 2218 Mature tree removed from above large boulder to prevent wind loading on roots within mass, by Skye Rope Access.</p>			
Inspection Findings:			
<p># 1968 Culvert clear. # 2014 Culvert clear. # 2042 Culvert clear. # 2053 Large partially undercut block on small ridge – keep under observation during annual inspections. # 2080 Culvert clear. Ditches have been infilled and turned in to French Drains</p>			
Current Hazard Index Value:			
RHI not applicable to this slope			
Remedial / Maintenance Works Required:			
# 2053 Large partially undercut block on small ridge – keep under observation during annual inspections.			

AA11	Chainage: 2285 - 2325		Length: 40m	Height: 10 - 25m
	Grid Ref	Start: NG 90655 37253	Finish: NG 90689 37271	
Description of Slope:				
Excavated rock slope. Grass and shrub covered hillside with woodland above slope. Ditch at # 2309 to 2325 (<0.5m wide x <0.5m deep).				
Failure Characteristics:				
General ravelling.				
Existing Remedial Works:				
Draped chain link netting. This was repaired with double twist rockfall netting in 1992. In addition an extra bottom anchor was added. # 2298 – 2309 masonry toe buttress.				
January 2006:				
Netting between # 2285 to 2298 and # 2310 to 2323 replaced by TRAC. Top cable installed in existing netting between #2298 to 2310 by TRAC.				
February 2008:				
# 2298 – 2309 Re-pointing of buttress masonry work, by Skye Rope Access.				
Inspection Findings:				
Note poor condition of trees on slopes above rock slopes. Bottom cable of netting installed during 2006 shows signs of corrosion.				
Current Hazard Index Value: <1				
Remedial / Maintenance Works Required:				
None				

AA12	Chainage: 2329 - 2404	Length: 75m	Height: 20 - 40m
	Grid Ref	Start: NG 90688 37272	Finish: NG 90739 37331
Description of Slope:			
<p>Natural and excavated rock slope. Grass and shrub covered hillside with woodland above slope. Ditch: # 2329 to 2375 ditch has been infilled with a French drain. # 2375 – 2383 (1.0 – 2.0m wide, 0.5 - 1.0m deep) # 2383 – 2404 (<0.5m wide, <0.5m deep).</p>			
Failure Characteristics:			
General ravelling.			
Existing Remedial Works:			
January 2006:			
# 2350 Potential small plane / ravelling area scaled and vegetation removal by TRAC (Photograph 16).			
# 2367 Removal of holly bush, undertaken by TRAC.			
February 2008:			
# 2350 Heavy scaling of block by Skye Rope Access.			
# 2367 Holy bush re-poisoned by Skye Rope Access.			
Inspection Findings:			
# 2378 Culvert beneath waterfall clear.			
# 2395 Tree (300 to 500mm girth) has died on the talus slope between the rock slope and the road.			
The ditch is no longer present due to the widening of the road. Replaced with a French drain.			
Current Hazard Index Value: 8			
Remedial / Maintenance Works Required:			
None			

AA13	Chainage: 2404 - 2500	Length: 96m	Height: 20 - 40m
	Grid Ref	Start: NG 90146 37002	Finish: NG 90242 37024
Description of Slope:			
<p>Natural and excavated rock slope. Grass and shrub covered hillside with woodland above slope. Ditch: # 2404 – 2431 (0.5 – 1.0m wide, 0.5m deep) # 2431 to 2458 ditch has been infilled by French drain. # 2458 – 2500 (0.5 – 1.0m wide, 0.5m deep, with a 2.0 – 4.0m wide verge)</p>			
Failure Characteristics:			
<p>General ravelling. Potential plane, wedge and toppling failures.</p>			
Existing Remedial Works:			
1998:			
100m ² Light scaling.			
30m ³ Heavy scaling.			
# 2404-2492 3740m ² Draped double twist rockfall netting. Reinforced with vertical 10mm diameter galvanised steel cables at 1m c/c at the nose.			
# 2439 Doweling of "Nose" with stainless steel dowels (2 No).			
2002:			
Cleared and poisoned gorse bushes at top of nose.			
February 2008:			
# 2439 Vegetation removed from "Nose" and crest. 2 No. 5m long stainless steel dowels installed into block, by Skye Rope Access.			
Inspection Findings:			
# 2447 Pod of loose material approximately 5m above the road, will be controlled by the netting.			
# 2491 Scar from superficial slip (January 2007) continues to re-vegetate.			
Current Hazard Index Value: 8			
Remedial / Maintenance Works Required:			
None			

AA14 West	Chainage: 2500 - 2560	Length: 60m	Height: 10 - 20m
	Grid Ref	Start: NG 90792 37401	Finish: NG 90871 37458
Description of Slope: Excavated rock slope. Grass and shrub covered hillside with woodland above slope. No / limited ditch.			
Failure Characteristics: General ravelling. Potential plane and wedge failures.			
Existing Remedial Works: 1992: # 2514 – 2562 Area scaled and re-netted with localised draped chain link netting. # 2550 - 2556 masonry toe buttress. 2002: 50m ² Light Scaling (particularly # 2552 and 2543). # 2526 2 No Dowels installed. # 2500 - 2515 and # 2515 – 2562 300m ² Draped double twist rockfall netting. # 2539 – 2549 Anchored concrete buttress 4m high at base. February 2008: # 2559 Missing Shackle replaced, by Coffey.			
Inspection Findings: # 2515 Undercut blocks on slope, no significant change. Keep under observation. # 2539 - 2549 Material above toe buttress - # 2543 rock fall (<0.125m ³) material lying on top of buttress. # 2550 - 2556 Masonry toe buttress has a minor amount of vegetation growth from between the mortar joints.			
Current Hazard Index Value: 8			
Remedial / Maintenance Works Required: # 2543 rock fall (<0.125m ³) material lying on top of buttress. Keep under particular observation.			

AA14 East	Chainage: 2560 - 2585		Length: 25m	Height: 10 - 20m
	Grid Ref	Start: NG 90792 37401	Finish: NG 90871 37458	
Description of Slope: Natural rock slope. Grass and shrub covered hillside with woodland above slope. A talus slope (35 +/- 5) runs down from the toe of the slope to the ditch at the edge of the road. Ditch (0.5m wide x 0.5m deep).				
Failure Characteristics: General ravelling. Potential plane and wedge failures.				
Existing Remedial Works: 2002: 75m ³ Heavy scaling / controlled removal. # 2555 – 2562 200m ² Draped double twist rockfall netting. # 2560 – 2585 Rockfall catch fence.				
Inspection Findings: Tree has fallen from above crest of slope and is leaning against the rock slope next to the waterfall. # 2578 Culvert clear.				
Current Hazard Index Value: 8				
Remedial / Maintenance Works Required: Trees on upper slope between slopes AA11 and AA22 are becoming a significant hazard. Plans need to be developed for managing / removing them.				

AA15	Chainage: 2592 - 2760	Length: 168m	Height: 20 - 40m
	Grid Ref	Start: NG 90792 37401	Finish: NG 90871 37458
Description of Slope: Natural and excavated rock slope. Grass and shrub covered hillside with woodland above slope.			
Failure Characteristics: General ravelling. Potential plane, wedge and toppling failures.			
Existing Remedial Works: 1998: 500m ² Light scaling. 50m ³ Heavy scaling. # 2597-2707 6,050m ² Draped double twist rockfall netting. Reinforced with vertical 10mm diameter galvanised steel cables at 1m c/c at the nose. 2006: Tree perched above the crest of the slope removed by Skye Rope Access Ltd. Root ball left in place and secured to tree stumps. February 2008: Tree root ball removed from above crest line, by Skye Rope Access.			
Inspection Findings: # 2605 Scaled area, could undermine other blocks – keep under observation. # 2619 Area of ravelling and blocks just below crest – keep under observation. # 2640 Buttress of rock approximately 15m above the road on the rock slope, no current rockfall activity – keep under observation. # 2679 Culvert clear. Ditch has been partially replaced by road widening, this has resulted in a reduction of the rock trap.			
Current Hazard Index Value: 9			
Remedial / Maintenance Works Required: Trees on upper slope between slopes AA11 and AA22 are becoming a significant hazard. Plans need to be developed for managing / removing them.			

