PERTH AND KINROSS COUNCIL

Environment Committee

12 November 2014

Blairgowrie, Oakbank Road Landslip

Report by the Executive Director (Environment)

PURPOSE OF REPORT

This report gives an update on the condition of the leased Oakbank Road and associated embankments in Blairgowrie following an investigation by specialist consultants. It concludes that further landslips are likely. The remedial cost options are detailed and are no guarantee against further landslips. As a result it is recommended that the route should remain closed for public safety and that the Council should maintain an alternative route.

1. BACKGROUND / MAIN ISSUES

1.1 The track known as Oakbank Road in Blairgowrie was formed in the mid-19th Century, is privately owned and is currently leased to the Council. It is a core path, (route BLAI/1), and has provided a valued and popular surfaced route along the attractive wooded west side of the River Ericht. It connected the town centre and Riverside Park with viewing platforms, a bridge at Keithbank Mill and forms part of the Cateran Trail (Appendix 1). It is an important part of the recreational attractions within Blairgowrie. The track has been occasionally used for vehicular access to the Lornty Cottages, particularly in the winter when conditions can be difficult on the steeper Lornty Road. The track is cut into a steep embankment located in a highly dynamic river valley which is naturally subject to constant change from the cycle of alluvial erosion and deposition.

1.2 A severe landslip occurred on the Oakbank Road just prior to Christmas 2012 following a period of sustained heavy rain. This saturated the embankment material and increased the river flow causing erosion to the base and subsequent collapse. A section of the track up to 1.3m wide was lost over a length of approximately 19m to a width of about 30m. An estimated 600 tonnes of material was washed down the river (Appendix 2). The edge of the track continues to erode. There has been previous movement of the slope on a 12 metre long section with partial failure of a retaining wall in 2011, further north of the 2012 landslip. There is evidence the whole area has been subject to several slippages in the past.

1.3 To protect the public from the edge of the landslip and possible further landslips, fencing preventing access was erected and permanent signage installed to direct the public around the slippages via Lornty Road (shown as a black line on Appendix 3). The alternative routes are suitable for the able bodied only, which is the same situation for those using the rest of the Cateran Trail. The distance to the start of the Cateran trail using the alternative route is almost the same as using the Oakbank Road route.

1.4 The most recent landslip has been of considerable concern to the Council, landowner and community with a 2,125 signature petition being sent in to the Council on 1 August 2013. This was acknowledged and a letter written in response explained the Council's position at the time. There has also been considerable concern from the Community Council and from local elected members about the path closure and the need to find a solution as quickly as possible.

1.5 Following an initial investigation by the Council's consultant engineers, it was clear a full specialist ground investigation, requiring trial pits and bore holes, was needed to properly identify the likely causes behind the landslips. The site works and subsequent laboratory tests were carried out in early 2014 and a report completed including options for stabilizing the slope and reinstating the road (Appendix 4). The results of the ground investigation revealed that there is no bedrock below Oakbank Road until the river level is reached (Appendix 5). The material above the bedrock is a mixture of clays, sands, gravels and cobbles which is inherently unstable and relies on cohesion for stability. The cohesion is significantly reduced when the material becomes wet. The key points relating to the condition of the embankment have been extracted from the consultants' report and are summarised below:

- **General** "Numerous areas of slope creep and landslip are evident on the steep flanks of this river terrace between Cargill's Leap and Cuttle Burn." p2-1

- **2011 Landslip** "The resulting slope face is currently at 1 in 1.5 (35^0) and is likely to have only marginal stability and be susceptible to soil creep…A section of wall remains but it is likely to tumble at some point." p2-1

- **Slope between Landslips** "The toe of this slope is over-steep due to erosion by the river and will have only marginal stability." "The large embayment … represents a relic landslip with debris removed by the river." p2-1 "This slope is over-steep due to erosion by the river and contains several minor landslip features. The outer slope will have only marginal stability." p2-2

- **2012 Landslip** "The exposed soil face along the north edge of the landslip is …an over-steepened lower slope where river erosion and landslip has removed the toe of slope. This would be a key preparatory factor in the landslip incident that was observed in December 2012, this in combination with wetting up of the materials in a period of heavy rainfall." p2-2

- "The cutting slope above the road… For much of its length this isn't a natural slope and there is evidence that it has been cut too steep, or that the material has weathered and the slope now presents only marginal stability…At some locations only tree roots hold the crest of slope together." p2-3.

- Ground Conditions are set out at section 3.1 on p3-1 to 3-3. Most risks are currently 'significant' with a few 'trivial'

- "In simple terms, the angle of repose of the material is around 32 degrees so many of these slopes have only marginal stability and rely on apparent cohesion. To improve this situation requires either an improvement in strength, a reconfigured slope or reduced water ingress. Similarly the slopes above the road are cut steep and therefore also rely on apparent cohesion, which makes them susceptible to soil creep and landslip on wetting." p3-5

1.6 In summary, the slope has no firm foundations above river level, is over steep in a several locations, is susceptible to erosion at the base and relies on cohesion for stability which is affected by moisture content.

1.7 Oakbank Road is on land currently leased from a local land owner for a period of 99 years which commenced in 1989. It was leased for the purpose of public enjoyment in allowing access along the river bank and includes the north end of the Riverside Park, Cuttleburn steps as well as two viewing platforms, (Cargill's Leap and Salmon Leap) which were constructed in 1991. The public now have a legal right of responsible access to the land through the Land Reform (Scotland) Act 2003, irrespective of the lease.

1.8 The lease places a duty and number of conditions on the Council to maintain the land in good order. Whilst the Council accepts responsibility for routine maintenance, the repairs to the significant damage caused by the landslip are considered to be well beyond routine maintenance. Also in relation to responsibilities under the lease, the exposure of a drainage pipe that was left hanging within the area of the more recent landslip, has raised public speculation that the pipe may have contributed to this by wetting the surface soils. The consultants' report acknowledges there may have been a contribution to the soil wetting from the pipe, but that this cannot be proved. The report indicates the principal cause of the landslip was the steepness of the slope and type of material from which it is formed. In addition, it is not known when the pipe was installed or by whom. Records show that Oakbank Road was previously managed by the Ericht Riverside Improvement Committee, a body of local members and residents. The pipe may have been installed by them in 1981 as part of works identified in correspondence from the time.

1.9 Council officers have met with Local Elected Members and representatives of Blairgowrie Community Council to outline the current situation, the investigation works and officers' conclusions. Council officers have also met with the landowner to provide him with the same information. The Community Council have also been undertaking their own investigations over what remedial measures could be feasible.

2. PROPOSALS

2.1 The Council's consultants have put forward five indicative options for dealing with the landslip. These are made up of one from their original Technical

Note and a further four outline options in their more recent report. In addition, (see section 2.9) an option put forward by the Community Council has been considered. These options are set out together with plans of the area affected and outline drawings in the appendices.

2.2 The construction costs estimated for each of the feasible options are purely for the specific measures at each landslip and would need to be applied to both. The costs are based on the Council's experience of landslips adjacent to a public road where access was less of a problem. In this particular location, there would be significant additional costs for undertaking the works for all of these options. These include haul routes, fencing, site accommodation, working in the river, reinstatement of the access routes on completion and consultants' fees. As a result, all of the options will be technically difficult to construct and will be costly.

2.3 Option 3 is the consultants' preferred option as it replaces the material that has been washed out and provides some protection to the base of the slope from further erosion. The impact on the Riverside Park would be considerable as in excess of 1,000 tonnes of material would require to be brought in for each landslip. The 2012 landslip can be reached from the park, but the 2011 landslip has been cut off by the later landslip. It is very unlikely that material could be brought in from the Lornty Road on the other side. There would also be difficulties and costs with access due to tree cover, the repair of failing retaining walls at the edge of the road and there is no existing vehicular access below the Oakbank Road. This would mean construction and access within the River Ericht itself which is designated under the European Water Framework Directive. In addition, gabion baskets placed close to the river's edge are unlikely to meet with SEPA's approval. Notwithstanding these technical and regulatory issues, the total cost of Option 3 for each landslip is likely to be:

<u>2012 Landslip Area</u>

- £100,000 as shown in section 2.6 + £50,000 to stabilise crest of slope
- Repair retaining wall at foot & tie in gabions £50,000
- Accommodation & mitigation through park £50,000

Sub-total: £250,000

<u>2011 Landslip Area</u>

- £100,000 as shown in section 2.6
- Repair retaining wall at crest of slope £100,000
- Removing trees from slope £15,000
- Providing temporary access road below Oakbank Rd. £50,000

Sub- total: £265,000

- Consultants' fees for design & contract management £130k

Total estimated cost: £645,000

2.4 Given the nature of the ground and location in a river valley, there is no guarantee that any of the options, including Option 3, would provide a long term solution. It is inevitable that these and other areas of ground above and

below the Oakbank Road along its length will be susceptible to further landslips. These will occur in response to prevailing weather conditions, the timing and frequency of which are impossible to predict. It has been estimated that the cost of trying to protect the whole of the unstable slope by extending the measures set out above would be in excess of £2.3 million. Furthermore, these may not be technically feasible and would potentially have a very detrimental effect on the visual and ecological value of the river corridor. On this basis, repair of the landslips is not considered feasible and as such, there are four options for maintaining public access on routes around Oakbank Road:

Option 1

2.5 Continue with the closure and current diversion which is the option with the lowest risk to the Council and maintains access to a reasonable level. However, it is only suitable for able bodied access. There is the possibility that closure fencing may be vandalised or damaged, which would carry a level of risk for the Council, either under the lease or as the access authority. The works involved in improving an alternative access are estimated at around £3,000.

