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A Technical and Perceptual Evaluation of Wig-Wag Signs at the A83 Rest and be Thankful

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Executive Summary

The Scottish Road Network Landslides Study made a number of recommendations for landslide management and mitigation. Amongst these was that ‘wig-wag’ signs could be suitable at sites with specific conditions, particularly those sites at which debris flow events occur on a regular basis. Such signs incorporate a standard rockfall/landslide red warning triangle, flashing lights, and a sub-plate that warns of ‘Higher risk when lights flash’.

A trial of such signs commenced on the A83 in 2011 and was centred on the section of the route that includes the Rest and be Thankful. As part of this trial it was intended that a detailed technical and perceptual evaluation of the signing arrangements be undertaken. Accordingly, the aims of the work presented in this report were to examine the efficacy of the operation of the wig-wag signing arrangements at this location, and to explore the perceptions and attitudes of road users to these specific signs.

It is broadly concluded that the trial has had a satisfactory outcome. With one exception, the debris flow events that occurred during the period of the trial were within a period when the lights were activated. The one event that did not occur during such a period was of a somewhat different character and further investigation is recommended.

The period during which the lights were activated and were not associated with a debris flow event corresponds to between 11% (2011) and 15% (2012) of the days of the year; this is considered to be broadly acceptable in the light of the rainfall triggers that are currently available to determine the timings of switch-on and switch-off.

The results of the driver survey element of the work indicate that, in general, desired behaviours are promoted by the use of the signs. It is, however, suggested that widespread media promulgation that the signs are switched on, and an associated misinterpretation of that fact, may be the source of the erroneous suggestion that ‘mid-Argyll is closed for business’ at such times. As a result, one of the key recommendations is that the practice of placing notifications that the signs are activated on the Traffic Scotland website be discontinued.

The A83 Rest and be Thankful locality is known for the frequency with which debris flow events occur, much more than any other part of the trunk road network in Scotland. It is thus well-suited to the use of this type of temporal warnings. The potential application of wig-wag signs to other parts of the network is limited and any proposals should be the subject of detailed location-specific assessment.
1 Introduction

Landslides in the form of rainfall-induced debris flows are a common occurrence in Scotland. The events of August 2004 which adversely affected the Scottish trunk road network led to the Scottish Road Network Landslides Study (Winter et al. 2005; 2009).

The overall purpose of that study was to systematically assess and rank the hazards posed by debris flows and to put in place a management and mitigation strategy for the Scottish trunk road network. The ranking system allows lengths of the network subject to risk from debris flow events to be prioritised for action.

The approaches to management and mitigation were based upon exposure reduction and hazard reduction respectively (Winter et al., 2009). There are many forms of landslide management and mitigation (e.g. VanDine, 1996) and a classification scheme has been developed (Winter, 2013; In Press). This particular scheme is intended to provide a common lexicon and to allow a clear focus on outcomes from such activities whilst avoiding an overemphasis on individual processes and techniques. This approach ought to be of particular value to those who fund such works, including infrastructure owners and local governments. Management involves the reduction of the exposure of road users to the hazard by means of either:

1) education;
2) geographical (non-temporal) warnings; or
3) response (including temporal, or early, warnings).

Mitigation primarily, but not exclusively, involves reduction of the actual hazard by means of:

a) works to engineer or protect the elements at risk;
b) remediation of the hazard to reduce the probability of failure; or
c) removal, or evacuation, of the elements at risk

One of the recommendations put forward by Winter et al. (2009) was that a form of temporal warning sign incorporating a standard rockfall/landslide red warning triangle, flashing lights and a sub-plate that warns of ‘higher risk when lights flash’ (i.e. during periods of high rainfall) might be suitable for sites where debris flow events occur on a regular basis. Such signs are colloquially known as ‘wig-wags’.

A two-year trial of such signs commenced in January 2011 and it has since been extended for a period of one year. The terms of the trial approval required that the effectiveness of the signs should be monitored and that the results should be incorporated into a report; this report is intended to satisfy that requirement.

The aims of the work, as determined by Transport Scotland, were as follows:

- **Technical evaluation**: Determine the efficacy of the wig-wag switch-off/switch-on protocol in terms of its alignment with actual events and also to assess the rainfall threshold used for the switch-on.
- **Evaluation of drivers’ attitudes and behavioural responses**: Explore the attitudes held by local and non-local drivers towards landslide wig-wag signs on the A83 in terms of their perceived meaning and their impact on road safety.
The report presents the technical evaluation (Section 3) and the evaluation of drivers’ attitudes and behavioural responses (perceptual evaluation) (Section 4) of the wig-wag signs, which provide both a geographical and temporal warning of potential landslides as part of a management strategy. Pertinent background information is presented in Section 2 and conclusions are drawn and recommendations made in Section 5.
2 Background

2.1 Debris Flows and the Trunk Road Network

The Scottish Road Network Landslides Study (Winter et al., 2005; 2009) was instigated in response to the rainfall-induced landslide events of August 2004. The rainfall experienced in Scotland in August 2004 was substantially in excess of the norm. Some areas of Scotland received more than 300% of the 30-year average August rainfall (source: www.metoffice.gov.uk), while in eastern parts between 250% and 300% was typical. Although the percentage of the monthly average rainfall that fell during August reduced to the west, some parts still received 200% to 250%.

Long lasting and intense rainfall led to a large number of landslides, in the form of debris flows, in the hills of Scotland. Critically, some of these affected important parts of the major road network, linking not only cities but also smaller, remote communities. Notable events occurred at the A83 between Glen Kinglas and to the north of Cairndow (9 August), the A9 to the north of Dunkeld (11 August), and the A85 at Glen Ogle (18 August) (Figure 1).

Subsequent analysis of radar data indicated that at Callander, 20km from the A85 events, 85mm of rain fell in four hours on 18 August. Some 48mm fell in just 20 minutes and the storm reached a peak intensity of 147mm/hour. The 30-year average August
rainfall varies between 67mm on the east coast and 150mm in the west of Scotland (Anon., 1989).

While there were no major injuries, some 57 people were taken to safety by helicopter after being trapped between the two main debris flows on the A85 in Glen Ogle. However, the real impacts were social and economic, in particular the severance of access to and from relatively remote communities. The A83, carrying up to 5,000 vehicles per day (all vehicles two-way, 24 hour annual average daily traffic, AADT) was closed for slightly in excess of a day, the A9 (carrying 13,500 vehicles per day) was closed for two days prior to reopening, initially with single lane working under convoy, and the A85 (carrying 5,600 vehicles per day) was closed for four days. The traffic flow figures are for the most highly trafficked month of the year (July or August). Minimum flows occur in either January or February and are roughly half those of the maxima reflecting the importance of tourism and related seasonal industries to Scotland’s economy. Substantial disruption was thus experienced by local and tourist traffic, and goods vehicles.