AA16	Chainage: 2770 - 2838	Length: 68m	Height: 10 - 20m
	Grid Ref	Start: NG 91001 37563	Finish: NG 91065 37609
<p>Description of Slope: Natural and excavated slope, probably a section of relict-sea cliff with a cave. Grass and shrub covered hillside with woodland above slope. Ditch: # 2770 – 2782 (2.0m wide, 0.5m deep) # 2782 – 2875 no ditch # 2875 – 2838 (1.0m wide, 0.5m deep)</p>			
<p>Failure Characteristics: General ravelling. Potential plane and wedge failures.</p>			
<p>Existing Remedial Works: Two tell tales on the main buttress of rock that forms the paleo-sea cave. February 2008: # 2800 – 2820 Vegetation removed from face and directly above crest of slope and light scaled with targeted heavy scale. Rope access inspection undertaken by Coffey. Drill steel stuck in face while attempting to drill dowel, steel left in face. Skye Rope Access. October 2008: # 2792 – 2814 Slope reprofiled to remove large mass., by RJ McLeod. # 2790 – 2818 Slope netted, by Geo-Rope Ltd. # 2800 6 No. rock bolts and 6 No. rock dowels installed by Geo-Rope Ltd. # 2804 – 2811 Large wedge failure bolted and sprayed with shotcrete, and drainage holes installed, by Geo-Rope Ltd.</p>			
<p>Inspection Findings: Ditch clear. Bottom cable of netting shows signs of corrosion.</p>			
<p>Current Hazard Index Value: 9</p>			
<p>Remedial / Maintenance Works Required:</p>			

AA17	Chainage: 2838 - 2908	Length: 70m	Height: 20 - 40m
	Grid Ref	Start: NG 91066 37609	Finish: NG 91118 37637
Description of Slope: Excavated rock slope. Ditch (0.5 – 1.0m wide x 0.5m deep). Grass and shrub covered hillside with mixed woodland above slope.			
Failure Characteristics: General ravelling. Potential plane, wedge and toppling failures.			
Existing Remedial Works: 1994 to 1995: Reprofiling removed 2500t of rock. Fixed double twist rockfall netting, rock bolts anchors and dowels, tensioned cables and erosion protection at crest. Wider verge and rock barrier were employed. The newly reprofiled slope was reported as being unstable. No additional explanation, has been reviewed by EDGE. Drainage installed above the slope. 2002: 10m ² Light Scaling at # 2860, under existing netting – keep under observation. 450m ² Draped double twist rockfall netting over the previous netting (#2845-2865). February 2008: # 2897 Lift off tests performed on the 4 anchors present on the slope, by Skye Rope Access.			
Inspection Findings: No significant change. # 2860 Column of fractured rock under existing netting by “Hughie MacKenzy” graffiti, no significant change - keep under observation.			
Current Hazard Index Value: 13			
Remedial / Maintenance Works Required: # 2860 Column of fractured rock, keep under observation during periodic and annual inspections.			

AA18	Chainage: 2908 - 2978		Length: 70m	Height: 20 - 40m
	Grid Ref	Start: NG 91119 37635	Finish: NG 91186 37657	
Description of Slope: Excavated rock slope. Ditch 0.5 – 1.0m wide x 0.5m deep. Grass and shrub covered hillside with mixed woodland above slope.				
Failure Characteristics: General ravelling. Potential plane, wedge and toppling failures.				
Existing Remedial Works: 1990: Slope treated with rock bolts. 1991/92: Some areas were scaled and re-netted, with a bottom anchor cable. 1994: Clearance of debris from behind netting. Draped chain link and some double twist rockfall netting. Drainage installed above the slope. 1998: Replaced chain link net with 600m ² double twist rockfall netting (# 2908-2919, 2949-2953). Reinforced netting with 10mm diameter vertical cables (# 2912-2930, 2942-2949, 2960-2965). Reinforced bottom netting with 10mm diameter horizontal cables (# 2908-2972). Improved and strengthened top anchorage system (new stainless steel dowels added). February 2008: # 2927 Installation of 1 No. 3m long, 3 No. 4m long and 3 No. 5m long stainless steel dowels, by Skye Rope Access. Rope access inspection undertaken by Coffey. # 2950 Missing shackle replaced, by Skye Rope Access.				
Inspection Findings: # 2911 Hole between sections of netting from the toe to 2m up. Not significant, old netting underneath and low down on face. # 2916 Culvert clear. # 2927 Recently installed dowels require packing washers, ends of bar cutting down and nuts tightening. # 2935 Unstable blocks at crest, will be controlled by the netting. # 2949 Gully catch fence (incorporated part of netting system) has caught a boulder (Appendix B - photograph 21) # 2950 Small nose of rock has dilated along several joints 5m above road level – Keep under observation. # 2955 Blocks failed from approx. 8m height. No fresh falls - Keep area under observation.				
Current Hazard Index Value: 11				
Remedial / Maintenance Works Required: Clear out ditch (Annual Maintenance).				

AA19	Chainage: 2990 - 3052	Length: 62m	Height: 10 - 20m
	Grid Ref	Start: NG 91201 37664	Finish: NG 91244 37686
Description of Slope:			
Excavated rock slope (# 2990 to 3035).			
Gabion wall retaining feature and rock trap (# 3035 to 3052).			
Grass and shrub covered hillside with mixed woodland above slope.			
Ditch (0.5m wide x 0.5m deep) at the toe the slope.			
Failure Characteristics:			
General ravelling.			
Potential wedge failures.			
Existing Remedial Works:			
Pre 1972:			
# 3035 – 3052 3 tier high stepped gabion wall			
Pre 1995:			
# 3000 – 3027 Slope netted			
1992 to 1993:			
Draped double twist rockfall netting replacing previous Chain link (still present).			
Some areas of chain link only.			
2002:			
Replaced 25m length of the netting bottom cable with 16mm diameter galvanised steel cable.			
February 2008:			
# 3032 Nose of material heavy scaled, tree on the face removed and 1 No. 3m long and 2 No. 4m long stainless steel dowels installed, by Skye Rope Access.			
# 3052 Corner of gabion basket wall repaired, by Skye Rope Access			
October 2008			
Culvert reinstated and road edge markers installed, by RJ McLeod.			
Inspection Findings:			
# 2980 (boundary between AA18 and AA19) Culvert reinstated during recent contract.			
# 2998 Overhanging block (<0.25m ³) 2m above road level. Side releases have begun to dilate, likely to be contained by the ditch.			
# 3017 Column beginning to dilate 1m above road level – keep under observation.			
# 3032 Minor ravelling around the dowels installed in 2008.			
Current Hazard Index Value: <1			
Remedial / Maintenance Works Required:			
# 2980 (boundary between AA18 and AA19) keep erosion of stream bank under observation during annual inspections.			

AA20	Chainage: 3072 - 3132	Length: 60m	Height: 5 - 10m
	Grid Ref	Start: NG 91270 37696	Finish: NG 91322 37729
<p>Description of Slope: Excavated rock slope on north east side of major gully. "I" beam wall in front of gully acting as a deflection barrier and extending east in front of slope as a retaining wall. The rock slope is vegetated with trees at the crest. Grass, shrub and mixed tree covered hillside above slope. Verge (<0.5m wide) at the toe of the slope (# 3104 no verge). No ditch.</p>			
<p>Failure Characteristics: General ravelling. Potential wedge and toppling failures.</p>			
<p>Existing Remedial Works: Pre 1972: # 3072 to 3104 "I" Beam and segmental Concrete retaining wall. # 3095 Small concrete buttress / block above "I" beam wall supporting rock slope above. # 3103 Very wide joint infilled with cement mortar. September 2001: Concrete toe buttress secured with Ischebeck 40/16 anchorages; wire rope slings; and erosion protection installed September 2001. To secure blocks on northeast flank of gully at # 3072. April 2002: # 3123 10m² Light scaling. 4.5m³ Heavy scaling / controlled removal (# 3094, 3097, 3115, 3129). Doweling (2 No. at # 3131, 2 No. at # 3129). October 2008 2 No. damaged concrete panels in "I" beam wall replaced with "I" beams. 4th "I" beam from the west end has had a metal flange installed to retain concrete panels, by RJ McLeod.</p>			
<p>Inspection Findings: Vegetation is continuing to establish on the coir matt, in the area of the September 2001 Emergency remedial works. Top tell tale: hor = +6.5mm, vert = +2.5mm (Appendix B - photograph 24). Bottom tell tale has been removed during installation of flange. No significant change to "I" beam wall since June 2006 Annual Inspection. Trees immediately above "I" beam wall have been cut down. # 3079 Culvert clear. # 3130 Culvert partially blocked by material behind wall next to avalanche shelter.</p>			
<p>Current Hazard Index Value: 5</p>			

Continued...