Option 2

2.6 Improve the informal 'desire line' route created through use by the public, immediately above the road. This route is rough and not well defined but it is usable with care by the able-bodied only. It has been used by the public for many years which they are entitled to do through statutory access rights. However, the slope on which this route sits is also not stable and any works to improve it would be difficult to implement and could further destabilise the slope. Any improvements would only make the surface smoother. It would not make it accessible to all because of the steps.

Option 3

2.7 Provide a new alternative parallel route above Oakbank Road. As with option 2, this would not address the instability of the land underneath. It would require stabilising measures itself and would require agreement to access land owned by the landlord and an adjacent owner. This option would also be difficult to construct due to very limited access for construction machinery and materials.

Option 4

2.8 To partially re-open the road on a "risk based approach" as set out in the consultants' Options Report. This would require fencing restrictions, minor works to reduce run-off, signage to inform the public of the risk and regular monitoring. In addition, sections of existing retaining wall along the route would also need to be repaired at a considerable cost. Restriction fencing could be installed without affecting the stability of the remaining slope and would leave a path 1.2m wide next to the landslip. The total cost of these

works would be in excess of £100,000. Monitoring the landslip would require a suitably qualified person to undertake recorded, regular inspections. These would need to be monthly for at least 3 months initially, reducing to every two months or quarterly thereafter. An engineer would also need to ensure the correct inspection and recording methods and procedures were established and attend on a less frequent basis or after the road had been subject to severe weather conditions. This would be needed for as long as the route was to remain open. The frequency of inspections requires an unsustainable level of resource. It also leaves the Council and public exposed to the risk of potential further unforeseeable landslips at any time. The Council have obligations under the Health and Safety at Work Act to ensure the health and safety of its employees, and those affected by its actions. It is considered a risk to allow the public access and to direct Council employees or consultants to undertake monitoring activities in a situation where there is a likelihood of further landslips.

Community Council Option

2.9 Council officers and elected members have met with representatives at the Community Council to discuss all aspects of the landslip. The Community Council suggested an alternative option of using a temporary light weight bridge to span the 2012 landslip and this suggestion was repeated at the most recent meeting with the Community Council on 28 October 2014, when they proposed one such type of bridge at a cost of £15,000 (excluding erection costs). This would provide some protection to the public along the edge of the landslip. However the bridge would require construction of concrete footings which would either need to sit on the unstable ground either side of the landslip, or be deep enough to reach the bed rock at road level. These construction operations could further destabilise the slope themselves and would not address the inherently unstable ground conditions. As such, the risk of slope failure, both above and below the Oakbank Road, and risk to the public and bridge would remain. In addition, the regular inspection set out in Option 4 above and inspections of the bridge itself would also be needed.

2.10 The only realistic option is Option 1. It is fully acknowledged that this means that the affected section of Oakbank Road will no longer be provided by the Council for public access.

3. CONCLUSION AND RECOMMENDATIONS

3.1 The permanent closure of the Oakbank Road for pedestrians is not undertaken lightly and the consequential loss of this recreational route is of considerable concern to the Council and public. Public safety, however, is paramount and the Council must ensure this is the overriding priority in this case. Every effort will be made to ensure the alternative route is as accessible and well signed as possible.

3.2 Given the long term instability of the whole river embankment in this area together with the technical and regulatory difficulties and high cost of repairs, estimated at over £600,000, the Committee is asked to agree that:

(i) Undertaking a permanent repair to the areas of landslip and that the risk of further landslips in the area, is too great to sustain safe public access along Oakbank Road.

(ii) Partially re-opening Oakbank Road for pedestrian use carries too many risks, as well as costs.

(iii) Option 1 is the only realistic option, creating an alternative core path route around the landslips at the side of the Cuttle Burn Den and the alternative narrow link path between Oakbank Road and Lornty Road, estimated at £3,000.

(iv) The Council will continue to maintain assets on the leased land which are of value to the wider public. This includes both viewpoints and the steps at the north end of the Riverside Park.

(v) The issues relating to the lease should be referred to the Head of Legal Services, with a report to be submitted to a future Property Sub Committee.

(vi) Further engagement with the community will remain ongoing.

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ANNEX

1. IMPLICATIONS, ASSESSMENTS, CONSULTATION AND COMMUNICATION

Strategic Implications	**Yes / None**
Community Plan / Single Outcome Agreement	**None**
Corporate Plan	**None**
Resource Implications	
Financial	**Yes**
Workforce	**None**
Asset Management (land, property, IST)	**Yes**
Assessments	
Equality Impact Assessment	**Yes**
Strategic Environmental Assessment	**None**
Sustainability (community, economic, environmental)	**Yes**
Legal and Governance	**Yes**
Risk	**Yes**
Consultation	
Internal	**Yes**
External	**None**
Communication	
Communications Plan	**Yes**

1. Strategic Implications

Community Plan / Single Outcome Agreement

1.1 The proposals relate to the delivery of the Perth and Kinross Community Plan/Single Outcome Agreement by ensuring safe alternative access is maintained for the general public.

Corporate Plan

1.2 The Council's Corporate Plan 2013 – 2018 lays out five outcome focussed strategic objectives which provide clear strategic direction, inform decisions at a corporate and service level and shape resources allocation. They are as follows:

i. Giving every child the best start in life;
ii. Developing educated, responsible and informed citizens;
iii. Promoting a prosperous, inclusive and sustainable economy;
iv. Supporting people to lead independent, healthy and active lives; and
v. Creating a safe and sustainable place for future generations.

1.3 This report contributes to Objective (v).

2. Resource Implications

Financial

2.1 The cost of over £600,000 to fully repair the landslips, road and existing retaining walls is considered too great given the long term instability of the land in this area. Even to temporarily reopen the existing road would require strengthening the collapsing retaining wall, repairing the remainder of the wall, providing the temporary fencing and signage and other minor works which is estimated to cost at least £100,000. A temporary opening would also require regular inspection of the condition of the landslip which is also unbudgeted and unsustainable and does not adequately protect the public and Council from the risk.

2.2 The costs to create the alternative core path route have not been fully identified but are likely to be relatively minor (estimated at £3,000) and will be accommodated within existing maintenance budgets within The Environment Service.

2.3 In the event that the Council withdraws from the lease, it could agree limited reasonable repair works with the landlord. The costs for this would need to be considered as part of that process and budgets identified as appropriate.

Workforce

2.4 The proposals in this report have no workforce implications for the Council.

Asset Management (land, property, IT)

2.5 The proposals in this report has direct land and property implications. The Depute Director (Environment) and Head of Legal Services has been consulted, and has indicated agreement with the proposals.

3. Assessments

Equality Impact Assessment

3.1 Under the Equality Act 2010, the Council is required to eliminate discrimination, advance equality of opportunity, and foster good relations between equality groups. Carrying out Equality Impact Assessments for plans and policies allows the Council to demonstrate that it is meeting these duties.

3.2 The function, policy, procedure or strategy presented in this report was considered under the Corporate Equalities Impact Assessment process (EqIA) with the following outcome:

Assessed as **relevant** and the following negative outcomes expected following implementation:

- Loss of access north of the Riverside Park to all but the able bodied.

Strategic Environmental Assessment

3.3 The Environmental Assessment (Scotland) Act 2005 places a duty on the Council to identify and assess the environmental consequences of its proposals.

- The matters presented in this report were considered under the Environmental Assessment (Scotland) Act 2005 and no further action is required as it does not qualify as a PPS as defined by the Act and is therefore exempt.

Sustainability

3.4 Under the provisions of the Local Government in Scotland Act 2003 the Council has to discharge its duties in a way which contributes to the achievement of sustainable development. In terms of the Climate Change Act, the Council has a general duty to demonstrate its commitment to sustainability and the community, environmental and economic impacts of its actions.

3.5 The proposals have been assessed in terms of the requirements to manage the Council's Greenspace assets in a sustainable long term way. Closing the existing route on Oakbank Road an improving the alternative routes as far as possible is considered a sustainable use of resources.

Legal and Governance

3.6 The Head of Legal Services has been consulted. The proposals require the Council to negotiate to end the lease for the area of land in question.

Risk

3.7 There is a risk that the public and land owner will not accept the permanent closure of the route and this will be managed through a consultation plan.

4. Consultation

Internal

4.1 The Head of Legal Services, the Head of Democratic Services and the Head of Finance have been consulted in the preparation of this report.

External

4.2 The landowner and Community Council were consulted during the preparation of this report.

5. Communication

5.1 An ‘FAQ’ document will be prepared outlining the community’s concerns about the landslip and providing robust answers to the questions they are raising. It is also intended that officers will meet with representatives of Blairgowrie Community Council to outline the Council’s position and answer questions. Negotiations will be undertaken with the landowner in relation to issues connected with the termination of the lease.