The events of August 2004 are described by Winter et al. (2006). These events are by no means unique and further debris flows have affected both the A9 and the A83, for example, since August 2004. The event pictured at the A83 in Figures 2 and 3 occurred around at 0330 hours on Sunday 28 October 2007. Figure 2 illustrates the event and the surrounding hillside; the photograph is taken from the opposite side of the valley and evidence of numerous past events can be clearly observed. Figure 3 illustrates the event in more detail and it is clear that the system of mass movement comprises two discrete but related events. The flow above the road commenced with a relatively small slide (or slides) into an existing drainage channel. This then triggered the movement of a large amount of marginally stable material in and around the stream channel depositing an estimated 400 tonnes of material at road level. This material blocked the open drain which carries water along the upslope side of the road to a series of culverts beneath the road. While the material from above the road had limited impact upon the slopes below the road, water diverted from the drain was channeled across and over the edge of the road causing some significant undercutting of the slope below and associated deposition further down the hill as can be seen in Figure 3.

Due to the major contribution that tourism makes to Scotland’s economy the impacts of such events can be particularly serious during the summer months, during which period debris flows usually occur in July and August. Nevertheless, the impacts of any debris flow event occurring during the winter months, during which debris flow usually occurs between October/November and January, should not be underestimated. Not surprisingly, the debris flow events described created a high level of interest in the media in addition to being seen as a key issue by politicians at both the local and national level. Indeed, the effects of such small events which may, at most, affect directly a few tens of metres of road cast a considerably broader vulnerability shadow (Winter & Bromhead, 2012); Winter (In Press) estimated the boundaries of the vulnerability shadow cast as illustrated in Figure 4.
Figure 2. View of the hillside above and below the approach to the Rest and be Thankful from the east (from NGR NN 23160 06559 on the opposite side of Glen Croe). Not only can the event dated 28 October 2007 be clearly seen but evidence of numerous past events can be seen on the surrounding hillside.

Figure 3. View of the debris flows above and below the A83 on the approach to the Rest and be Thankful (from NGR NN 23160 06559 on the opposite side of Glen Croe). The head scar is at approximately 370m AOD, the A83 at 240m AOD and the old road at 180m AOD.
Figure 4. A relatively small debris flow event (blue square) closed the A83 at the Rest and be Thankful in October 2007; the vulnerability shadow that was cast (bounded in red) was extensive.

The A83 Rest and be Thankful site has been extremely active in recent years with multiple debris flow events and associated closures and events in 2007, 2008 and 2009 had an adverse effect on the travelling public. Subsequent events in 2011 and 2012 have continued this trend. This has meant that the area has become the focus of not only concern but also of extensive landslide management and mitigation activity. This culminated in a study being commissioned to assess and make recommendations on potential landslide remediation actions (Anon., 2013; Winter & Corby, 2012).

2.2 Wig-wag Signs

The installation of trial wig-wag signs was one of the options recommended by Winter et al. (2009) as part of the overall management strategy. The wig-wag signs (Figures 5 and 6) provide both a geographical and temporal warning of potential landslides as part of a management strategy (see Section 1).

The design of the wig-wag signs used in this setting incorporates both a static landslide warning sign and lights that flash during periods of heavy rainfall, to indicate an elevated risk of landslide (Figures 5 and 6). Such signs are commonly used to indicate the presence of school crossings or ice, both of which have a clear temporal aspect and are
eminently suited to the use of flashing lights when such risks are at a higher level than at other times (i.e. at school start and end times, and during periods of cold weather, respectively).

Figure 5. Standard design of landslide wig-wag warning sign.

Figure 6. Wig-wag warning sign in operation.

A two-year trial of such signs was approved, originally for commencement on 21 April 2009 (this was later revised to 1 October 2010 and then to 1 November 2010) and this was subsequently extended for a period of one-year. The trial commenced in January
2011 and the area was defined as the A83 between Ardkinglas and a point to the west of the Cairndow just before the turn to the Achadunan Brewery (Figure 7).

Figure 7. Wig-wag warning sign trial location.

A total of six signs was installed, three each for eastbound and westbound traffic. The sign plates are permanently visible to drivers and the flashing lights are switched on remotely, using mobile telecommunications technology, in response to warnings (or forecasts) of heavy rainfall. When the lights are switched on, to indicate a period of higher risk (of landslides), a notification is placed on the Traffic Scotland website (www.trafficscotland.org); such notifications are frequently broadcast both locally and nationally.

The wig-wag signs are switched on by the Traffic Scotland Control Centre in response to Heavy Rainfall Warnings. These are predicated upon meteorological forecasts that suggest that one or other of two threshold values is likely to be exceeded. The thresholds are defined by the Met Office as follows:

- 25mm in a 24 hour period, or
- 4mm in a three hour period.

The lights then flash from the time that the forecast period commences until six hours after the forecast period finishes; the six hour period was agreed, at the outset of the trial, as the best estimate of the period over which the residual risk would persist. The content of a typical Heavy Rainfall Warning is shown in Box 1. The warning is also emailed to the Operating Company who consult with Transport Scotland and make a decision on whether landslide patrols should be activated, although it should be noted that these operate in daylight hours only.

The wig-wags have prompted diverse views from road users and local residents. The promulgation of messages in the media, when the lights are switched on, along the lines of “There is a higher risk of landslides at the Rest and be Thankful … nothing has happened but drivers should be advised to take care …”, may erroneously send out the message that mid-Argyll is effectively closed for business at such times. Such a message was not stated in the recommendations made by Winter et al. (2009); what was
contained in those recommendations was that such signs should be used to alert drivers to the need to take extra care. The actions that drivers should take were detailed in Appendix F of Winter et al. (2009) and repeated and reinforced in leaflets issued jointly by Transport Scotland and Scotland TranServ. These leaflets included the following messages:

“These new [wig-wag] signs will flash when there is a higher risk of a landslide, alerting drivers to take extra care while continuing their travel on the road.

“Our aim is to keep roads open as safely as possible and you can help make your trip even safer by:

- planning your journey in advance at www.trafficscotland.org
- checking the weather forecast before you set off
- allowing extra travel time
- being alert for water or debris on the road
- listening for travel bulletins and looking for roadside messages displayed on Variable Message signs
- avoid stopping on bridges or next to water courses in mountainous areas
- planning your stops in towns and villages rather than the open roadside

“For more information about the Landslide Action Plan and Wig-Wag trial visit http://www.transportscotland.gov.uk/.”