AA20 (Continued...)

Remedial / Maintenance Works Required:

The "I" beams require maintenance to treat existing corrosion and to protect the steel work from further corrosion (Annual Maintenance) **Outstanding**.

Clear culverts (Annual Maintenance).

The above measurements do not enable monitoring of the wall in the plane perpendicular to the wall. Hence, a monitoring / recording system should be put in place which can be used to monitor such movements. In conjunction with a monitoring / recording system the wall should be re-laser surveyed immediately prior to the 2012 inspection (5 year review).

AA21	Chainage: 3196 - 3304	Length: 108m	Height: 10 - 20m
	Grid Ref	Start: NG 91340 37746	Finish: NG 91427 37820
<p>Description of Slope: Excavated rock slope. Grass and shrub covered hillside with mixed woodland above slope. Verge (<0.5m wide) at the toe the slope. No ditch.</p>			
<p>Failure Characteristics: General ravelling. Potential plane, wedge and toppling failures.</p>			
<p>Existing Remedial Works:</p> <p>1998: New bottom cable and additional bottom anchors installed. # 3272-3277 masonry toe buttress. Draped chain link netting (poor condition). Patched with double twist rockfall netting.</p> <p>2001: # 3260 Bottom cable anchor eye and shackle replaced.</p> <p>2002: 116m³ Heavy scaling / controlled removal (# 3206, 3209, 3216, 3217, 3219, 3220, 3222, 3229, 3239, 3244, 3258, 3261, 3268, 3274, 3281). 2700m² Cable reinforced double twist rockfall netting over previous netting. Doweling (4 No. at # 3198, 2 No. at # 3202, 3 No. at # 3206, 3 No. at # 3217, 2 No. at # 3218, 12 No. at # 3229, 3 No. at # 3244, 1 No. at # 3249, 4 No. at # 3261, 9 No. at # 3268, 5 No. at # 3274).</p> <p>2004: # 3206 and 3217 – shackle and eye threads smeared with epoxy resin by EDGE, to deter theft. # 3248 Shackle replaced and threads smeared with epoxy resin by EDGE.</p> <p>2005: # 3269 Eye replaced with spare eye from slope AA19.</p> <p>2006: # 3233 and 3269 shackles replaced and threads smeared with epoxy resin by EDGE. # 3232 Hole in netting by dowel – repaired by TRAC January 2006.</p> <p>February 2008: # 3272 – 3277 Vegetation removed from buttress and poisoned, by Skye Rope Access.</p>			

Continued...

AA21 (Continued...)

Inspection Findings:

3199 Culvert clear

3216 6m high column of material – no change since last year– keep under observation for deterioration.

#3220 Block (400 X 150 X 300mm) 6 to 7m up on slope. Would be contained by rockfall netting.

3272-3277 Masonry toe buttress in satisfactory condition, plants are still growing on the buttress.

3270 Column of material. Keep under observation.

3276 Block from superfcials on top of buttress.

3282 Block (300 X 300 X 150mm) 3m up on slope likely to fail but will be retained by the verge / ditch / netting.

Current Hazard Index Value: 8

Remedial / Maintenance Works Required:

None

AA22b	Chainage: 3346 - 3550	Length: 204m	Height: 20 - 40m
	Grid Ref	Start: NG 91461 37863	Finish: NG 91551 37982
<p>Description of Slope: Excavated rock slope. Grass and shrub covered hillside with mixed woodland above slope. Verge (0.5m to 4m wide) at the toe of the slope with a double height "Armco" safety barrier for some of the slope length.</p>			
<p>Failure Characteristics: General ravelling. Potential plane, wedge and toppling failures.</p>			
<p>Existing Remedial Works:</p> <p>1995: Area was scaled and re-netted with Draped Double twist rockfall netting (with poor top anchorage system). # 3445 – 3450 Masonry toe buttress. Double height "Armco" safety barrier along base of highest section of slope (up to # 3437).</p> <p>1998: Reinforced existing netting with vertical cables (# 3346-3355, 3368-3373, 3379-3383, 3388-3401, 3405-3418). Reinforced existing netting with horizontal cables (# 3346-3373, 3378-3418). Improved and strengthened top anchorage system (new stainless steel anchorage dowels). # 3456 Shackle removed to render netting more flexible.</p> <p>2004: Eastern end of slope reprofiled to improve visibility.</p> <p>2005: Further reprofiling of eastern end of slope.</p> <p>February 2008: # 3445 – 3450 Vegetation removed from buttress and poisoned, by Skye Rope Access. # 3480 – 3495 Superficial material above the slope reprofiled and face light scaled, by Skye Rope Access.</p>			

Continued...

AA22b (Continued...)

Inspection Findings:

3352 to 3356 Area on face undercut rock 25m up. Material is likely to fail at this location, but should be controlled by the reinforced rockfall netting. Keep under observation.

3362 Block (2m high x 1.5m wide x 1m deep) will continue to break up and fail with time. The debris should be contained and controlled by the rockfall netting. No signs of further deterioration.

3372 Nose of material approx. 10m up. Failures may occur at this location, but should be controlled by the reinforced rockfall netting. Keep under observation.

3382 Failure scar from 20t rockfall in December 2001. More material is likely to fail at this location, but should be controlled by the reinforced rockfall netting. Keep under observation.

3438 Culvert clear.

3445 – 3450 Small rocks behind netting, not significant.

3477 Small block removed during inspection.

3480 New / reinstated culvert – clear.

Current Hazard Index Value: 11

Remedial / Maintenance Works Required:

3356, 3372 and 3382 – Potential failures keep under particular observation during periodic and annual inspections.

AA23N	Chainage: 3553 - 3607	Length: 54m	Height: 2 - 5m
	Grid Ref	Start: NG 91551 37982	Finish: NG 91577 38011
Description of Slope: Excavated rock slope forming Northbound side of a "box cutting". Grass and shrub covered hillside above slope. Verge (2m wide).			
Failure Characteristics: General ravelling.			
Existing Remedial Works: 1995: Verge built up and ditch deepened. February 2008: # 3579 Blast damaged area heavy scaled by Skye Rope Access. October 2008: #3565 – 3585 Slope reprofiled and dense gorse removed by RJ McLeod and Geo-Rope. July 2009: # 3570 – 3580 Slope scaled by CAN.			
Inspection Findings: Slope has been partially reprofiled and the dense gorse removed. Ditch has been infilled during recent reprofiling and is no longer acting as an effective rock trap.			
Current Hazard Index Value: 1			
Remedial / Maintenance Works Required: # 3570 – 3580 Light scale. Clear out and reform ditch (Annual Maintenance).			

AA23S	Chainage: 3541 - 3624	Length: 83m	Height: 5 - 10m
	Grid Ref	Start: NG 91551 37982	Finish: NG 91577 38011
Description of Slope: Excavated rock slope forming Southbound side of a "box cutting". Grass and shrub covered hillside above slope. Verge (2m wide) that includes a ditch (0.5m to 1m wide x 0.5m deep).			
Failure Characteristics: General ravelling.			
Existing Remedial Works: 1995: Verge built up and ditch deepened. February 2008: # 3608 Blast dilated mass removed by heavy scaling by Skye Rope Access. October 2008 Slope has been partially reprofiled and the dense gorse removed by RJ McLeod and Geo-Rope. July 2009: # 3585 Potential wedge failure and surrounding area scaled by CAN.			
Inspection Findings: # 3569 Block 3m above road level. Discontinuity (joint) not through going at present. Slope has been partially reprofiled and the dense gorse removed.			
Current Hazard Index Value: 4			
Remedial / Maintenance Works Required: None			

AA24	Chainage: 3640 -3723	Length: 83m	Height: 10 - 20m
	Grid Ref	Start: NG 91632 38067	Finish: NG 91735 38104
Description of Slope: Excavated rock slope. Grass and shrub covered hillside above slope. Ditch at toe of some of the slope (0.5 - 1.0mwide x 0.5m deep).			
Failure Characteristics: General ravelling. Potential plane and wedge failures.			
Existing Remedial Works: 2002: 65m ³ Heavy scaling / controlled removal (# 3650, 3653, 3657, 3675). 150m ² Draped double twist rockfall netting (# 3640-3646). Repair of existing netting damaged during heavy scaling / controlled removal. Dowelling (1 No. at # 3650, 1 No. at # 3653, 3 No. at # 3655, 1 No. at # 3657, 2 No. at # 3669, 2 No. at # 3671, 2 No. at # 3673). Draped double twist rockfall netting, not full coverage.			
Inspection Findings: # 3662 Wedge should be contained by netting. # 3672 Small rockfall (<0.25m ³). Scar is 4m above road level behind netting, debris contained at the toe. Dilated blocks immediately next to the scar, likely to be contained by the netting. Small sapling growing out from between the blocks (Appendix B - photograph 29).			
Current Hazard Index Value: 4			
Remedial / Maintenance Works Required: Rope access inspection by Coffey of rockfall at # 3672 during next phase of remedial works.			