2. BACKGROUND PAPERS

None

3. APPENDICES

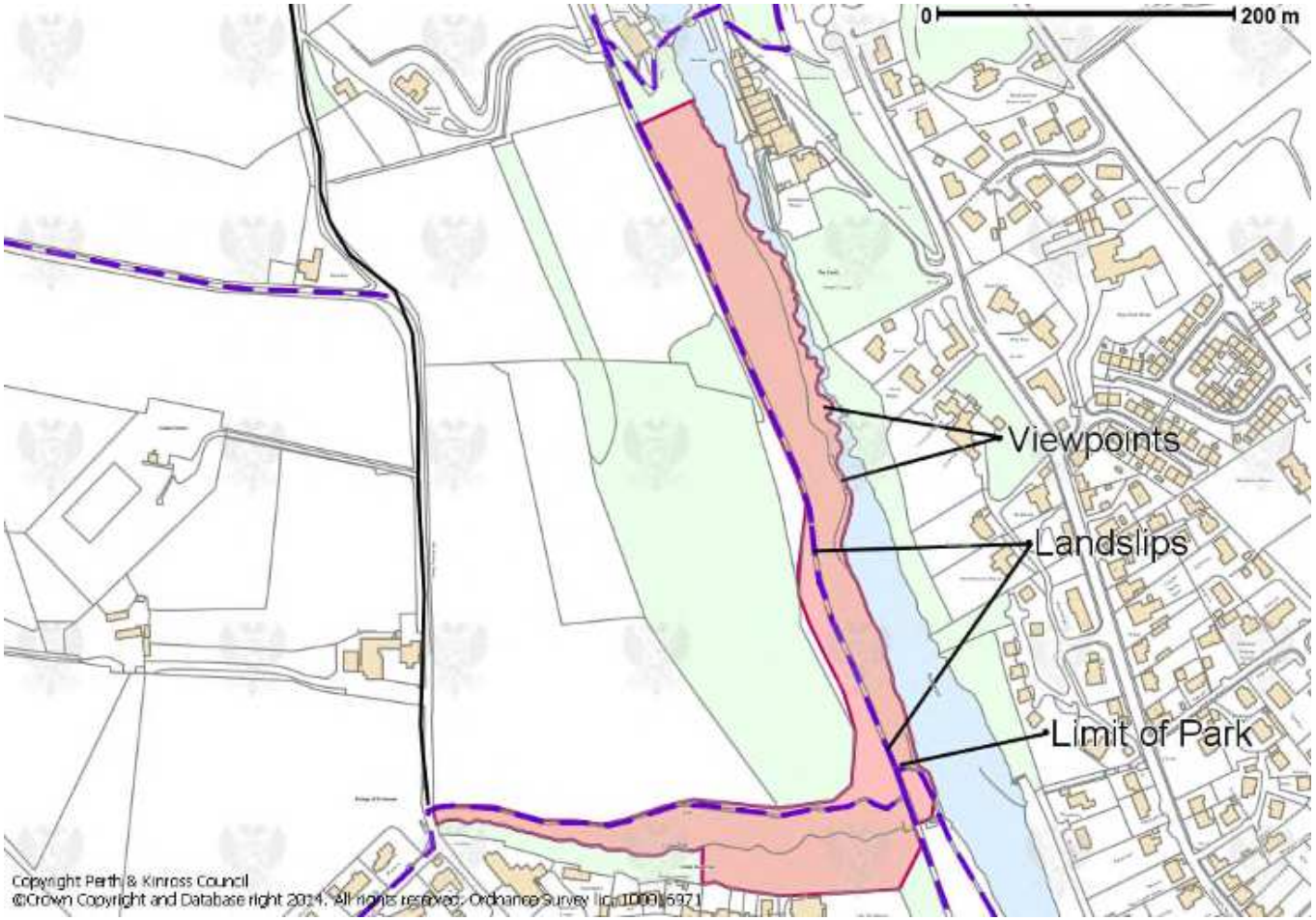
Appendix 1 – Plan 1. Oakbank Road and Core Paths
Appendix 2 – 2012 Landslip Damage
Appendix 3 – Plan 2 - Oakbank Road Leased Land and Infrastructure
Appendix 4 – Copy of Consultant’s Options Report
Appendix 5 - Bedrock and Sections of Retaining Wall on Leased Land
Appendix 6 - Stabilisation Option
Appendix 7 – Map of Alternative Site

Plan 1. Oakbank Road and Core Paths

Appendix 2

2012 Landslip Damage

Appendix 3



Plan 2. - Oakbank Road Leased Land and Infrastructure

Appendix 4

Landslip Options Report

Blairgowrie Riverside

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Prepared for

Perth & Kinross Council

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Document history

Landslide Options Report
Blairgowrie Riverside
Perth & Kinross Council

This document has been issued and amended as follows:

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1	14/03/14	For Issue	G.Barton	A.Morgan	G Barton

Contents

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SECTION 1

Introduction

1.1 Background to Report

Oakbank Road in Blairgowrie is an unmade access track leading from the Riverside Park on Mill Street up the west bank of the River Ericht (see Figure 1). The road is not adopted, but is a busy route on the core paths network and is an important link from the town to the Cateran Trail. It provides access to the viewing platform at Cargill's Leap and is a popular part of the local path network.

In 2011, Perth & Kinross Council reported movement of the slope below the road with partial failure of a retaining wall. A proposal to investigate this landslip incident was included in Halcrows 'Proposal for WP H118 – Blairgowrie Riverside' in July 2012 (identified as Area 5). This item was excluded from the Instruction received from Perth & Kinross Council at that time (letter dated 25 July 2012) and other than an initial site walkover, this incident was not investigated further.

In 2012, Perth & Kinross Council reported further movement of the slope below the road. Following a period of sustained heavy rain, up to 1.3m was lost from the edge of Oakbank Road, some 125m south of the previous incident. Following a site walkover on 17 May 2013 with Alistair Godfrey of Perth & Kinross Council, a preliminary geotechnical review was carried out and recommendations made for further investigation (Technical Note dated 17 July 2013 refers).

The two sections of road affected by landslip were fenced off to protect the public from further land slip incidents. The 2011 landslip, the 2012 landslip and the section of slope between these were all then incorporated within 'Brief Update WP H118 (Change Order No 1) – Blairgowrie Riverside', now known as 'Oakbank Road - Extended Area 5'. This Brief identified the following work items:

- A plan identifying the borehole locations.
- The contractor's cost for the boreholes shall be presented to the client for approval before the start of work and the cost of the topographical survey.
- The client will be advised of the engineers fees before instructing contractors to proceed.
- The risk of further damage to the road arising from invasive investigation is to be discussed with the contractor before the start of the work, and should this arise the contractor is to advise the Geotechnical Engineer, who shall discuss the issue with the client before the contractor proceeds further.
- The Geotechnical Engineer is to provide the client with a report identifying the options for reinstatement and the results of the borehole data and a topographical survey. This shall contain:

  (a) Plans identifying the exact locations of structures, excavations, drainage or any other work identified as an option.
  (b) The rationale for each option eg why intercepting potential failure surfaces at the crest of the slope on its own might be successful. These should relate to similar problems experienced elsewhere in Perth & Kinross, such as Glen Goulandie and the Sma' Glen. The report shall provide a life expectancy for each option and identify if further measures might be required during this period.
  (c) Options for an alternative route above the Oakbank Road as outlined in the Geotechnical Engineer's report of 17th July are to be included in the further report.
  (d) An assessment of the access routes required for the options and protective measures for land over which they will be taken.
  (e) Estimates for each option broken down into quantities, construction costs, accommodation work costs and engineers' fees.

Halcrow supplied a proposal on 03 Sep 13 that satisfied this brief, by outlining a staged approach to the investigation, reporting and design of remedial works. It was proposed that investigation works be co-ordinated with those required for Cuttle Burn Improvement. A more limited scope was then sought by Perth & Kinross Council and a further proposal dated 26 Sep 13 offered three options; Option 2 being accepted on 22 Oct 13 (Purchase Order 113203256 refers). Under this option, Halcrow was 'to carry out

the absolute minimum analysis of ground investigation data and assessment of options' and then 'informed by the GI the Options Report is to cover:

- A discussion of the issues and likely causes
- A discussion of potential options for dealing with the issues
- Outline cost estimates for the above options
- A recommendation of the option that should be taken forward.'

1.2 Information Available

1.2.1 Desk Study

The British Geological Survey map has been inspected (sheet 56W, scale 1:50,000 solid and drift editions), which shows the site to be underlain by alluvial river terrace deposits comprising silt, sand and gravel of Quaternary age. This is underlain by dull reddish brown, cross bedded sandstone with beds of conglomerate, being part of the Tannadice Sandstone Member of Lower Devonian age.

Technical Note dated 17 July 2013 recorded the following:

> 'A search of the BGS website revealed that there are no available historical boreholes within the vicinity of the site. The client has provided a report from the ground investigation at Blairgowrie Visitor Centre and whilst this provides some background information, the ground information is deemed too distant from the slope failure to be of any use in the design of a solution.'

Boreholes from that investigation recorded the following materials to be present alongside the river:

- Made Ground. Very loose to medium dense silty sand.
- Glacial Deposits. Stiff to very stiff slightly sandy slightly gravelly CLAY with low cobble content.
- Bedrock. Medium strong thickly bedded CONGLOMERATE interbedded with SANDSTONE.

Instruction was not received for carrying out a full desk study and so the following information is not currently available for this site:

- Aerial photos - Perth and Kinross Council provided a photo dating from 1944 of Blairgowrie Mill, located some distance downstream of the site.
- Historical Maps – only maps freely available on the web have been reviewed.
- Archaeological and Historical investigations.
- Records of Mines and Mineral Deposits.
- Land Use and Soil Survey Information.
- Contaminated land records.
- Hydrogeological information.
- Hydrological information.
- Consultation with statutory bodies and agencies.
- Flood records.
- Information on outfalls and discharge licenses.
- Services search.