Box 1: Rainfall Warning Service for A83 Wig-Wag Signs

Heavy Rainfall Warning

Warning Number 3
Valid From: 0900 on 13th May 2012
Valid Until: 2100 on 13th May 2012
A83 Rest and be Thankful (Ardgartan to Cairndow)

Applicable Criteria:
1. Rainfall accumulation of 25mm in a 24hour period, or
2. Rainfall expected to fall at a rate of 4mm/hour or more, giving a total of 12mm or more within 3 hours.

Action:
Switch ON Wig-Wags at: 0900 on 13th May 2012
Switch OFF Wig-Wags at: 0300 on 14th May 2012

Issued by:

It is clear that there are three aspects to the wig-wag signs, as follows:
1) The standard fixed-plate rockfall/landslide warning red triangle sign which is used internationally to indicate risks of both rockfall and other types of landslide.

2) The flashing lights that are activated during periods of heavy rainfall.

3) The notifications that are posted on the Traffic Scotland website and thus picked up and promulgated more widely by the media.

In the following sections evaluations are presented of the technical success, or otherwise, of the mechanisms and procedures used to trigger the flashing lights and of the perception of road users’ of the flashing wig-wag signs.
3 Technical Evaluation

The technical evaluation assesses, both qualitatively and quantitatively, the success or otherwise of the procedures and methodologies used to switch the wig-wag signs on and off. In order to evaluate success of the initiative what should be assessed is whether the wig-wags were switched on too frequently when debris flow events did not occur – ‘false positive’ – and switched off when debris flow events did occur – ‘false negative’.

However, it is important to note that the flashing lights indicate a higher risk of debris flow occurrence, not a certainty of an event, and that their absence indicates a lower risk period, not a zero risk state. In this context it should be clear that the phrases ‘false positive’ and ‘false negative’ are used as shorthand.

3.1 Data Assessment

A number of data sets were compiled for the period 1 January 2011 to 31 December 2012, unless stated otherwise, as follows:

- Rainfall data from a Vaisala rain gauge located adjacent to the A83 carriageway on the easterly approach to the Rest and be Thankful (data for 2011 only).
- Rainfall data from a Scotland TranServ rain gauge located adjacent to the A83 carriageway on the easterly approach to the Rest and be Thankful.
- Rainfall data from a SEPA rain gauge station located to the south of the B828 near to the beginning of the forestry road that traverses the west side of Glen Croe (Station Name: Rest and be Thankful; Station number: 485490; National Grid Reference: NN 22835 06967) (data from 29 April 2012).
- Rainfall data from a SEPA rain gauge station located to the east of the A83 on the westerly approach to the Rest and be Thankful opposite the northern end of Loch Restil (Station Name: Loch Restil; Station Number: 485489; National Grid Reference: NN 23249 08496) (data from 29 April 2012 only).
- The days on which Heavy Rainfall Warnings were in operation for the Rest and be Thankful area (these were supplied by Net Weather until 23 November 2011 and by Met Office thereafter).
- The times for which snow warnings were in operation for the Rest and be Thankful area (these were supplied by Net Weather until 23 November 2011 and by Met Office thereafter).
- The days on which landslide patrols were active. (This is presented for information only and does not form part of the technical evaluation.)
- The days on which the flashing lights on the wig-wag signs were activated.
- The times and dates of debris flow events in the area.

The location of the Vaisala and Scotland TranServ rain gauges in close proximity to the A83 carriageway may mean that the measurements recorded are influenced by spray from passing vehicles. Certainly there are a number of spikes during 2011 (Figure 8) that are illustrated by one or other of the data sets, Vaisala or Scotland TranServ, but not the other. In addition, the Scotland TranServ data set shows some spikes that are not shown by either of the SEPA rain gauges that were commissioned on 29 April 2012 (Figure 9).
### Table 1. Debris flow events during 2011 and 2012 in the A83 Rest and be Thankful area and Heavy Rainfall Warning and wig-wag status.

<table>
<thead>
<tr>
<th>Time</th>
<th>Date</th>
<th>Event Description</th>
<th>Heavy Rainfall Warning and Wig-wag Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not known</td>
<td>11-12 September 2011</td>
<td>A small event at Butterbridge in Glen Kinglas. It is not known if this event reached the carriageway.</td>
<td>Heavy Rainfall Warning in force. Wig-wags switched on.</td>
</tr>
<tr>
<td>Not known</td>
<td>4-5 October 2011</td>
<td>A small event at the east end of Glen Kinglas that did not reach the carriageway.</td>
<td>Heavy Rainfall Warning in force. Wig-wags switched on.</td>
</tr>
<tr>
<td>Not known</td>
<td>29 November 2011</td>
<td>A small event at the west end of Loch Restil. It is not known if this event reached the carriageway.</td>
<td>Heavy Rainfall Warning in force. Wig-wags switched on.</td>
</tr>
<tr>
<td>07:12</td>
<td>1 December 2011</td>
<td>A significant event on the easterly approach to the Rest and be Thankful. Adjacent potential failure areas were associated with this event.</td>
<td>Heavy Rainfall Warning not in force (lapsed on 30 November 2011). Wig-wags not switched on.</td>
</tr>
<tr>
<td>12:14</td>
<td>22 February 2012</td>
<td>Failure of one of the potential failure areas identified adjacent to the December 2012 event, on the easterly approach to the Rest and be Thankful.</td>
<td>Heavy Rainfall Warning in force. Wig-wags switched on.</td>
</tr>
<tr>
<td>Not known</td>
<td>27-29 June 2012</td>
<td>This relatively small debris flow did not reach the road although some small boulders did (this event may have occurred on 26 June) on the easterly approach to the Rest and be Thankful.</td>
<td>Heavy Rainfall Warning in force on 27 June (not 26 June). Wig-wags not switched on.</td>
</tr>
<tr>
<td>16:00</td>
<td>1 August 2012</td>
<td>A significant event on the easterly approach to the Rest and be Thankful.</td>
<td>Heavy Rainfall Warning in force. Wig-wags switched on.</td>
</tr>
<tr>
<td>07:00</td>
<td>19 November 2012</td>
<td>A significant event on the easterly approach to the Rest and be Thankful.</td>
<td>Heavy Rainfall Warning in force. Wig-wags switched on.</td>
</tr>
</tbody>
</table>
Figure 8. Rainfall data, weather warnings, landslide patrols and wig-wag switch-on periods for the Rest and be Thankful Rainfall for the period 1 January 2011 to 31 December 2011. Debris flow events are shown as vertical lines. (Note that the SEPA rainfall gauges were not activated until 29 April 2012.)
Figure 9. Rainfall data, weather warnings, landslide patrols and wig-wag switch-on periods for the Rest and be Thankful Rainfall for the period 1 January 2012 to 31 December 2012. Debris flow events are shown as vertical lines. (Note that the Vaisala rainfall gauge was not active in 2012.)
During the limited time during which they have been in operation the two SEPA rain
gauges reported broadly similar results (Figure 9). Indeed, it is generally rather difficult
to observe the data from the Loch Restil gauge in Figure 9 as it is largely visually
obscured by that from the Rest and be Thankful gauge.