Frenchman's Burn (Allt an Fhrangaich)	Chainage: 2200
	Grid Ref: NG 90609 37219
<p>Description: Large deeply incised gully with a stream. The stream flows in most weather conditions and flows in spate during / following heavy rainfall / snowmelt. The stream carries significant quantities of rock debris during spate events.</p>	
<p>Existing Remedial Works:</p> <p>1999: 2 No stilling basins located just upstream from culvert under road and railway.</p> <p>2002: Removal of 2 No. tree trunk dams.</p> <p>October 2008: Repair to gabion wall of lower stilling basin. Raising and installation of new wing walls. Reprofilng of east bank of gully above upper stilling basin.</p>	
<p>Inspection Findings:</p> <p>The lower and upper stilling basins have a quantity of debris accumulation within them (Appendix B - photograph 30). Further erosion has occurred on the South west gully wall above upper and lower stilling basins. There has been a significant number of large rock falls (totalling approximately 100m³) into the gully bed approximately 200m upstream of the stilling basins. The area of the rock falls is likely to suffer ongoing rock falls, particularly during / post adverse weather. Deer gates and fencing installed around the lower stilling basin.</p>	
<p>Remedial / Maintenance Works Required:</p> <p>Remove half the stone from the two central baskets – if flow becomes obstructed. The debris source is likely to lead to a larger than "normal" scale debris flow during / post adverse weather. Hence, it is vital that the stilling basins are kept clear of debris accumulations. Further means of increasing their capacity or retention capacity may be required in future. The debris in the culvert requires removal (Annual Maintenance).</p>	

Stream Gully Between Slope AA19 and AA20	Chainage: 3072
	Grid Ref: NG 91270 37696
Description: Large deeply incised gully with a small stream. The stream flows in wet weather conditions and flows in spate during / following heavy rainfall / snowmelt. The stream carries significant quantities of rock debris during spate events.	
Existing Remedial Works: # 3072 to 3104 "I" Beam and segmental Concrete retaining wall at base of gully installed pre-1972. In November 1994 a significant rockfall damaged the retaining wall.	
Inspection Findings: Following a landslide with block fall, approximately 40m above road, observed in October 2000, remedial works were completed in September 2001. Vegetation is well established on the coir mat. The concrete beam and associated works show no observable signs of deterioration. Up the gully from the coir matting an area was noticed in 2005 to have been eroded away (3m high by 2m wide) – this has not deteriorated further.	
Remedial / Maintenance Works Required: Monitor and observe eroded area within the gully during monthly and annual inspections.	


<p>Debris Flow within gully between Slope AA5 and AA6</p>	<p>Chainage: 1330 - 1350 Grid Ref: NG 89956 36756 – NG 89903 36816</p>
<p>Description: The debris flow occurred in October 2001 The debris flow has eroded the superficial deposits down to rock head. The debris flow occurred within an infilled gully.</p>	
<p>Existing Remedial Works: October 2001: Interceptor drain to collect water from behind the crest of the soil slope and redirect to discharge on the exposed rock at the toe of the slope. Erosion protection on the upper scar of the debris flow. Deflection wall comprising concrete traffic protection blocks installed on the verge to act as a rock / debris trap. February 2008: # 1330 – 1350 Leaking interceptor pipe repaired and new sections installed. Large snapped branch in drainage ditch removed and large mature fallen tree stabilised, by Skye Rope Access. # 1350 Breeze block tank re-pointed, by Skye Rope Access.</p>	
<p>Inspection Findings: The drainage works appear to be working satisfactorily. The catch pit is partially filled (Appendix B - photograph 33) and requires cleaning out. The coir mat forming part of the erosion protection is continuing to vegetate (Appendix B - photograph 34). No significant erosion below discharge point of pipe. Still some flow of water from superficials in the ditch on the south side of the gully. Large tree that had fallen in to crest drainage ditch has been cleared from the ditch, but still remains on the slope. Branch from tree opposite fallen tree on crest of slope has been cut up and stacked above the drainage ditch. The pipe was noted to be leaking at the 1st elbow joint down from the catch pit (Appendix B - photograph 35). A galvanised eye from the 1st collar below the above elbow joint is missing. The anchorage wire was not connected to the pipe or collar. The wire has looped around the collar during the inspection until the eye can be replaced (Appendix B - photograph 36).</p>	
<p>Remedial / Maintenance Works Required: The leaking elbow joint requires repairing and the missing eye replacing with the anchorage re-attaching during the next phase of remedial works. The area around the crest of the debris flow scar requires planting with appropriate trees –outstanding from 2003 inspection. Top drainage catch pit / debris trap requires clearing (Annual Maintenance).</p>	

Natural slope between AA18 and AA19	Chainage: 2980 - 2990
	Grid Ref: NG 91183 37657 – NG 91201 37664
Description: The rockfall occurred in May 2007. The rockfall originated from a natural crag 100m above road level.	
Existing Remedial Works: February 2008: Location of failure had vegetation and tree removal. Failure scar and surrounding area was heavy scaled. 1 No. 4m dowel installed. Attempt to remove tree trunk unsuccessful, strapped to face until future remedial works for removal, by Skye Rope Access.	
Inspection Findings: No significant change since February 2008 remedial works.	
Remedial / Maintenance Works Required: Keep area under observation for signs of deterioration and fresh rockfall. Remove strapped trunk and cut root ball flush with rock face during next remedial works contract (Phase VI).	


Appendix B

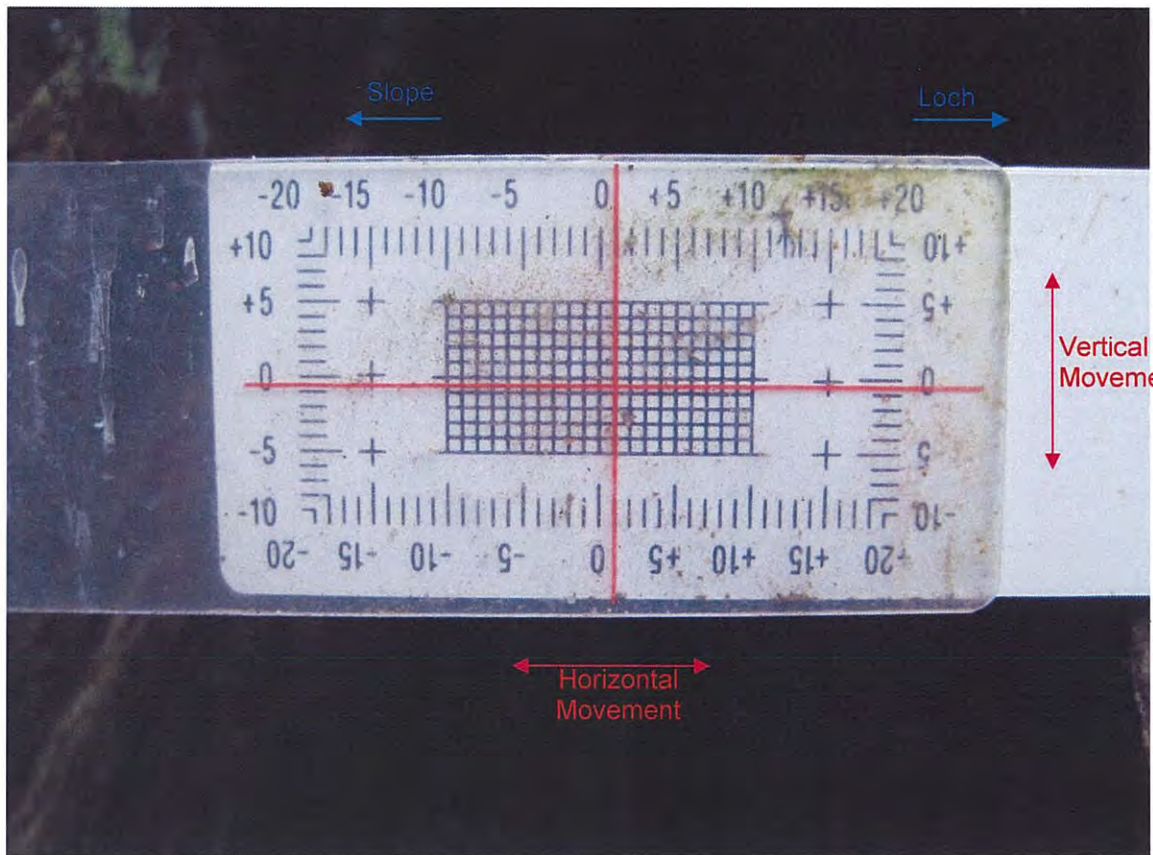
Annual Rock Slope Inspection Photographs June 2009



drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA1		
scale	NTS		project no:	454.1	photograph no:	1
original size	A4					



drawn	RMD	 <p>coffey geotechnics SPECIALISTS MANAGING THE EARTH</p>	client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA2		
scale	NTS		project no:	454.1	photograph no:	2
original size	A4					




drawn	RMD		client:	The Highland Council	
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009	
date	10th June 2009		title:	Slope AA3 & Tell Tale	
scale	NTS		project no: 454.1	photograph no: 3 & 4	
original size	A4				



drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA4 & Undercut Superfcials (sic)		
scale	NTS		project no:	454.1	photograph no:	5 & 6
original size	A4					



drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA5		
scale	NTS		project no:	454.1	photograph no:	7
original size	A4					




drawn	RMD
approved	N/A
date	10th June 2009
scale	NTS
original size	A4



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client:	The Highland Council
project:	A890 Stromeferry Bypass Annual Inspection June 2009
title:	Slope AA6
project no:	454.1
photograph no:	8




drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA7		
scale	NTS		project no:	454.1	photograph no:	9
original size	A4					




drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Strome ferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA8		
scale	NTS		project no:	454.1	photograph no:	10
original size	A4					




drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA9		
scale	NTS		project no:	454.1	photograph no:	11
original size	A4					




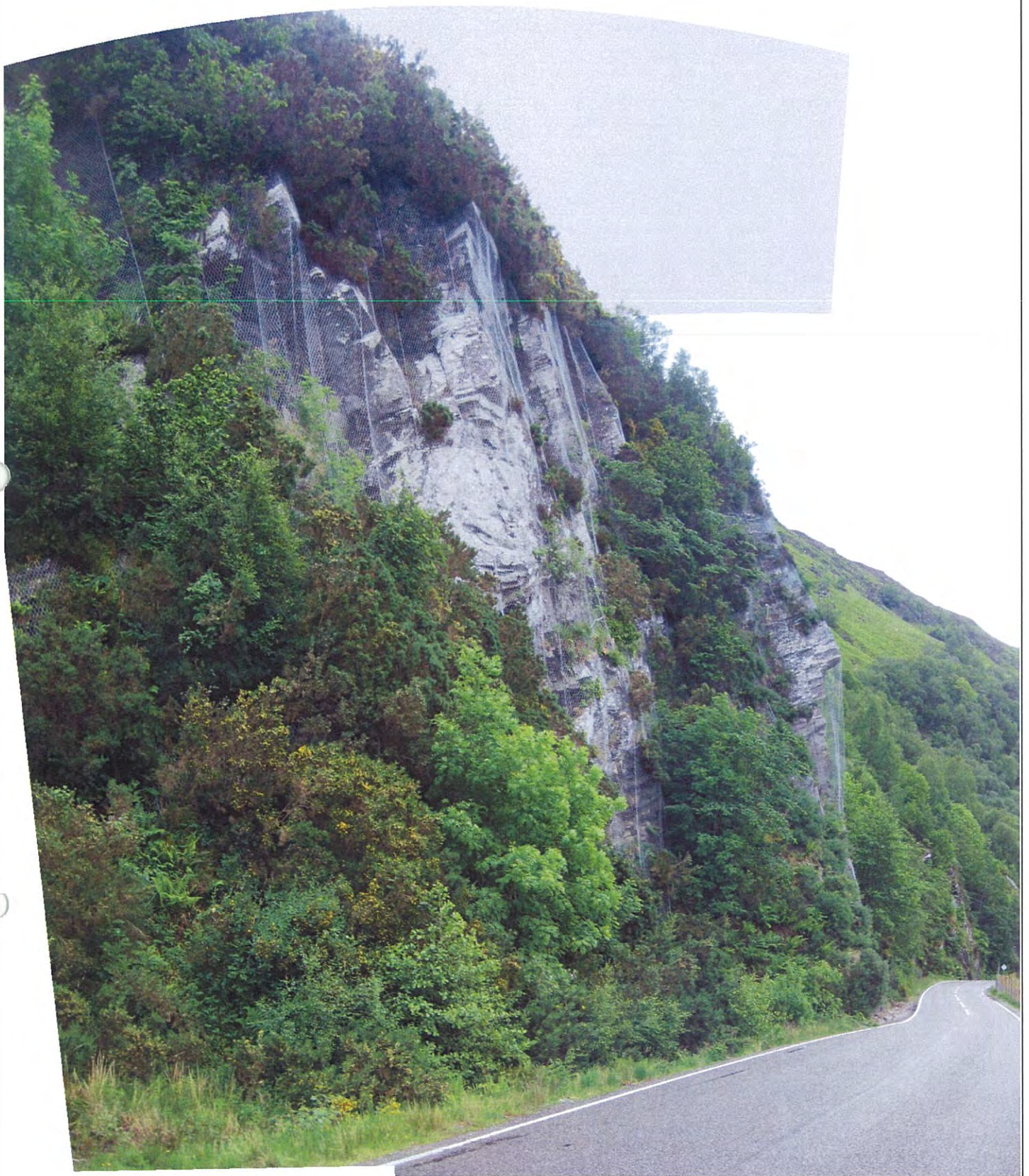
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approved	N/A			project:	A890 Stromeferry Bypass Annual Inspection June 2009
date	17 June 2009			title:	Slope AA10
scale	NTS			project no:	454.1
original size	A4				photograph no: 12




drawn	RMD		client:	The Highland Council	
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009	
date	10th June 2009		title:	Slope AA11	
scale	NTS		project no: 454.1	photograph no: 13	
original size	A4				



drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA12		
scale	NTS		project no:	454.1	photograph no:	14
original size	A4					




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approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA13		
scale	NTS		project no:	454.1	photograph no:	15
original size	A4					