1.2.2 Site Walkover

A site visit was carried out on 17th May 2013 during which the slopes were inspected and a Technical Note dated 17 July 2013 recorded the following:

> ***The 2012 Landslip***
> *'A severe landslip occurred in December 2012 following a sustained period of heavy rain. At the failed section the slope height is typically 10.5m. The toe of the slope is retained by a stone wall which varies in height from 1.0-3.5m. The width of the failed section was measured as 19m at the top of slope and 20m at the foot of the slope. The depth of the failure is typically 1m. Upon visual inspection the slope appeared to*

comprise 0.2m of topsoil underlain by brown gravelly slightly clayey SAND. The sand layer extends at least to the underside of the failed section, although its total extent is unknown.

Since the original failure in December 2012, the client has reported continued erosion at the edge of Oakbank Road. In addition there has been movement and loss of stonework in a retaining wall at the foot of the slope. As such, this section of Oakbank Road has been fenced off to exclude the public from accessing the site.'

The 2011 Landslip
'This section is north of the latest incident. It is understood that superficial slope movements have occurred in this section since October 2011. Partial failure of a retaining wall has been noted. A tension scar has been noted within the footpath above this slope.

Again, this section of path has been fenced off to exclude the public. In addition, a wooden fence has been locally erected at the crest of the slope in the area of known movement.

During the inspection, ground conditions could not be assessed. At the foot of both slopes, bedrock is present at river bed level, as evidenced during the inspection.'

1.2.3 Topographic Survey

Topographic survey was carried out by 'Douglas Land Surveys Ltd' on 13 November 2013. The information was supplied in hard copy and digital 2-D and 3-D AutoCad DXF and PDF format. This was accompanied by a photo presentation comprising 12No site photos and a photo location diagram.

The base plan is presented as Figure 2.

1.2.4 Field Mapping

Field mapping has been carried out and the findings are outlined in Figure 2.

1.2.5 Ground Investigation

Ground investigation was carried out by Raeburn Drilling and Geotechnical Ltd between 13 and 23 January 2014. The objective was to gain a greater understanding of the site and to provide geotechnical information to better determine the current ground conditions. The investigation was to:

- Provide information on the extent and nature of the drift deposits;
- Prove depth to rockhead, establish nature and weathering profile of bedrock;
- Provide geotechnical parameters for slope stability assessment and possible design solution options.

The investigation comprised the following:

- 3No cable percussion boreholes with rotary core follow on drilling;
- 7No mechanically excavated trial pits (the Cuttle Burn Culvert Investigation);
- In situ testing and groundwater monitoring within exploratory holes;
- Laboratory testing of soil and rock to determine geotechnical parameters;
- Preparation of a Factual Report and AGS file.

A copy of the Factual Report was issued on 28 February 2014.

SECTION 2

Site Conditions

2.1 Site Description

Oakbank Road is an unmade access track leading from a Riverside Park, along the west bank of the River Ericht and through to Lornty. The east bank of the river is wooded with properties on the elevated slopes off Balmoral Road.

The **River Ericht** flows north to south from the Keith at Lornty, where it spills through a narrow rock channel known as Cargills Leap. The river widens to the west bank to present a relatively straight 30m wide channel down to Cuttle Burn. At low flow, bedrock outcrops as a series of ridges across the river bed, with water tumbling over and around. When in spate the river flow is likely to be turbulent with potential for erosion. Historical Plans show a weir used to exist across the river in the south of the site, immediately upstream of Cuttle Burn (1865 Plan). A sluice fed impounded water into a lade (Mill Inch). Cuttle Burn presumably used to outfall to this lade, which fed a flax mill to the south (Meikle Mill). The weir is now absent and the lade infilled, but a rough masonry wall that recently collapsed alongside the 2012 Landslip (see below) is likely to be a relic of this period.

The west bank between Cargills Leap and Cuttle Burn, presents high wooded slopes rising above the river. This appears to be a natural river terrace; **Oakbank Road** being constructed by cutting mid-slope through this terrace. The track is evident on the 1865 Plan along much the same alignment as the current day. The track is some 5m wide with a central crown shedding runoff to either side with a shallow ditch on sections of the upslope edge. The road runs beneath a canopy of trees and the outer edges are silted; the few vehicle movements that there have been remain within the central 2.5m. The elevation of the track reduces north to south from 70.5mOD at the steps to Cargills Leap, some 14m above the river, to 65.5mOD at the steps near Cuttle Burn, being some 10m above the river (see Figure 2).

Numerous areas of slope creep and landslip are evident on the steep flanks of this river terrace between Cargills Leap and Cuttle Burn. The main features are located on Figure 2 and these are summarised below:

The 2011 Landslip is a section where the track is retained by a rough masonry wall, some 1m high, part of which has tumbled away (see Plate I). The inference would be that a shallow natural embayment was infilled when the track was constructed. This embayment does not appear to have been a channel eroded by runoff from the higher ground to the west and so was probably produced by the river undercutting the toe of slope. The resulting slope face is currently at 1 in 1.5 (35^0) and is likely to have only marginal stability and be susceptible to soil creep. The slope is now heavily vegetated and it is not clear whether the wall collapsed due to general dilapidation of the wall itself, ingress of surface water from the road loosening blocks, or loss of support due to soil creep and landslip. A section of wall remains but it is likely to tumble at some point. The road is some 14m above the River Ericht (70mOD). Borehole 2 was located on the road to investigate ground conditions at this landslip.

The Slope between the two identified landslips can be characterised as two bluffs (north and south) and a large embayment between them (see Figure 2). The north bluff presents a relatively wide platform alongside the track and a heavily vegetated steep face directly above the river. The toe of this slope is over-steep due to erosion by the river and will have only marginal stability. The large embayment between the two bluffs also presents a heavily vegetated steep upper slope at 1 in 1.3 (37^0), but this is offset from the river behind a lower slope of lesser gradient, being 1 in 2 (26^0). It can be conjectured that this feature represents a relic landslip with debris removed by the river. Borehole 1 was located on the road to investigate ground conditions. The south bluff also presents a relatively wide platform alongside the track and a

heavily vegetated steep face directly above the river. This slope is over-steep due to erosion by the river and contains several minor landslip features. The outer slope will have only marginal stability.

The 2012 Landslip measures some 19m at the crest of slope where it has encroached into the edge of road and has removed the road verge (see Plate IV). A similar width, some 21m, is evident at the toe of slope where debris has spilled out and over a low wall into the river (see Plate V).

This is a shallow translational failure with some characteristics of debris flow that has spilled a slab of soil off the slope face and into the river. Coincidentally there is a scar in the slope above the road directly behind this landslip (see Plate VI). Consideration has been given to this being part of a more deep seated landslip with the observed failure being a secondary collapse of an over-steepened toe. However, the absence of lateral tears across the road to connect the two areas suggests that these features are unrelated. The depth of observed landslip is self evident as the steepness of the slope has resulted in the 'slip bowl' being fully evacuated to expose in-situ material. The exposed face is approaching 1 in 1 (42^0) in the upper slope and 1 in 2 (27^0) in the lower slope.

Road construction is exposed at the crest of slope, along with a flexible drainage pipe located centrally within the backscar. The drainage pipe protrudes some 2m and presumably collected runoff from the shallow ditch on the upslope side of the road and discharged this to the slope. This would be a contributory factor in wetting up the surface soils at periods of heavy rainfall. A cluster of cobbles is also evident at the north end which may also have been a contributory factor in wetting up the soils. It is notable that large trees appear to be absent from the debris at the toe of slope, which suggests that soil creep has been ongoing in this slope for many years. The exposed soil face along the north edge of the landslip is informative (see Plate IV) in that it records the depth of landslip, typically 1.5m; the material type, being a clayey silty sand and gravel; and an over-steepened lower slope where river erosion and landslip has removed the toe of slope. This would be a key preparatory factor in the landslip incident that was observed in December 2012, this in combination with wetting up of the materials in a period of heavy rainfall. It is possible that surface water runoff along Oakbank Road also washed down this slope face but this is not known.

In addition to the above, we understand that a wall some 15m south of the 2012 landslip collapsed at around the same time (see Plate VII). This is some 1.5m in height and carries a narrow footpath below a wooded area and alongside the river bank. It is believed to have been constructed around the same time as the weir/ sluice/ mill lade structures. It may be that the landslide impacted directly on the wall further along, which caused vibration and collapse of this vulnerable section of masonry, but other than that the two incidents appear to be unrelated.

Two further landslips of note, which are south of the steps and therefore outwith our current brief are:

- Road embankment containing Cuttle Burn Culvert that collapsed when the culvert blocked and water over-topped the embankment. This got remediated prior to 2011 (Plate VIII).
- Road embankment above the grassed amenity area, identified as Area 3 in 'Brief for WP H118 – Blairgowrie Riverside'. Proposals have been made for remediating this section of embankment.

Both of the above indicate the susceptibility of material to erosion and landslip on wetting up. Numerous areas of slope creep and landslip are also evident on the steep slopes above the road between Cargills Leap and Cuttle Burn. The main features are identified on Figure 2 and summarised below:

'Relic Landslip bowl' located above the road immediately north of Cuttle Burn. This could be simply a 'borrow area' for embankment fill associated with construction of Oakbank Road, however, it is notable that this feature is absent from the banking shown on the 1865 and 1900 Plan. This suggests that it post

dates construction of the road. Nothing further is known about this feature other than to note that the wall that recently collapsed at the riverside retains this section of slope.