Road closures, including those that were a result of landslide activity, are excluded from
the data illustrated in Figures 8 and 9 as such closures are usually complete for only part
of the road and are often for only part of the day. For example, closures during 2011-12
were typically between Ardinglas and the A83-B828 junction (Figure 7) and over the
winter of 2011-12, for example, were mainly during the hours of darkness. Road
closures thus reduced rather than eliminated the function of the wig-wag signs.

The data are presented in Figures 8 and 9 for 2011 and 2012 respectively and the debris
flow events that occurred during this period are summarised in Table 1. The Heavy
Rainfall Warnings, snow warnings, landslide patrols and wig-wag sign activations are
plotted on a daily basis: thus a point appears on Figures 8 and 9 even if the event to
which it refers covers only a small part of the day. For debris flow events of uncertain
date of occurrence each possible date of occurrence is shown.

### 3.2  Wig-Wag Switch-On Periods

It is clear from Figures 8 and 9 that both the number and duration of Heavy Rainfall
Warnings and associated switch-on periods of the wig-wag signs is significant; this is
particularly the case during November and December of 2011 and late-June to August
2012. Certainly the number of these is significantly greater than the number of debris
flow events and these may be described as ‘false positives’ (see above). Such ‘false
positives’ may be defined in a number of ways. However, for the purposes of this
evaluation two definitions have been used:

1) The number of times the wig-wag signs are switched on when a debris flow
event does not occur.

2) The number of days on which the wig-wag signs are switched on when a debris
flow event does not occur.

In both cases the three days before and after a debris flow event have been excluded as
the rainfall is likely to be associated with that event. In the case of definition (1), where
a switch-on period encompasses part of the three day period either side of a debris flow
event it is also not counted.

The number of times that, and the number of days on which, the wig-wags indicated
‘false positives’ is detailed in Table 2.

<table>
<thead>
<tr>
<th>Table 2. 'False positives' indicated by the wig-wag signs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of times</td>
</tr>
<tr>
<td>Number of days</td>
</tr>
</tbody>
</table>

This number of ‘false positive’ is certainly significant and it is noticeable that the wig-
wags were switched on a significantly higher number of times in 2012 than in 2011.
However, the difference between the number of days that the wig-wags were switched
on, while still greater for 2012 than 2011, is not so significant. That is a greater number
of the switch-on periods were within a single day or, put in a slightly different way, the average switch-on period was less. In the west of Scotland both 2011 (2,297.9mm; 133% of the annual 1971-2000 average) and 2012 (1,917.1mm; 107% of the annual 1981-2010 average) were wetter than the average. However, 2011 was clearly wetter than 2012 in the region although this may well mask more localised differences in the immediate Rest and be Thankful area.

During 2011 and 2012 the wig-wags were switched on for 11% and 15% of the days of the year, when the switch-on period was not associated with a debris flow event. This is not considered exceptional given that the rainfall trigger thresholds are under development (see Section 3.4). In must be recognised that the Met Office (and Net Weather) Heavy Rainfall Warnings are not specifically purposed to forecast periods during which debris flows are more likely to occur but are a purely meteorological forecast that conform to an accepted definition of heavy rainfall.

Climate change forecasts suggest that winter rainfall may increase, and that storm rainfall (higher intensity/shorter duration) may be more prevalent throughout the year; associated landslide activity is likely to increase also (Winter & Shearer, 2013).

It is also clear, that there are days when there is a mis-match between the heavy rainfall warnings being active and the wig-wag flashing lights being switched on. However, it should be noted that the wig-wag switch-on is intended to continue for six hours after the Heavy Rainfall Warning ceases and therefore the wig-wag switch-on period may be shown in Figures 8 and 9 as being one day longer than the Heavy Rainfall Warning. In general this seems to explain the majority of the periods when the wig-wags were switched on when there has been no Heavy Rainfall Warning in force.

Other such periods coincide with snow, as opposed to heavy rainfall, warnings being in force. However, the trigger for switching on the wig-wags in response to forecast snowfall is not clear. It should also be noted that a direct link between snowfall and debris flow triggering is not anticipated; landslides are, more generally, associated with significant snow melt but there is insufficient evidence to postulate a precise triggering mechanism for the Rest and be Thankful location. Other such instances of this scenario are most likely attributable to a reasoned decision to keep the wig-wags switched on during prolonged periods of particularly heavy rainfall (e.g. late-November 2011).

There were also periods when Heavy Rainfall Warnings were active but the wig-wags were not switched on. These were particularly prevalent during 2011 and may have been as a result of early-life equipment breakdowns and commissioning problems; certainly high winds caused damage to some of the signs over the winter of 2011-12 (remedial measures have since been implemented). There were, however, some, albeit shorter and less frequent, instances of this type of occurrence in 2012. The reasons for these are not entirely clear but the process for switching on the wig-wag signs in response to heavy rainfall warnings does need to be examined in order to ensure that the likelihood of ‘false negative’ events is minimised.

### 3.3 Debris Flow Events

Table 3 lists the known debris flow events for the 2011-12 period and compares their occurrence with wig-wag switch-on periods, weather warnings (heavy rainfall and snow), and the use of landslide patrols.
In general, the more detailed data in Table 3 supports the observations that can be made from a visual inspection of Figures 8 and 9. That is, that debris flows generally occurred during periods when Heavy Rainfall Warnings were in effect and the wig-wags were switched on. There are two possible exceptions to this and these are described and discussed in the following paragraphs.

Table 3. Detailed Heavy Rainfall Warning, wig-wag and landslide patrol status for periods surrounding debris flow events: the day (or days, where this is not certain) of occurrence is highlighted.