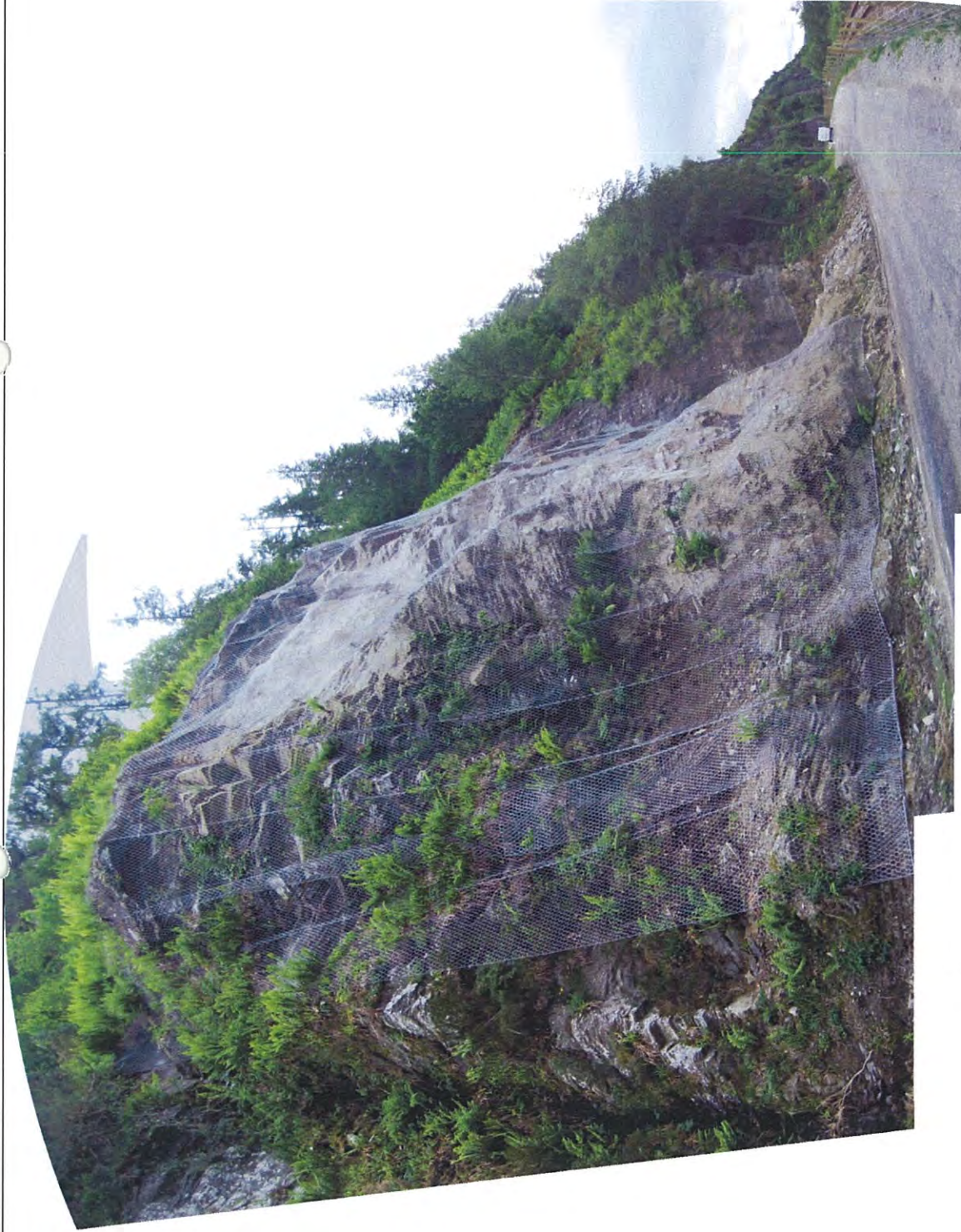
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approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009	
date	10th June 2009		title:	Slope AA14 West	
scale	NTS		project no: 454.1	photograph no: 16	
original size	A4				



drawn	RMD	 <p>coffey geotechnics SPECIALISTS MANAGING THE EARTH</p>	client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA14 East		
scale	NTS		project no:	454.1	photograph no:	17
original size	A4					



drawn	RMD	 coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA15		
scale	NTS		project no:	454.1	photograph no:	18
original size	A4					




drawn	RMD
approved	N/A
date	10th June 2009
scale	NTS
original size	A4


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client:	The Highland Council
project:	A890 Stromeferry Bypass Annual Inspection June 2009
title:	Slope AA16
project no:	454.1
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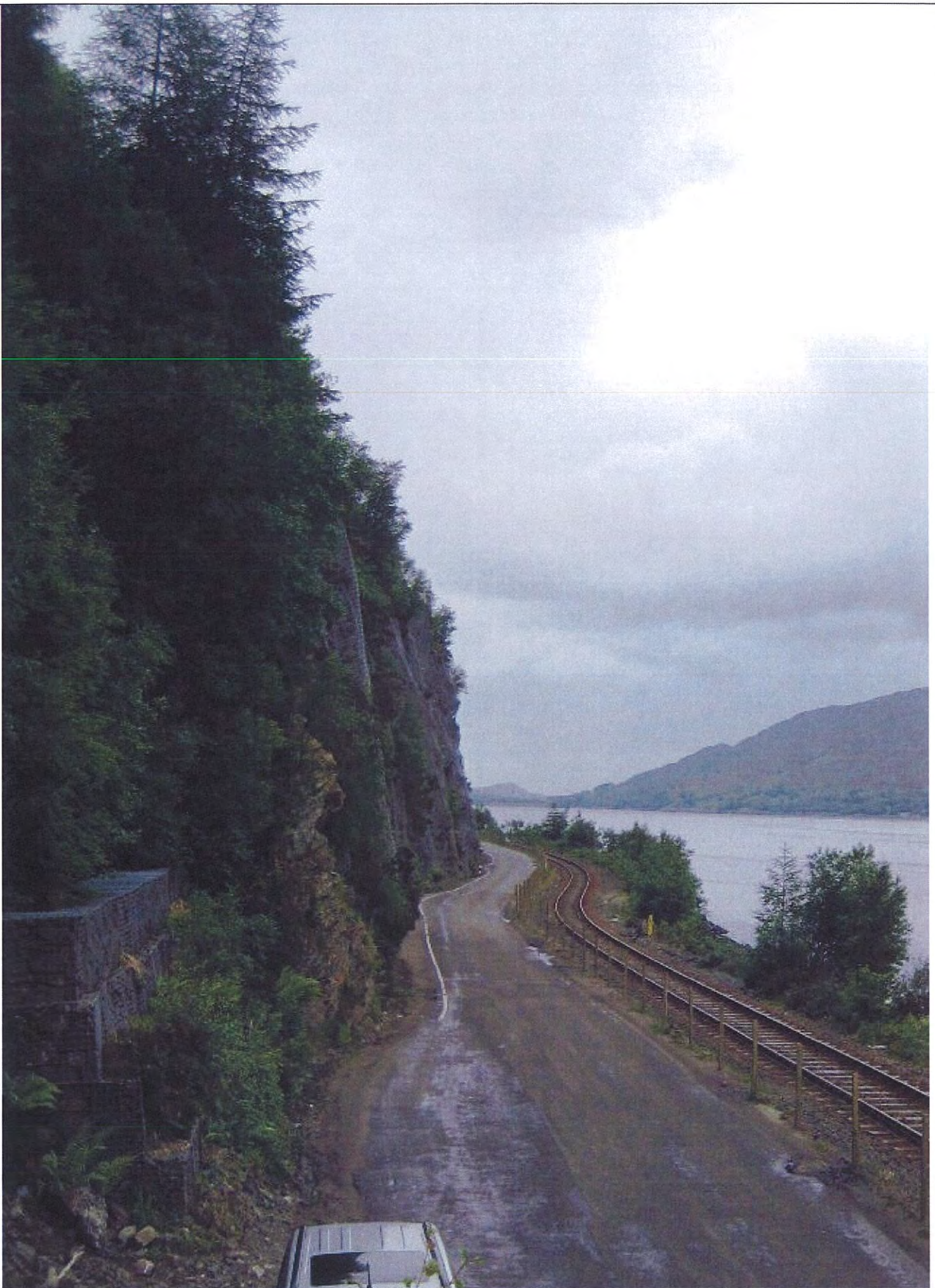