The cutting slope above the road is in part heavily vegetated and in part sparsely vegetated; the trees on the cutting being noticeably less mature than those on the natural ground above the crest of slope or on the downslope. The height of slope is typically 8.5m, some sections rising to 10.5m. The slope angle is very steep, typically 1 in 1 (45^0). For much of its length this isn't a natural slope and there is evidence that it has been cut too steep, or that the material has weathered and the slope now presents only marginal stability. There are numerous areas of slope creep, where the vegetation has not been able to establish ground cover, or wash down has allowed the lower slope to re-grade itself over time and leave a scar in the upper slope. At some locations only tree roots hold the crest of slope together. The recent history of maintenance and clean up of this section of slope is not known to us. It is clear that runoff can discharge over the crest of slope washing debris onto the track (see Plate III dating from 1991), and that fallen trees have been removed relatively recently.

2.2 Ground Conditions

Ground conditions revealed by ground investigation carried out along Oakbank Road are outlined below.

The 2011 Landslip. Borehole 2 records:

0.9m Made Ground (gravel over slightly clayey gravelly sand)

1.0m Loose, very silty very sandy GRAVEL with low cobble content

12.5m Stiff to very stiff, sandy gravelly CLAY with low cobble content.

14.4mbgl Weak to medium strong CONGLOMERATE

Groundwater was encountered at a depth of 6.25mbgl and rose to 3.75mbgl over a period of 8-days. A standpipe piezometer installed in clay (filter between 3.0 and 4.0m) recorded a water table rising to 3.3mbgl over a period of 4No weeks.

Slope between the two identified landslips. Borehole 1 records:

0.2m Made Ground (gravel)

2.2m Medium dense, very silty very sandy GRAVEL with low cobble content

9.1m Very stiff, sandy gravelly CLAY with low cobble content.

11.5mbgl Weak to strong CONGLOMERATE

Groundwater was encountered at a depth of 5.7mbgl and rose to 5.5mbgl after 20 minutes and 2.4mbgl overnight. A standpipe piezometer installed in bedrock (filter between 12.0 and 18.0m) recorded a water table at 11.4mbgl after a period of 4No weeks.

The 2012 Landslip. Borehole 3 records:

0.5m Made Ground (200mm gravel over 200mm gravelly sand)

8.2m Very stiff, sandy gravelly CLAY with low cobble content.

8.7mbgl Weak to medium strong CONGLOMERATE

Groundwater was not encountered during drilling. A standpipe piezometer installed in clay (filter between 2.5 and 4.5m) also recorded dry over a period of 4No weeks.

The ground conditions encountered by ground investigation are broadly consistent with that predicted by BGS and as encountered downstream at the Blairgowrie Visitor Centre (see Section 1.2.1). For the purposes of this report, the strata is attributed as follows:

- Made Ground (Road Construction/ Embankment Fill);

- River Terrace Deposits (Gravel);
- Glacial Till (Clay);
- Bedrock (Conglomerate).

Material Parameters - Made Ground/ River Terrace Deposits
Particle size distribution determinations typically recorded 16% fines, 20% sand and 64% gravel/cobbles (median of 3No tests). An estimate of the 'critical state angle of shearing resistance for silt-sand-gravel mixes can be obtained following procedures in the British Standard (BS8002:1994). Assuming sub-angular to sub-rounded particles (A=2) and a moderate grading (B=2) an effective shear strength for loose material of $\phi'_{crit} = 34°$ is derived. Where this is sufficiently well compacted to form moderately dense material (C=4), this strength would increase to give an effective angle of internal friction approaching $\phi'_{pk} = 38°$.

Material Parameters - Glacial Till
Particle size distribution determinations typically recorded 42% fines, 20% sand and 38% gravel/cobbles (median of 6No tests) and classify this as a fine deposit. Plasticity index ranged between 12% and 15% with a median of 13%, which would indicate a friction angle of 32 degrees for this material (after Gibson, 1953). Shear box testing was carried out on samples of slightly sandy, very gravelly clay with a bulk density of 2.23Mg/m^3 (BH01/2.5m), 2.13Mg/m^3 (BH02/4.5m) and 2.15Mg/m^3 (BH03/3.5m) and the reported shear strengths is as follows:

- $c' = 11kN/m^2$, $\phi' = 31°$.
  Individual specimens recorded $\phi' = 37°$, $\phi' = 34°$, $\phi' = 33°$.
- $c' = 7kN/m^2$, $\phi' = 29°$.
  Individual specimens recorded $\phi' = 32°$, $\phi' = 32°$, $\phi' = 31°$.
- $c' = 10kN/m^2$, $\phi' = 28°$.
  Individual specimens recorded $\phi' = 34°$, $\phi' = 31°$, $\phi' = 30°$.

The existing profile for this slope frequently approaches 38° (1 in 1.25) and for this to have remained stable over any period of time the slope deposits would need to either have a friction angle in excess of $\phi' = 38°$ or contain an element of cohesion. For the purposes of design analyses it is considered that a cohesion should be introduced to the characteristic effective shear strength giving the following design value:

effective cohesion intercept:	$c' = 5kN/m^2$
effective angle of shearing resistance:	$\phi' = 32°$.

2.3 Back analysis of Landslip

Back analysis of the landslip to verify the ground model and the above parameter selection has not been carried out at this stage.

SECTION 3

Risk Assessment

3.1 Degree of risk

This section presents the Geotechnical Risk Register developed for the site, together with a qualitative approach to risk assessment based on the procedures set out in Managing Geotechnical Risk (2001). In this assessment, the degree of risk is the expected impact of damage, loss or harm from a given hazard under particular circumstances which is expressed as:

Degree of Risk = Likelihood x Effect

The likelihood and the scale of effect is determined using Table 3.1 and 3.2 respectively, which together then provide the degree of risk based on Table 3.3.

The Geotechnical Risk Register is presented here as Table 3.4.

Table 3.1 – Scale of likelihood

Likelihood	Scale
Very likely	4
Likely	3
Unlikely	2
Negligible	1

Table 3.2 – Scale of effect

Effect	Scale
Very high	4
High	3
Low	2
Very low	1

Table 3.3 – Degree of risk

Degree of Risk	Risk Level	Recommended Response
1 to 4	Trivial	None
5 to 8	Significant	Consider attention
9 to 12	Substantial	Attention required
13 to 16	Intolerable	Attention required

Table 3.4 - Possible hazards, associated events, risk determination and overall consequences

Risk No.	Hazard	Risk / undesirable consequence	Risk assessment (Existing)				Practicable mitigation	Risk assessment (After mitigation)			
			L	E	R	Risk level		L	E	R	Risk level
Geotechnical risks											
1	Existing Instability (2011 Landslip and 2012 Landslip)	Injury to General Public from continued instability and deterioration of the slope below the road.	2	3	6	Significant	Implement slope remediation measures.	2	2	4	Trivial
2	Existing Instability (2011 Landslip and 2012 Landslip)	Injury to occupants of vehicles from continued instability below the road.	2	3	6	Significant	Implement slope remediation measures.	2	2	4	Trivial
3	Existing Instability (2011 Landslip and 2012 Landslip)	Continued closure of the Walkway and loss of amenity due to ongoing instability and deterioration of the slope.	3	2	6	Significant	Implement slope remediation measures.	1	2	2	Trivial
4	Existing Instability (2011 Landslip and 2012 Landslip)	Continued closure of the road to vehicles due to ongoing instability and deterioration of the slope.	3	2	6	Significant	Implement slope remediation measures.	1	2	2	Trivial
5	Existing Instability below the road	Injury to General Public from continued instability and deterioration of the slope causing fall of debris/ fall of trees onto riverside path.	2	2	4	Trivial	Stabilise landslip. Remove selected trees.	1	2	2	Trivial
6	Instability below the road	Injury to General Public from new instability and deterioration of the slope below the road.	3	2	6	Significant	Stabilise landslip.	1	2	2	Trivial
7	Instability above the road	Injury to General Public from ongoing instability and deterioration of the slope above the road.	3	2	6	Significant	Stabilise landslip. Remove selected trees	1	2	2	Trivial

Risk No.	Hazard	Risk / undesirable consequence	Risk assessment (Existing)				Practicable mitigation	Risk assessment (After mitigation)			
8	Existing Instability	Further damage to existing trees due to continued instability and deterioration of the slopes.	4	1	4	Trivial	Implement slope remediation measures.	2	1	2	Trivial
9	Existing Instability below the road	Potential damage to the road structure due to instability and deterioration of the slope.	3	2	6	Significant	Stabilise landslip.	2	2	4	Trivial
10	Existing Instability below the road	Potential environmental impact on the River Ericht where debris continues to spill due to deterioration of the slope.	2	2	4	Trivial	Implement slope remediation measures.	2	2	4	Trivial
11	Increased run-off	Increased instability with potential for debris flow.	2	3	6	Significant	Observe surface runoff on slope in periods of heavy rainfall and control.	2	2	4	Trivial
12	Incorrect ground/ groundwater conditions analysed	Remediation solution may not stabilise the slope and further works required at increased cost.	2	2	4	Trivial	Continue monitoring of landslip. Verify ground/ groundwater conditions as part of construction works. Update of design where necessary.	2	2	4	Trivial

3.2 Risk Mitigation Options

Technical Note dated 17 July 2013 proposed the following in relation to remediating the 2012 Landslip:

> *'There has been considerable public concern following closure of the road and questions are being asked about what options there are for re-opening the road. In order to provide the public and the Council with information on what options there might be and an estimate of the cost, the engineer was asked to carry out a visual inspection and advise on the possible options and costs.*
>
> *One possible solution is to simply reinstate the slope to its original profile whilst improving drainage in the vicinity of the slope. Improved drainage would be designed to carry water away from the slope thereby improving stability within the uppermost deposits. Drainage could be improved by upgrades to the existing ditch. This strategy, however, would not prevent future slips from occurring if the failure mode involved deeper slip planes and may therefore only provide a temporary solution.*
>
> *The introduction of gabion baskets into the slope would provide a more robust solution. The purpose of the baskets is to improve slope stability by intercepting potential failure planes whilst retaining a reinstated profile. The baskets would also be utilised to encourage drainage away from vulnerable areas of the slope. The exact position of the baskets cannot be established at present, as this will be determined through slope stability analysis.*
>
> *In addition it is considered that the damaged retaining wall at the foot of the slope could be replaced by gabion baskets which would again provide stability to the toe of the slope and permit drainage outfall to the River Ericht.'*

Recommendations were also made for the slope above the road:

> *'It is considered that the introduction of gabion baskets at the foot of the slope would provide improved stability and prevent superficial slippage of material within the upper slope. It is noted that a drainage ditch exists at the toe of the slope. At present the ditch is clogged, but could be cleaned out, deepened and lined with granular fill. The ditch would be connected to the gabions to encourage drainage form the upper slope, thereby reducing potentially destabilising porewater pressures within the soil skeleton. This measure may reduce destabilising water pressures within the slope.*
>
> *It is considered that the installation of drainage above the slope and improvements within the slope will prevent further excessive movement and increase the overall stability of the slope.'*

Various approaches could be taken to mitigate risk at this site; depending on the available funding and degree of risk that is acceptable. One approach being the 'do minimum option', which is effectively what has been implemented since October 2011. Fencing currently excludes the general public and limits the likely impact of an incident. There would be scope to reduce these restrictions to allow pedestrian access along the road and past the affected areas (the 2011 Landslip and the 2012 Landslip); an alternative path is currently being used on higher ground, above the crest of slope. Vehicle access would be more difficult to secure. Any risk based approach would need to be combined with adequate signs to inform persons of the risk, fencing to restrict access to the head of the landslip, minor works to control runoff and reduce risk of incident, and regular inspection of the condition of slope, which would allow a reactive strategy to be implemented as required. Some slope instability can lessen with time as a more stable configuration is achieved, but more usually a disturbed slope would begin to unravel and deteriorate with time. This is particularly in the situation where water is allowed to discharge to the head of the slope. Ingress of runoff would produce increased likelihood of incident and in particular increased likelihood of the more severe consequences that might affect the General Public. Where the risk

becomes 'substantial' then some form of slope reinstatement measures would still be required (Re-active Strategy).

In simple terms, the angle of repose of the material is around 32^0 so many of these slopes have only marginal stability and rely on apparent cohesion. A designed slope would normally have a factor of safety to account for variability of the materials, surface saturation by rainfall and future fluctuations in groundwater. The natural slopes below the road are formed by erosion and will be approaching the angle of repose and thereby susceptible to soil creep and landslip on wetting up. To improve this situation requires either an improvement in strength, a reconfigured slope or reduced water ingress. Similarly the slopes above the road are cut steep and therefore also rely on apparent cohesion, which makes them susceptible to soil creep and landslip on wetting.

To pro-actively promote stability of a natural slope then one or more of the following measures would normally be adopted, possibly in combination:

- Earthworks to produce a more stable configuration (slope re-grading).
- Ground Treatment to improve the strength of materials in the slope either in-situ or by replacement (dig out and replace).
- Drainage to remove or regulate pore water pressure within the slope (counterfort drainage)
- Strengthened Earthworks to reinforce the ground either insitu (soil nail systems) or by reconstruction (reinforced earth/ gabion baskets).
- Retaining Structure to support the existing or modified slope profile (retaining wall).

Each of these measures has been considered in terms of technical performance, buildability and cost. The earthwork/ground treatment/drainage solutions offer ease of construction and are normally less costly than strengthening and structural solutions. However, at this site the steepness of the natural slopes and proximity to the river restricts the benefit that can be achieved using these techniques.

Dig out and replacement (Figure 3 Option 1) would need to bring in material of better strength than what is currently within the slope. This material is already competent and standing at 38 degrees (1 in 1.25); the dense compaction and inherent cohesion would be difficult to replicate with engineered fill. A more stable configuration with a gradient of say 1 in 2 (Figure 3 Option 2) would take the toe of any new slope out into the river and would require a considerable quantity of fill to be imported. Drainage improvements may be of benefit in that the surface water drainage pipe is suspected as being a contributory factor in the 2012 Landslip but the underlying problem is that the slope is too steep for the given material strength and in the long term, this couldn't be addressed by drainage alone. The alternative of strengthened earthworks/ retaining structures can provide much reduced technical risk but at significantly more cost.

As outlined in the previous Technical Note, gabion baskets retaining a modified slope (Figure 3 Option 3) could potentially offer a cost effective solution. The height of gabion baskets located at the toe of slope is controlled by the requirement to limit the retained slope to a particular gradient. Buildability issues present a significant constraint to this solution at both the 2011 Landslip and the 2012 Landslip, and therefore would impact on cost. The gabion basket would be sufficiently robust to prevent erosion by the River Ericht but is potentially susceptible to vandalism at this location.

Previous schemes for Perth & Kinross Council have adopted an alternative strategy of isolating the road from the landslip, rather than seeking to stabilise the landslip itself (Figure 3 Option 4). At Glengoulande a concrete wall was piled to bedrock and the B846 reconstructed above this. At Sma Glen gabion baskets were buried at the crest of slope to secure the A822. Potentially this solution would simplify the temporary works at this site, reduce the quantity of backfill material being brought to site, and minimise the visible height of structure thereby making it less susceptible to vandalism. By not stabilising the landslip, however, there would remain a risk presented to users of the riverside footpath and a potential for continued loss of material into the river in the long term.

An assessment of the advantages and disadvantages attendant with the most effective options is summarised in Table 3.5. Analysis and design of the various options has not been carried out.

Table 3.5 – Risk Mitigation Options

Landslide Management Options	Advantages	Disadvantages
Do minimum: Inspections (biannually)	Minimal capital cost to client Provides warning of any major deterioration, allowing for pro-active management to be planned and implemented Provides appropriate evidence to support remediation work proposals in scheme Value Management	Does not address the underlying damage done to the site or allow opening of the road to vehicles. Slope expected to deteriorate in the long term with consequence to the road. Closure of the road may result from any rapid deterioration which may require unplanned emergency work
Dig out and replacement with rock	Material removed and slope reconstruction secures the slope and the road.	Requires more excavation of material with potential to de-stabilise hillside during construction. Requires disposal and import of material, increasing cost, project time and disruption to traffic in Blairgowrie. Potential for river to de-stabilise the toe of rock slope.
Re-grade slope to a 1v:2h profile	Slope reconstruction secures the slope and the road. Minimal excavation of material thereby reducing potential de-stabilising effect on the overall hillside Minimal export of material	Requires temporary access for plant onto the slope, which is difficult. Significant import of material. Drains to be installed in the lower slope, keeping the water table at least 500mm below ground level for this solution to be stable.
Installation of retaining wall at riverside	Provides protection against river erosion and more stability than re-grade or dig out. Slope reconstruction secures the slope and the road.	As above Requires sourcing and import of materials (gabion stone) Increased works time with associated costs.
Installation of retaining wall at road	Access readily available. Provides more stability than earthworks options Secures the road	As above Specialist construction giving added construction time and costs.

SECTION 4

Design proposals

4.1 Outline Cost Estimate

The various design options have not been analysed or designed at this stage. The following have been identified as providing solutions appropriate to mitigate risk at this site:

- Fencing, signing and landslip management.
- Slope reconstruction with gabion baskets to protect the toe of slope.
- Installation of a retaining wall (piled concrete) to isolate the affected section of road.
- Installation of a retaining wall (gabion baskets) to isolate the affected section of road.

Outline construction costs for remediating Oakbank Road, based on recent experience of similar works within Perth and Kinross are as follows:

2011 Landslip

- £100k to backfill a gabion wall at the toe of slope
- £200k to provide a concrete retaining wall with piled foundation at the crest of slope.
- £50k to construct a buried gabion at the crest of slope.

2012 Landslip

- £100k to backfill a gabion wall at the toe of slope
- £200k to provide a concrete retaining wall with piled foundation at the crest of slope.
- £50k to construct a buried gabion at the crest of slope.

4.2 Preferred Option for Remediation

The preferred scheme would be slope reconstruction with a gabion wall to protect the toe of slope against river erosion along with planting appropriate for the woodland setting.

4.3 Recommendations for Further Work.

Work items identified by Perth & Kinross under 'Brief Update WP H118 (Change Order No 1) – Blairgowrie Riverside, Oakbank Road, Extended Area 5' have not been fully addressed here as the Brief was subsequently modified to meet budgetary constraints. The following reconciles that Brief with the work carried out to date to identify outstanding work items:

a) Plans identifying the exact locations of structures, excavations, drainage or any other work identified as an option.

The modified brief provides for 'a discussion of potential options for dealing with the issues' and those are outlined in Figure 3. A detailed design has not been carried out at this stage.

b) The rationale for each option eg why intercepting potential failure surfaces at the crest of the slope on its own might be successful. These should relate to similar problems experienced elsewhere in Perth & Kinross, such as Glen Goulandie and the Sma' Glen. The report shall provide a life expectancy for each option and identify if further measures might be required during this period.