<table>
<thead>
<tr>
<th>Event Date</th>
<th>Wig-wags</th>
<th>Weather warnings</th>
<th>Patrols</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-12 September 2011</td>
<td>09-Sep</td>
<td>10-Sep</td>
<td>11-Sep</td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5 October 2011</td>
<td>02-Oct</td>
<td>03-Oct</td>
<td>04-Oct</td>
</tr>
<tr>
<td>Wig-wags</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 November 2011</td>
<td>26-Nov</td>
<td>27-Nov</td>
<td>28-Nov</td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 December 2011</td>
<td>28-Nov</td>
<td>29-Nov</td>
<td>30-Nov</td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 February 2012</td>
<td>19-Feb</td>
<td>20-Feb</td>
<td>21-Feb</td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Weather warnings</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>1 August 2012</td>
<td>29-Jul</td>
<td>30-Jul</td>
<td>31-Jul</td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wig-wags</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Weather warnings</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Patrols</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

Event dated 1 December 2011: There was no weather warning current and the wig-wags were thus switched off at the time of this event (switch-off was at around midday on 30 November). The event occurred on the first day on which Met Office weather warnings were used, these having been issued by Net Weather up until 23 November 2011. This change over in the source of the weather warnings is not thought to have adversely affected operation of the system. The fact that the landslide event occurred when there was not a heavy rainfall warning active and the wig-wag signs were switched off means that it must be classed as a ‘false negative’.
However, the nature of this debris flow event was somewhat different to those that more typically affect the area. Typically the events start high on the hillside as a small translational slide that enters an existing stream channel and then if there is sufficient water, it erodes material from the stream walls and becomes a debris flow within that channel (more extensive descriptions of this process are given by Winter et al., 2005; 2006; 2009). The December 2011 event, being very close to the road effectively comprised only the translational slide phase and the translational slide itself appears to have been somewhat larger than is typical. It may also be that the six-hour period between the end of the Heavy Rainfall Warning and the switch-off of the wig-wags is insufficient for this type of larger scale translational movement.

Event dated 27-29 June 2012: It is not known on which day (27, 28 or 29 June) this event which, beyond a few small rocks, did not reach the road occurred (see Table 1). As a Heavy Rainfall Warning was in force on 28 and 29 June these two dates seem to be more likely than 27 June. Indeed, the later date of 29 June seems to be the most likely of the three dates as this would minimise the amount of time that the event went unobserved and unreported. This event could be described as a ‘false negative’ if it occurred on 27 or 28 June. However, it is not clear why the wig-wag signs were not switched on when the Heavy Rainfall Warning was in force on 28 June. This potential ‘false positive’ would therefore seem to be a function of the operation of the warning and wig-wag system rather than of the system itself: i.e. the wig-wags should have been switched on but were not. However, if, as seems most likely, the event occurred on 29 June then the system seems to have worked correctly and a heavy rainfall warning was in force and the wig-wags were switched on at the time of the event. This cannot be confirmed with any degree of certainty as the time lag between the occurrence of the event and its detection is not known.

3.4 Forecasting Considerations

The Scottish Road Network Landslides Study (Winter et al., 2005; 2009) set-out the long-term aim of forecasting likely periods of higher landslide hazard. Work to date (Winter et al., 2010) has focussed upon the national rain gauge network and radar data to develop a tentative threshold for debris flow triggering (Figure 10).

However, at an early stage it was noted that the rainfall gauge network in Scotland is sparse in areas of interest for debris flow forecasting, not least as the primary function of meteorological observation stations is the collection of synoptic data; simple rainfall stations are more usually used for specific purposes related to water resources and hydroelectric power, for example. In addition, while the rainfall radar system covers some of the areas of interest at a resolution of 2km, most are resolved at just 5km, sufficient for the primary function of the weather radar network in monitoring precipitation patterns and their movement as input to general weather forecasting. Additionally, issues surrounding the performance of radar rainfall in mountainous, and indeed other, areas appear to be some way from being fully resolved. Roberts et al. (2009) state, in relation to an analysis performed in an area with 5km radar resolution that “… rainfall amounts estimated by the [UK] radar network were generally less than those measured by gauges and distributed somewhat differently”.

In addition, comparison of the threshold in Figure 10 with similar thresholds from other parts of the world indicates that it may underestimate the amount of rainfall required to trigger debris flows (Figure 11). Indeed, the work by Cannon et al. (2007) on debris flow
triggering in areas that have been subject to wild fires appears to support this. In such areas debris flows are generally considered to trigger with relatively little rainfall due to the hydrophobic nature of the ash left after the fires. The tentative rainfall threshold for Scotland suggests triggering at lower rainfall levels than those that would be expected to trigger debris flow in areas subject to wild fires (Figure 11). Notwithstanding this the rather short threshold for wildfires in Figure 10 also indicates that these events are caused by short duration/high intensity rainfall with relatively little influence from longer duration/lower intensity (antecedent) rainfall.

Figure 10. Tentative trigger threshold for Scottish debris flows in terms of rainfall intensity-duration showing events at the Rest and be Thankful that have been used for validation purposes. The wig-wag heavy rainfall warning triggers are also shown.

This may well be due to the fact that the rain gauge network in the UK generally and, more specifically, in landslide-prone areas of Scotland is not intended to provide data for the purpose of forecasting periods when landslides are more likely to be triggered by heavy rainfall.

Accordingly, two rainfall gauges were installed on land close to the A83 at the Rest and be Thankful and were commissioned on 29 April 2012. These were paid for by Transport Scotland but are operated by SEPA (see Figure 9). Ongoing work on rainfall thresholds will utilise the data from these rain gauges and assess rainfall events that do and do not coincide with debris flow events. This will allow the ongoing development of the tentative rainfall threshold to better enable the forecast of likely periods of debris flow activity. The tentative threshold requires further consideration, validation and testing prior to the development and implementation of a procedure for its use in terms of issuing warnings of increased likelihood of landslide activity. It has been estimated that, given the frequency of such events in Scotland, around five years’ worth of data may be required (Winter et al., 2009; 2010).
3.5 Discussion

There are four major considerations with respect to the technical evaluation of the wig-wag signs. These are as follows:

1) Periods when the wig-wags were switched on and a debris flow did not occur ('false positives').

It is clear from Table 2 that there was a significant number of ‘false positives’ and that these were of significant duration. With a system of this nature ‘false positives’ are to be expected, particularly one that is under trial and subject to ongoing development. There seems little doubt that given time the forecast values used to initiate switch-on of the wig-wag signs can be improved as set-out in Section 3.4. However, as also set-out in Section 3.4, this will take some time. During 2011 and 2012 the wig-wags were switched on for 11% and 15% of the year when the switch-on period did not contain a debris flow event.