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approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009	
date	10th June 2009		title:	Slope AA17	
scale	NTS		project no: 454.1	photograph no: 20	
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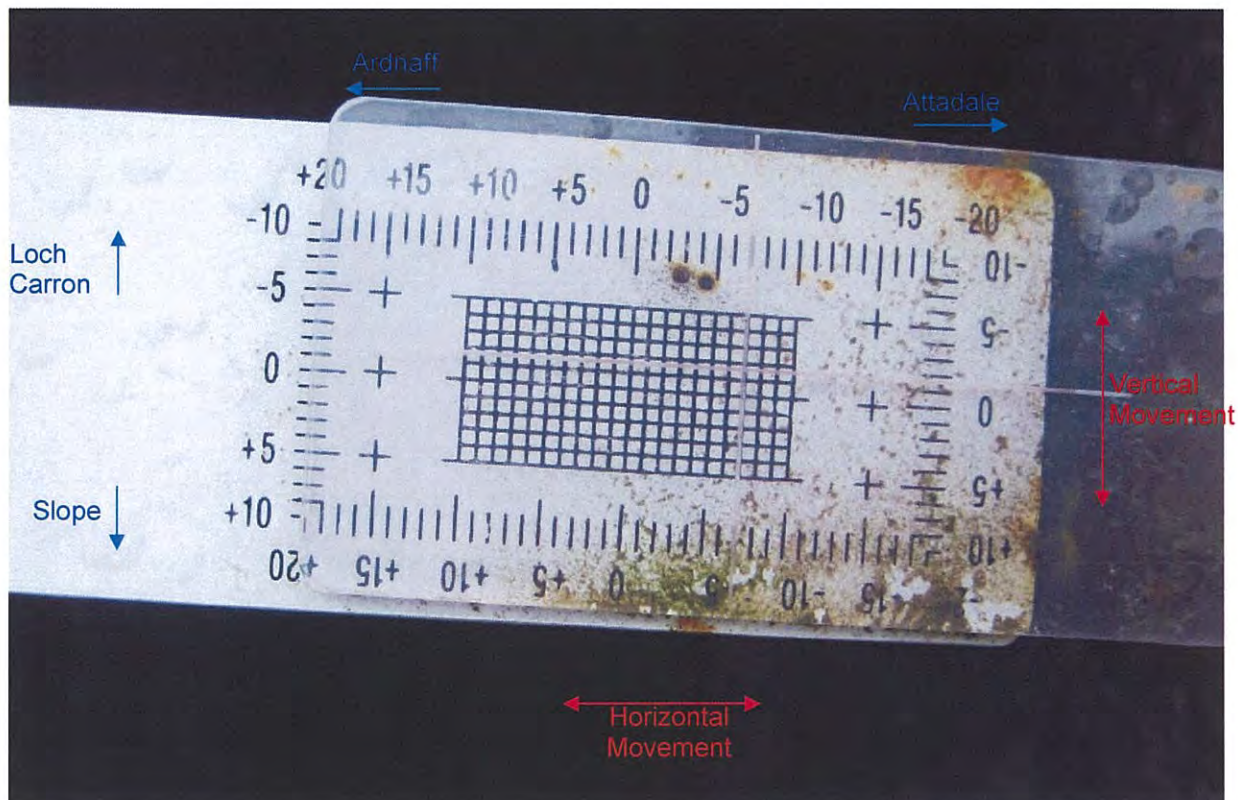



Block retained by gully fence / rock netting.

drawn	RMD	 <p>coffey geotechnics SPECIALISTS MANAGING THE EARTH</p>	client:	The Highland Council		
approved	N/A		project:	A890 Strome ferry Bypass Annual Inspection June 2009		
date	10th & 11 th June 2009		title:	Slope AA18		
scale	NTS		project no:	454.1	photograph no:	21
original size	A4					




drawn	RMD	 coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	The Highland Council	
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009	
date	10th June 2009		title:	Slope AA19	
scale	NTS		project no: 454.1	photograph no: 22	
original size	A4				



drawn	RMD	 <p>coffey geotechnics SPECIALISTS MANAGING THE EARTH</p>	client:	The Highland Council		
approved	N/A		project:	A890 Stroneferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA20 & Tell Tale		
scale	NTS		project no:	454.1	photograph no:	23 & 24
original size	A4					



drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	10th June 2009		title:	Slope AA21		
scale	NTS		project no:	454.1	photograph no:	25
original size	A4					




drawn	RMD
approved	N/A
date	10th June 2009
scale	NTS
original size	A4

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client:	The Highland Council	
project:	A890 Stromeferry Bypass Annual Inspection June 2009	
title:	Slopes 22a & 22b	
project no: 454.1	photograph no: 26	



drawn	RMD	 SPECIALISTS MANAGING THE EARTH		client:	The Highland Council
approved	N/A			project:	A890 Stromeferry Bypass Annual Inspection June 2009
date	12th August 2009			title:	Slope 23N
scale	NTS			project no:	454.1
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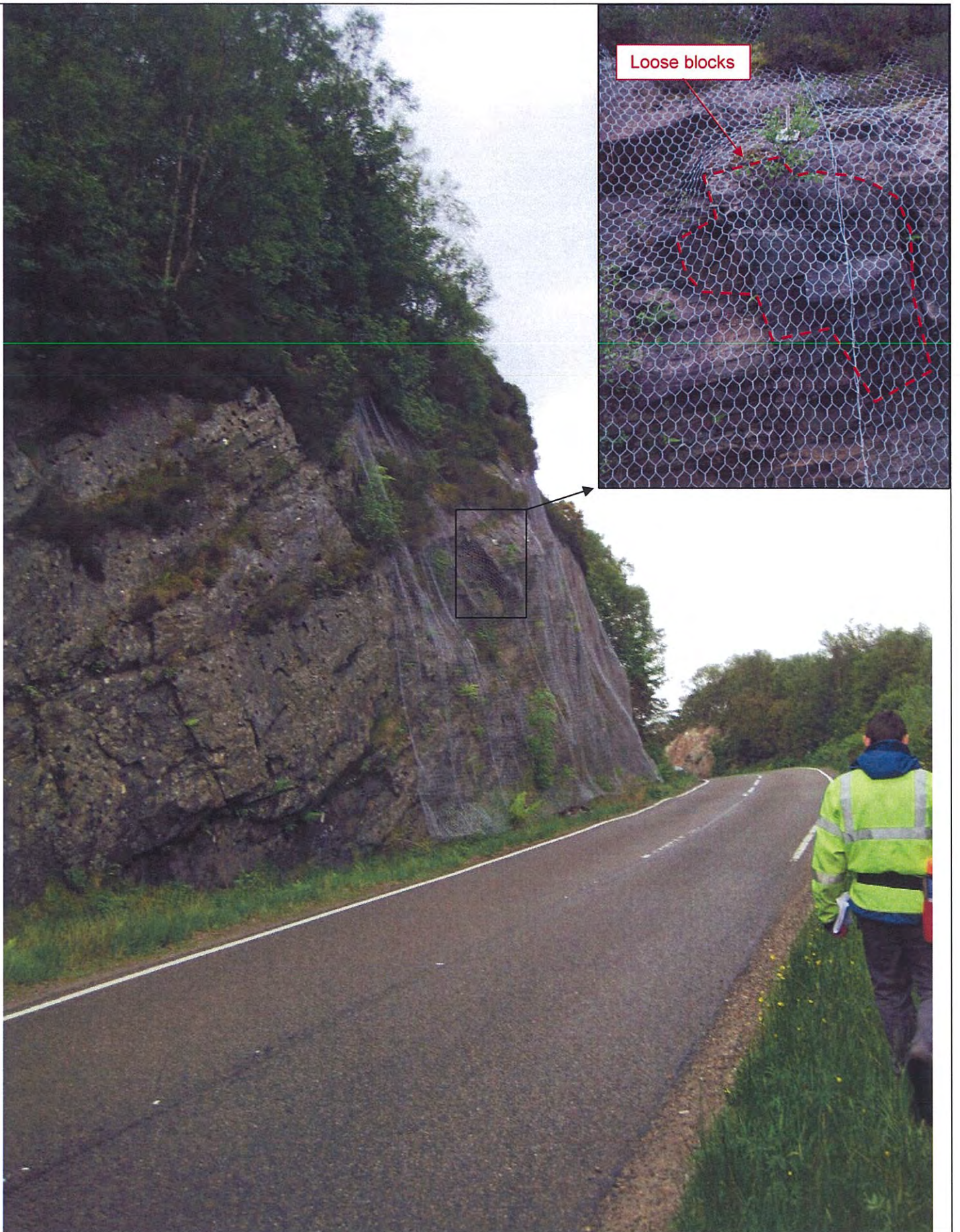


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approved	N/A
date	12th August 2009
scale	NTS
original size	A4


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client: The Highland Council
 project: A890 Stromeferry Bypass
 Annual Inspection June 2009
 title: Slope 23S
 project no: 454.1

photograph no: 28



drawn	RMD
approved	N/A
date	10th June 2009
scale	NTS
original size	A4


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client:	The Highland Council	
project:	A890 Stromeferry Bypass Annual Inspection June 2009	
title:	Slope AA24	
project no: 454.1	photograph no: 29	