The rationale behind each option is discussed here in Section 3.2.

c) Options for an alternative route above the Oakbank Road as outlined in the Geotechnical Engineer's report of 17th July are to be included in the further report.

The current study promotes use of the existing Oakbank Road for pedestrian access and developing alternative routes for pedestrians and vehicles has not been considered further in this report.

d) An assessment of the access routes required for the options and protective measures for land over which they will be taken.

Access to the site is readily available along Oakbank Road. Access within the site is difficult and specific buildability issues are outwith the current brief. This will be addressed under detailed design.

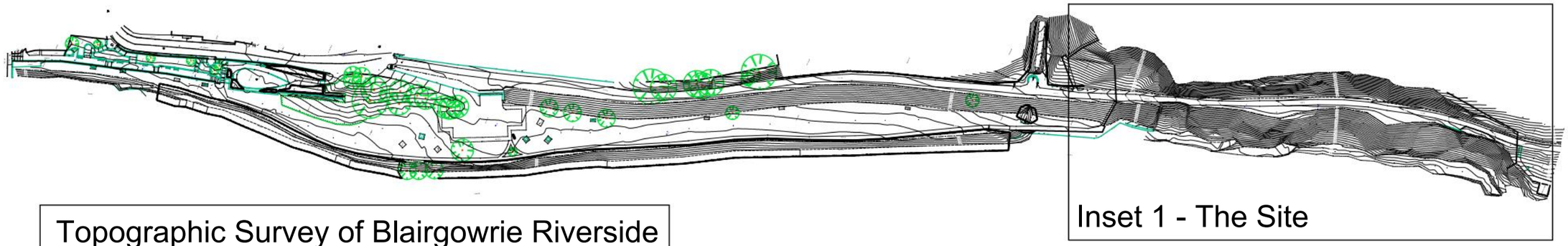
e) Estimates for each option broken down into quantities, construction costs, accommodation work costs and engineers' fees.

Our modified brief provides for 'outline cost estimates for the potential options' and these are presented in Section 4.2. More detailed estimates would be provided under Detailed Design.

SECTION 5

Figures

Figure 1 - Site Location

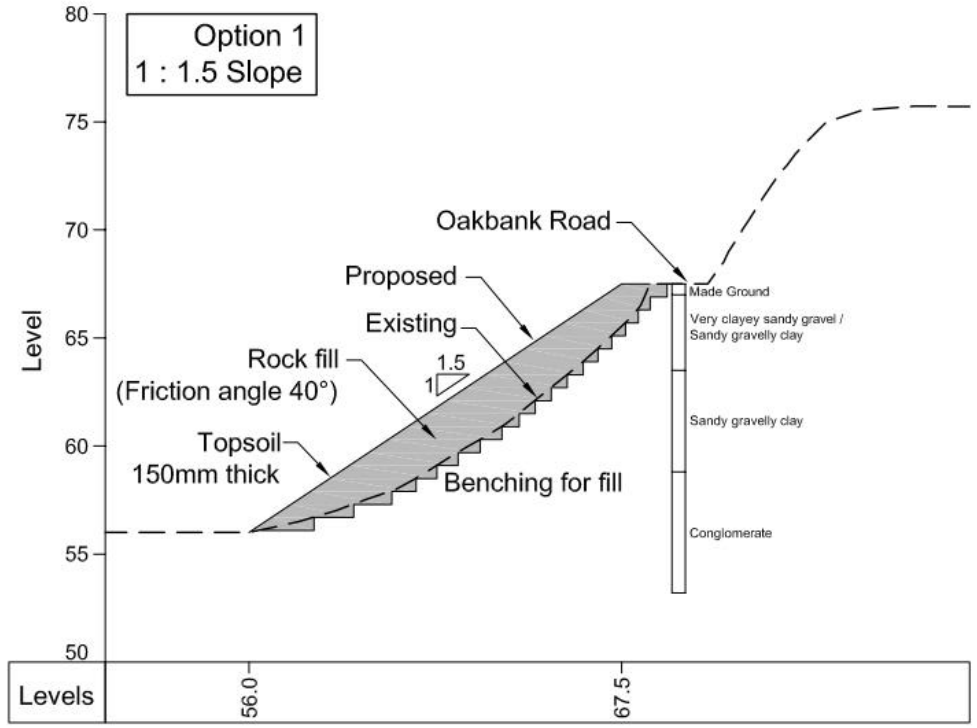


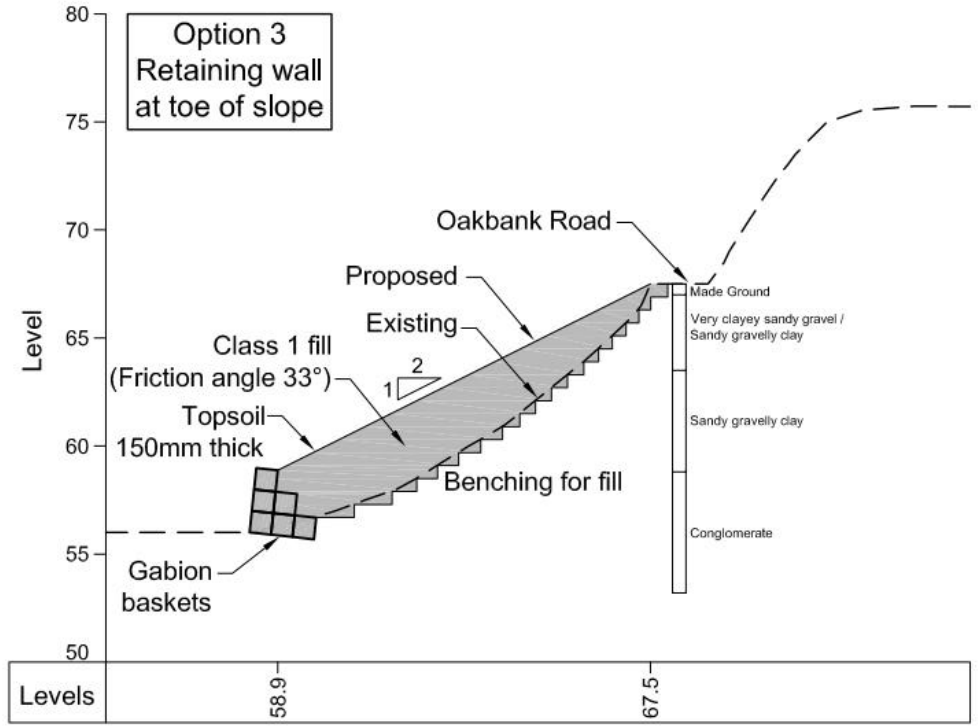
Topographic Survey of Blairgowrie Riverside

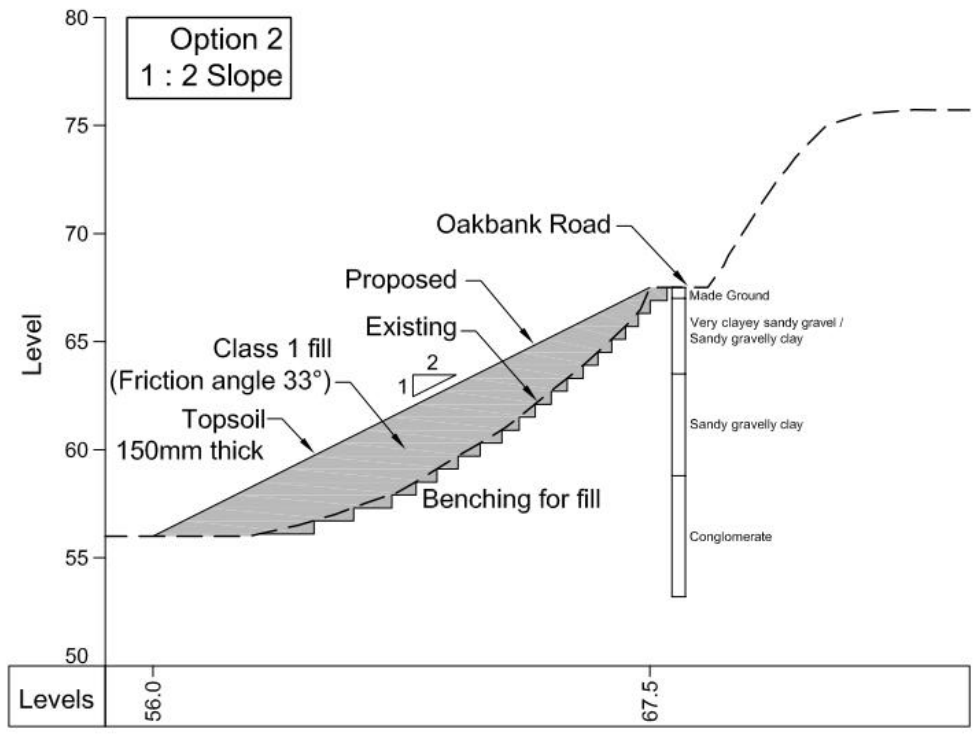
Inset 1 - The Site

Cuttle Burn Culvert
Steps North of Cuttle Burn
Large embayment (Relict landslip)
Section Line See Figure 3
South Bluff (Wide platform)
Slope creep in cutting
Ponding in ditch
North Bluff (Wide platform)
Ponding in ditch
Collapsed retaining wall
Steps to Cargills Leap
BH3
BH1
BH2
TP5
Former sluice for Mill Inch
Washout failure at Cuttle Burn
Collapsed retaining wall
The 2012 Landslip
Minor landslip features at riverside
Minor landslip features at riverside
Large embayment (Relict landslip)
Minor landslip features at riverside
The 2011 Landslip
River Ericht