2) Periods when the wig-wags were not switched on despite a heavy rainfall warning being in force.

The majority of these periods can be explained by the six hours that the wig-wags are intended to be switched on after a heavy rainfall warning ceases to be in force, their activation by snow warnings, and possible breakdowns. It does seem likely that there was a small number of occasions when a heavy rainfall warning was in force and the wig-wags were not switched on. It the operation of such signs is to continue then it is recommended that the procedures for switch-on and switch-off be reviewed to ensure that this happens as infrequently as possible.

3) Debris flow events that occurred when the wig-wag signs were switched on.

A total of eight debris flow events occurred during 2011 and 2012 in the Rest and be Thankful area. Of these, six occurred when a Heavy Rainfall Warning was in force and
the wig-wags were switched on. A seventh seems most likely to have also occurred during the warning period when the wig-wags were switched on although this cannot be confirmed with any degree of certainty as the debris flow did not reach the road.

4) Debris flow events that occurred when the wig-wag signs were switched off (‘false negatives’).

The eighth debris flow event occurred during a period when there was no heavy rainfall warning in force and the wig-wag signs were not switched on. The possible reasons for this are discussed in Section 3.3 and centre around the somewhat different nature of this event compared to the more typical small translation slides that trigger debris flows high on the hillside. The post-Heavy Rainfall Warning period during which the wig-wags remain switched on may need to be increased from the six hours at which it is currently set. However, inspection of Figure 8 reveals that there had been significant heavy rainfall in the preceding days and there may be a need for the current six hour period to be flexible depending upon the antecedent conditions. This would require further work as part of the ongoing work to further develop the tentative rainfall intensity-duration threshold described in Section 3.4.
4 Perceptual Evaluation

For the perceptual evaluation a face-to-face questionnaire survey was conducted to determine attitudes, perceptions and self-reported behavioural reactions to the signs by local and non-local drivers, when the signs are switched on and when they are off.

The aim of the perceptual evaluation was to answer the following research questions:

1) What is the effect of installing a landslide wig-wag sign on drivers’ self-reported behaviours?
2) What effect does the type of sign (e.g. landslide wig-wag sign versus other wig-wag warning signs) have on drivers’ behaviours?
3) What do drivers report they would do if they passed a wig-wag sign when the lights are flashing?
4) What do drivers think they should do if they pass a wig-wag sign when the lights are flashing?
5) Do drivers think the signs make the road safer and do drivers take the precautions that Transport Scotland publicised?
6) Are there differences between local and non-local drivers?

4.1 Method

4.1.1 Materials

A questionnaire (Appendix A) was designed to measure the attitudes, perceptions and self-reported behavioural responses of local and non-local drivers to the landslide wig-wag signs installed on the A83 Rest and Be Thankful.

The first section of the questionnaire required participants to respond to pictures of various road scenes with the speed at which they would choose to drive in that scene. There were 42 pictures in total; a description of the picture groupings can be seen in Table 4 and an example of one of the road scene images (with flashing wig-wag sign) is shown in Figure 12.

The pictures were published as show cards in two packs (Pack A and Pack B). Both packs started with the same three filler pictures to give participants a chance to practice and clarify instructions with the interviewer. Pack A (Appendix B) then presented pictures 4-42 in a pseudo-randomised order (the order was initially randomised, researchers ensured that no pictures of the same scene were adjacent). Pack B presented pictures 4-42 in the reverse of the order used in Pack A.

The questionnaire also included questions about drivers’ behavioural responses to each of the three wig-wag warning signs used in the show cards (landslide, ice and school). For each sign, participants were asked to state what they would do if they were driving and saw that: 1) the lights were not flashing; 2) the lights were flashing; and, 3) what they thought they were supposed to do when the lights flashed. Interviewers were instructed to code the participant’s response into one of six categories:

1. Continue at the same speed.
2. Slow down
3. Speed up.
4. Turn around.
5. Stop/Pull over.
6. Other.

**Table 4. Description of pictures used in the survey.**

<table>
<thead>
<tr>
<th>Scene Type</th>
<th>Description</th>
<th>Presented in digitally altered formats</th>
<th>Total number of pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landslide wig-wag</td>
<td>Pictures of four landslide sign locations from the A83.</td>
<td>• Sign flashing</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sign not flashing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No sign</td>
<td></td>
</tr>
<tr>
<td>Ice wig-wag</td>
<td>Pictures of two ice warning signs from other UK locations (not the A83 or surrounding area)</td>
<td>• Sign flashing</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sign not flashing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No sign</td>
<td></td>
</tr>
<tr>
<td>School wig-wag</td>
<td>Pictures of two school warning signs from other UK locations (not the A83 or surrounding area)</td>
<td>• Sign flashing</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sign not flashing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No sign</td>
<td></td>
</tr>
<tr>
<td>Filler</td>
<td>Various pictures of road scenes from around Scotland.</td>
<td>No digital altering. These images were used to disguise the fact that the questionnaire was focused on differences between wig-wag settings and lights.</td>
<td>18</td>
</tr>
</tbody>
</table>

**Figure 12. Example of a road scene used in the questionnaire. The image was digitally altered and presented in three conditions: flashing, not flashing and no sign.**
Further questions were asked in order to identify whether participants considered themselves as locals or visitors to the area and also to determine the regularity with which participants used the road. Those who stated that they used the road regularly were asked a series of questions to measure their attitudes towards a number of behaviours. These behaviours were all related to advice given to motorists by Transport Scotland in their information leaflet that accompanied the installation of the landslide wig-wag signs on the A83 and which is based upon the information presented by Winter et al. (2009).

Further questions included those regarding general demographic information and information about participants’ driving histories.

4.1.2 Participants

Opportunistic sampling was employed on two days in three selected areas in the area surrounding A83 Rest and Be Thankful. Filter questions were used to include only those who were either currently driving in the area or regularly drove in the general area. A total of 206 participants were interviewed. The sample had a mean age of 46.4 years (range 17-81 years) while male drivers were overrepresented (142 males and 64 females). Ninety-five per cent (N=196) of the sample were UK citizens and held a valid UK driving licence with the remaining 5% (N=10) not having UK citizenship but holding a driving licence from another country.

Eighty-nine participants reported driving on the A83 regularly. A breakdown of how regularly these drivers used the A83 can be seen in Table 5.

Table 5. Regularity of travel on A83 Rest and Be Thankful.