Lower Stilling Basin

Upper Stilling Basin


drawn	RMD
approved	N/A
date	11th June 2009
scale	NTS
original size	A4




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client:	The Highland Council	
project:	A890 Stromeferry Bypass Annual Inspection June 2009	
title:	Frenchman's Burn	
project no: 454.1	photograph no: 30	



drawn	RMD	 coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	The Highland Council		
approved	N/A		project:	A890 Strome ferry Bypass Annual Inspection June 2009		
date	11th June 2009		title:	Stream Gully Between Slopes AA19 & AA20		
scale	NTS		project no:	454.1	photograph no:	31
original size	A4					




drawn	RMD		client: The Highland Council	
approved	N/A		project: A890 Strome ferry Bypass Annual Inspection June 2009	
date	11th June 2009		title: Crest Drainage Trench Above Slope AA5	
scale	NTS		project no: 454.1	
original size	A4		photograph no: 32	



drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	11th June 2009		title:	Catch Pit and Mac Mat R above Slopes AA5 & AA6		
scale	NTS		project no:	454.1	photograph no:	33 & 34
original size	A4					

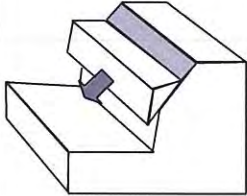

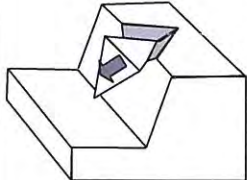

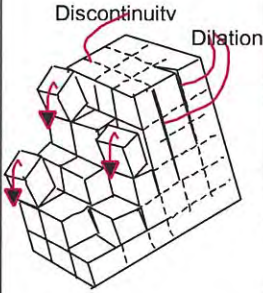
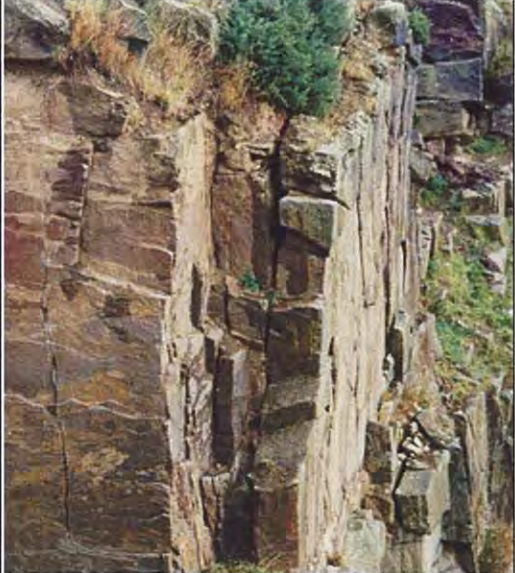


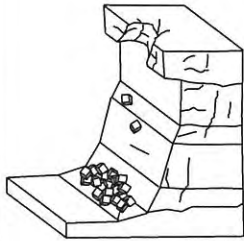
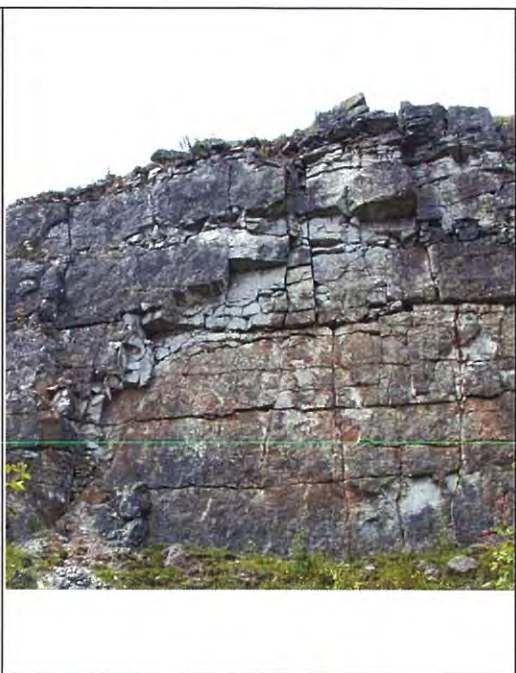
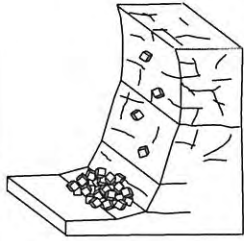

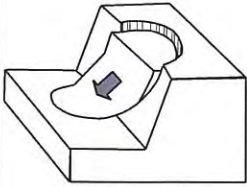

drawn	RMD		client:	The Highland Council		
approved	N/A		project:	A890 Stromeferry Bypass Annual Inspection June 2009		
date	11th June 2009		title:	Interceptor Pipe Above AA5 & AA6 – Leak and Missing Eye		
scale	NTS		project no:	454.1	photograph no:	35 & 36
original size	A4					

Appendix C

Rock Slope Failure Mechanisms

Rock Slope Failure Mechanisms

Mechanisms	Description	Example
<p>Plane</p> 	<p>Movement down a discontinuity plane.</p> <p>General criteria for failure are:</p> <ul style="list-style-type: none"> • Discontinuity dip < slope angle. • Discontinuity dip > friction angle of discontinuity plane. • Discontinuity plane must "daylight" on the face. • Dip direction should generally be within $\pm 20^\circ$ of the face dip direction. 	
<p>Wedge</p> 	<p>Movement of a wedge shaped rock mass down two intersecting discontinuity planes in the direction of the intersection.</p> <p>General criteria for failure are:</p> <ul style="list-style-type: none"> • Intersection must dip < face angle. • Intersection must dip > friction angle of discontinuity planes. • Intersection must "daylight" on the face. <p>Wedges may repeat at intervals due to nature of intersecting discontinuity planes.</p>	
<p>Toppling</p> 	<p>Movement out of the slope of elongated overbalanced blocks, developing due to rotation about the toe of the block. Once the centre of gravity of the block acts beyond its toe the block will topple.</p> <p>General criteria for failure are:</p> <ul style="list-style-type: none"> • Discontinuity set spacings producing vertically elongated, overbalanced blocks which lean out of the slope. • Steeply inclined discontinuity dipping into the slope. • Basal release discontinuity which must either dip out of the slope at < friction angle of discontinuity, or be sub-horizontal. • May require steeply inclined discontinuity forming a side release plane. 	

<p>Block Fall</p> 	<p>Sporadic, un-preceded detachment & falling from a rock slope of an isolated, protruding or unsupported boulder (>200mm*) or larger sized block.</p> <p>Fall is initiated by:</p> <ul style="list-style-type: none"> • Gravity: initiated by removal of support due to ravelling & blockfall. • Weathering: propagation of a discontinuity plane between block & rock slope where load stress on the block > the shear and tensile strength of the connecting material plane. • Vegetation: may provide a destabilising force e.g. roots "jacking" material. • Movement is rapid & the block may dislodge further material from the rock face. Fall material generally accumulates at the toe of the slope. May subsequently involve bouncing, rolling, sliding & fragmentation of the block/s. • Block dimensions are governed by spacing & orientation of discontinuities (natural or blast induced) within the rock mass. 	
<p>Ravelling</p> 	<p>Ravelling is a near surface mechanism generally occurring in weak or closely fractured (natural and blast induced discontinuities) rock masses.</p> <ul style="list-style-type: none"> • Continuous, detachment & fall of mineral grains, gravel sized (2 - 60mm*) fragments & occasional cobble sized (60 - 200mm*) blocks from a rock slope. This material may fall or roll down slope forming talus on & at the toe of the slope. • Driving mechanisms include long-term stress relief, physical & chemical weathering processes that gradually weaken & deteriorate a rock mass. • Ravelling results in progressive natural regression of an exposure. This proceeds until a stable slope angle between crest & toe is formed. 	
<p>Curvilinear failure</p> 	<p>Occurs in soil masses, soft rock masses and heavily jointed or broken hard rock masses.</p> <p>Materials behave like an engineering soil & a rotational slip occurs through the rock mass, forming a circular 'spoon like' geometry.</p>	

*According to the size categories defined in BS 5930:1999.