Figure 2 - Observed Landslip Features







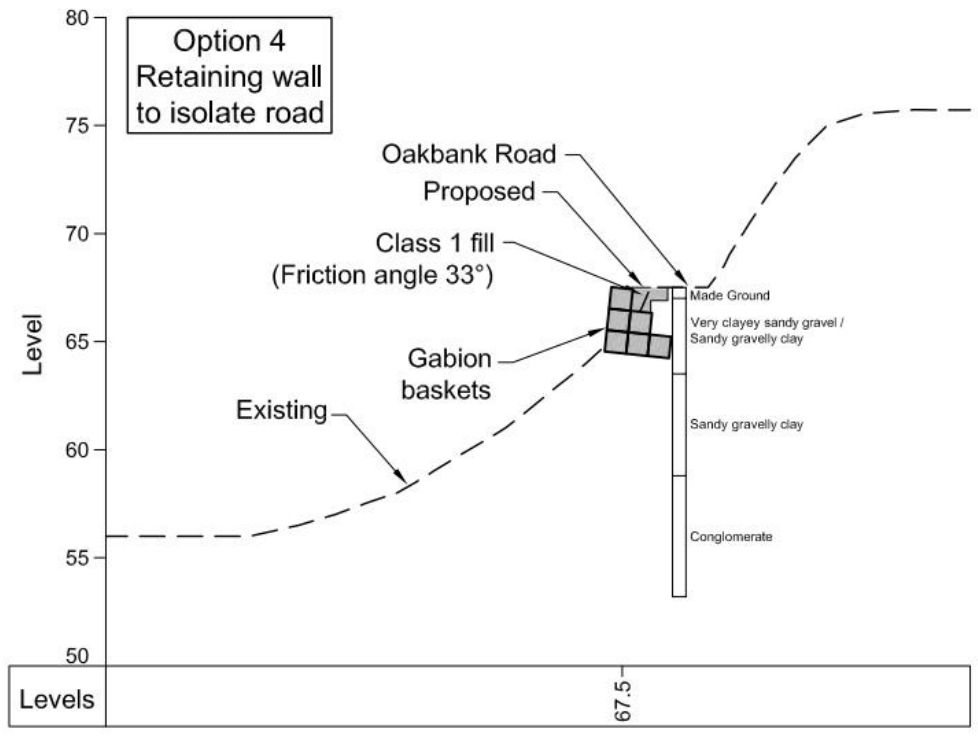


Figure 3 - Remedial Work Options

SECTION 6

Plates

Plate I - The 2011 Landslip – note masonry blocks tumbled down slope (Photo dated 12 Jun 12)

Plate II - The 2011 Landslip – intact section of wall (Photo dated 12 Jun 12)

Plate III - View North towards the 2011 Landslip
(Photo dated 12 Jun 12)

Plate IV - View North over the 2012 Landslip
(Photo dated Dec 12)

Plate V - View from the river up to the 2012 Landslip
(Photo dated Dec 12)

Plate VI - View up to the 2012 Landslip – note scar in slope above the road
(Photo dated Dec 12)

Plate VII - Wall collapse in the vicinity of the 2012 Landslip (Photo dated Dec 12)

Plate VIII

Appendix 5

Bedrock and Sections of Retaining Wall on Leased Land

Appendix 6

Stabilzation Options

Technical Note Option - gabion baskets at the crest or bottom of slope to stabilise further loss.

- Disadvantage: not a complete control measure
- Cost: £50k for each landslip excluding accommodation works.

Option 1 - a 1: 1.5 reinstated slope with rockfill, with neither gabions nor retaining features

- Disadvantage: heavy excavation, disposal, possible destabilisation of slope
- Cost: not provided as not a preferred option because whilst it would be theoretically possible, the technical challenges and likely costs would be too great given the risk of further slope destabilisation during construction.

Option 2 - a 1: 2 reinstated slope with granular infill (e.g. type 1), with neither gabions nor retaining features

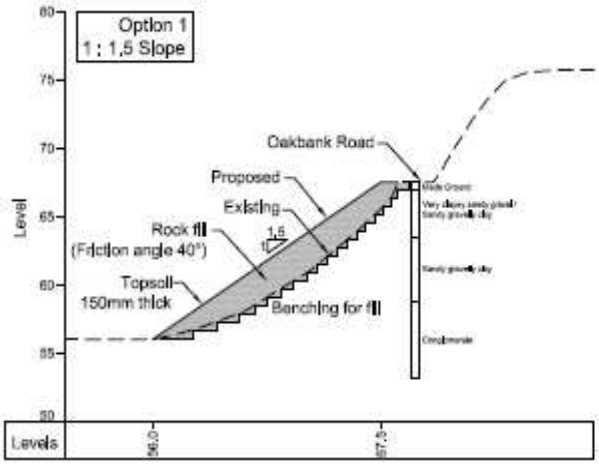
- Disadvantage: access to slope, large import of material, impact on river, and very susceptible to erosion.
- Cost: not provided as not a preferred option because whilst it would be theoretically possible, the risk of early subsequent erosion is too great.

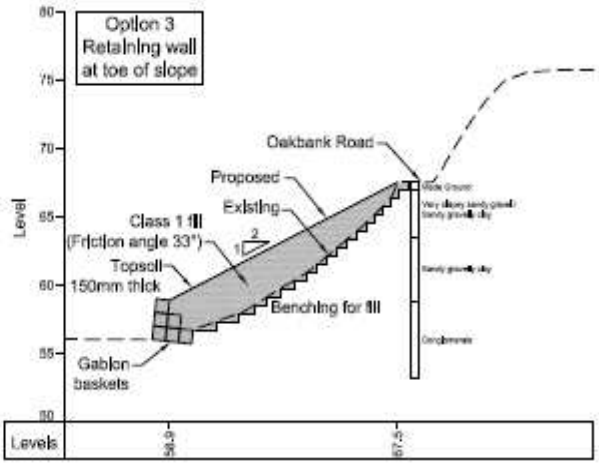
Option 3 - a 1: 2 reinstated slope with granular infill (e.g. type 1) with gabion retaining wall at toe of slope

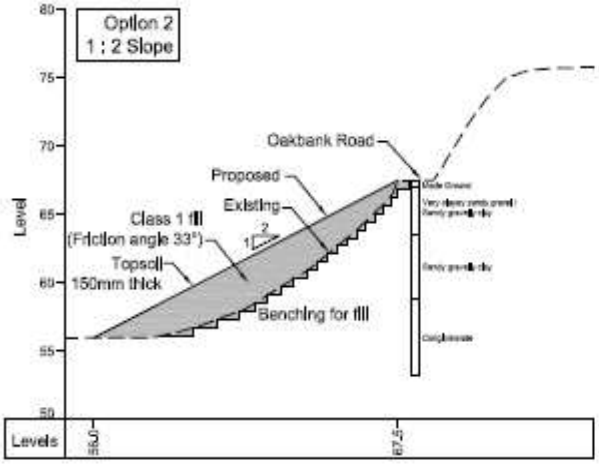
- Disadvantage: as for options 1 & 2 and longer to construct
- Cost: £100k for each landslip excluding accommodation works.

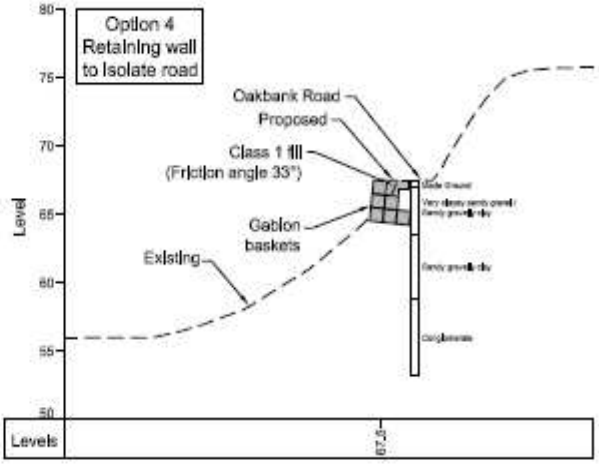
Option 4 - a retaining wall to isolate road, no fill

- Disadvantage: as for options 1, 2 & 3 and does not stabilise slope
- Cost: £200k for each landslip excluding accommodation works.


Option 1
1 : 1,5 Slope
Oakbank Road
Proposed
Existing
Rock fill
(Friction angle 40°)
1,5
1
Topsoil
150mm thick
Benching for fill
Level
Levels
56.0
67.5


Option 3
Retaining wall
at toe of slope
Oakbank Road
Proposed
Existing
Class 1 fill
(Friction angle 33°)
2
1
Topsoil
150mm thick
Benching for fill
Gabion
baskets
Level
Levels
56.0
67.5


Option 2
1 : 2 Slope
Oakbank Road
Proposed
Existing
Class 1 fill
(Friction angle 33°)
2
1
Topsoil
150mm thick
Benching for fill
Level
Levels
56.0
67.5


Option 4
Retaining wall
to Isolate road
Oakbank Road
Proposed
Class 1 fill
(Friction angle 33°)
Gabion
baskets
Existing
Level
Levels
67.5

Appendix 7

Oakbank Road Map – Map of Alternative Route