<table>
<thead>
<tr>
<th>Regularity</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>A few times a week</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Once a week</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>Once or twice a month</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Less than once or twice a month</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

Note that the percentages may not add up to 100 due to rounding.

Those who did not drive the road regularly were asked to indicate whether they had driven the road in the last 12 months. Seventy-seven had driven the road as a visitor to the area and 14 were locals who do not use the road regularly. Twenty-six indicated that they had not driven the road in the last 12 months.

Sixty per cent of the sample (N=123) considered themselves to be visitors to the area and 40% (N=83) stated that they were local. A comparison of local and non-local drivers can be seen in Table 6.

4.1.3 Design

A three-way mixed design was used. The dependent variable was the speed choice reported by participants to the pictures in the questionnaire. The independent variables were sign type (within participants, three levels: landslide wig-wag sign, ice wig-wag...
sign and school wig-wag sign), scene signage (within participants, three levels: flashing, not-flashing and no sign) and driver type (between participants, two levels: local and non-local).

To counter possible order effects, the order of the scenes after the first three practice scenes was pseudo-randomised as described in Section 4.1.1.

**Table 6. Comparison of local and non-local drivers.**

<table>
<thead>
<tr>
<th></th>
<th>Local (N=83)</th>
<th>Non-local (N=123)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>44.5 (SD=14.5)</td>
<td>47.7 (SD=13.7)</td>
</tr>
<tr>
<td>Licence held (years)</td>
<td>21.7 (SD=13.2)</td>
<td>24.1 (SD=13.5)</td>
</tr>
<tr>
<td>Annual mileage</td>
<td>11,867 (SD=7,848)</td>
<td>13,252 (SD=8,340)</td>
</tr>
<tr>
<td>Gender</td>
<td>69% Male</td>
<td>31% Female</td>
</tr>
<tr>
<td>Drive regularly on A83?</td>
<td>84% Yes</td>
<td>16% No</td>
</tr>
<tr>
<td>Answered Pack A or B</td>
<td>51% Pack A</td>
<td>49% Pack B</td>
</tr>
<tr>
<td>Date interviewed</td>
<td>40% 13/10/2012</td>
<td>60% 17/10/2012</td>
</tr>
</tbody>
</table>

**4.1.4 Procedure**

Interviews were carried out by Traffic Survey Partners (TSP) Ltd at natural stops for motorists driving in the area (e.g. car parks and rest stops). Areas identified and agreed with Transport Scotland for approaching motorists were Arrochar, Inveraray and the Rest and be Thankful (see Figure 7). These locations were visited by the interviewers on two dates (13th October 2012 and 17th October 2012). Permission was sought and granted for all areas where interviews were performed. These locations were selected as they were located on or around the A83.

Once on location, potential participants were approached and asked filter questions to confirm their suitability to take part in the research, as shown in Box 2.

After establishing that a participant qualified and agreed to take part, the interviewer began using the show cards to present pictures of the road scenes as described in Section 4.1.1, with participants responding to each picture with the speed they would choose to drive at in the scene depicted, when driving in their usual car. Once the participant had finished responding to the show card pictures, the interviewer continued to administer the remainder of the questionnaire until it was completed. Participants were then thanked for their co-operation and debriefed.

**4.2 Results**

Six research questions form the basis of the analysis reported in this section. The analyses on speed choice described in Section 4.2.1 and 4.2.2 are based on 198 participants who gave speed choices for all the signs. All remaining analyses are based on the full sample of 206 participants.


Box 2: Questionnaire filter questions.

Are you currently driving in this area?

<table>
<thead>
<tr>
<th>Yes=continue</th>
<th>No=do you regularly drive in this area?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes=continue</td>
<td>No=Thank and decline</td>
</tr>
</tbody>
</table>

We are conducting research into drivers’ views of different road scenes and would appreciate your response. We are simply seeking your honest opinion in response to a series of road scenes that we show you. We will then ask a few further questions. The interview will take 10 to 15 minutes and you are free to stop at any time.

Do you agree to take part?

| Yes=Start | No=Thank and move on |


4.2.1 Drivers’ behaviour and landslide wig-wag signs

What is the effect of installing a landslide wig-wag sign on drivers’ behaviour?

Participants were asked to report a speed choice for each of three landslide wig-wag sign conditions (missing, not flashing and flashing) in four different locations. The overall mean speed choices given by the participants for the three conditions are shown in Figure 13. Error bars on the chart indicate 95% confidence intervals around the mean, giving an indication of the uncertainty in an estimate of the true mean in the population.

![Figure 13. Overall means and 95% confidence interval for means speeds in response to landslide signs in three conditions.](image)

A repeated measures ANOVA showed that the overall mean speed choices for the sign condition was significant, with the overall mean speed for a flashing sign being statistically significantly lower than the other two sign conditions (not flashing and missing).
However, as Figure 14 shows, the result is not quite consistent across the four different locations:

- At locations 1 and 4 the mean speed choice given for the flashing sign was significantly slower than the other two sign conditions.
- At location 2 the mean speed choice given for the flashing sign was significantly slower than the other two sign conditions, and the mean speed choice for the not flashing sign was slower than the missing sign situation.
- At location 3 the mean speed choice given for missing sign was significantly slower than the two signs.

![Figure 14. Overall means and confidence interval for landslide signs in three conditions by four locations.](image)

There were some inconsistencies for some of the landslide signs related to the order of questionnaire seen by the participants. This is discussed in Section 4, in which the evidence as a whole in this evaluation pointing to the generally more variable responses to the landslide signs is considered.

### 4.2.2 Sign type and drivers’ behaviour

*What effect does the type of sign have on drivers’ behaviour?*

In addition to the landslide signs, two additional wig-wag sign types were included in the survey. Repeated-measures ANOVAs detected statistically significant differences between participants’ speed choices for the different sign conditions (flashing, not flashing and missing) for these additional sign types. Figure 15 shows that the pattern of these differences is the same for all the wig-wag sign types, but different in magnitude. That is, for all sign types, the overall means show a significantly slower speed choice once the wig-wag sign is flashing compared with not flashing or missing. However, for the landslide sign, the difference between the mean speed choice for flashing and not flashing/missing signs is smaller than the corresponding difference for the other two sign types (ice and school).
4.2.3 Drivers’ actions and wig-wag signs

What do drivers report they would do if they passed a wig-wag sign when it was flashing and not flashing?

In addition to the speed choices given for the selection of wig-wag signs, the participants also responded to a series of questions including ‘what would you do if you were driving and passed this sign when the lights were (and were not) flashing?’ Table 7 shows that all participants would either slow down or continue at the same speed if they observed the wig-wag signs while they were not flashing. This is consistent with the speed choice analysis shown in Section 4.2.2. For the landslide and ice signs, around three quarters would continue at the same speed, however for the school sign, the response is different, with two thirds opting to slow down.

Table 7. Distribution of participants’ actual speed responses to three wig-wag signs flashing and not flashing.

<table>
<thead>
<tr>
<th>Speed response</th>
<th>Landslide</th>
<th>Ice</th>
<th>School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not flashing</td>
<td>Flashing</td>
<td>Not flashing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flashing</td>
</tr>
<tr>
<td>Continue at same speed</td>
<td>74%</td>
<td>17%</td>
<td>77%</td>
</tr>
<tr>
<td>Slow down</td>
<td>26%</td>
<td>68%</td>
<td>23%</td>
</tr>
<tr>
<td>Speed up</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Turnaround</td>
<td>0%</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>Stop or pull over</td>
<td>0%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total number</td>
<td>206</td>
<td>206</td>
<td>206</td>
</tr>
</tbody>
</table>

When asked the same question with a flashing sign the majority of participants said they would slow down but the pattern of responses is different for the different signs. For the flashing school sign, almost all (203 of 206) participants said they would slow down. For the landslide and ice signs the responses are more mixed with a smaller majority saying
they would slow down for a flashing landslide sign than the ice and school signs. This is consistent with the differences shown in Figure 15.

### 4.2.4 Drivers understanding of wig-wag signs

What do drivers think they should do if they pass a wig-wag sign when the lights flash?

In addition to being asked how they would react to flashing wig-wag signs, the participants were also asked to say what they think they are supposed to do in response to flashing wig-wag signs. The results of these questions, shown in Table 8, are slightly different to how people think they actually would respond. Once again, for each sign type the majority believed that they should slow down in response to the flashing wig-wag signs. The proportion of participants who thought they should slow down was larger than the proportion of participants who responded that they would slow down, as shown in Table 7.

Table 8. Distribution of participants’ assumed correct speed responses.

<table>
<thead>
<tr>
<th>Speed response</th>
<th>Landslide</th>
<th>Ice</th>
<th>School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue at same speed</td>
<td>5%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Slow down</td>
<td>83%</td>
<td>92%</td>
<td>100%</td>
</tr>
<tr>
<td>Speed up</td>
<td>1%</td>
<td>&lt;1%</td>
<td>0%</td>
</tr>
<tr>
<td>Turnaround</td>
<td>5%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Stop or pull over</td>
<td>5%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

### 4.2.5 Road safety and precautions

Do drivers think the signs make the road safer and do drivers take the precautions that Transport Scotland publicised?

Of the 206 respondents, 89 said that they drove on the A83 regularly. These 89 participants were asked the extent to which they agreed or disagreed with the statement ‘I think these signs make the road safer’. Figure 16 shows the distribution of the responses: of the 89 participants, 71% agreed or strongly agreed with the statement and 18% disagreed or strongly disagreed.

![Figure 16. Distribution of responses to ‘I think these signs make the road safer’](image)
Transport Scotland publicises recommendations for precautions drivers using the A83 should take including checking the weather forecast, allowing extra time for a journey, and listening to traffic updates. The participants who said they drove on the A83 regularly were asked whether they follow these precautions and the distribution of the results are shown in Table 9. For each precaution, over half of the 89 respondents agreed or strongly agreed.

**Table 9. Distribution of responses to following Transport Scotland precautions.**

<table>
<thead>
<tr>
<th>Precaution</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I check the weather forecast before driving on the A83</td>
<td>2%</td>
<td>22%</td>
<td>21%</td>
<td>40%</td>
<td>13%</td>
</tr>
<tr>
<td>I allowed extra time for my journey because I was driving on the A83</td>
<td>2%</td>
<td>17%</td>
<td>25%</td>
<td>46%</td>
<td>10%</td>
</tr>
<tr>
<td>I listen to traffic updates on the radio when driving on the A83</td>
<td>10%</td>
<td>25%</td>
<td>12%</td>
<td>45%</td>
<td>8%</td>
</tr>
</tbody>
</table>

**4.2.6 Differences between local or non-local drivers**

*Are there differences between local or non-local drivers?*

Of the 206 participants, 83 classed themselves as local drivers and 123 as visitors to the area¹.

A mixed ANOVA design on the speed choice data analysed in Sections 4.2.1 and 4.2.2 shows that for the ice and school signs, the responses were not significantly different for locals and visitors; however responses to the landslide signs were different, as shown in Figure 17. Visitors tended to give slower speed choices overall, but substantially slower when the landslide sign was flashing.

Similarly, when participants were asked what they would do when they saw the three types of wig-wag signs flashing and not flashing, the responses from visitors and locals were not significantly different for the ice and school signs, but were significantly different for the landslide signs. Figure 18 shows that the visitors are more likely to slow down for a non-flashing sign and give more variation in their responses about what they do when they observed a flashing sign, suggesting a greater level of uncertainty in the correct response to a flashing landslide sign for this group.

These differences are also apparent between visitor and local responses to the question ‘what do you think you are supposed to do when the lights are flashing?’.

**4.3 Limitations**

There are limitations with any research methodology and these limitations must be considered when appraising the results. Face-to-face interviews can be influenced by social response bias whereby participants report a socially desirable response rather than what they really think or how they really behave. There is no reason to believe that

¹ Complete speed choice data were available for 81 locals and 117 visitors.
social response bias has affected the results of this study and measures were taken to minimise this risk. For example, an independent survey company was used to collect responses, an indirect proxy measure of behaviour was used and participants were explicitly asked to be as honest as possible. Nevertheless, the potential effect of such a bias cannot be discounted completely. A further limitation is that the study found some order effect where participants’ responses to the show cards were inconsistently influenced by what they had previously seen. This effect was controlled for in the analysis as far as possible and is not considered to have significantly influenced the main findings of the research.

![Figure 17. Overall means and confidence interval for landslide signs in three conditions by local drivers and visitors.](image)

![Figure 18. Distribution of participants’ actual speed responses to landslide wig-wag signs flashing and not flashing for visitors and locals.](image)

### 4.4 Discussion

The aim of this research task was to establish the impact of the installation of landslide wig-wag signs on the A83 Rest and be Thankful on driver behaviour and attitudes. A
survey design was utilised to measure drivers’ speed choice to a range of driving scenes including landslide and other wig-wag signs, whereby speed choice was considered a proxy for behavioural response. Road scenes were matched and digitally altered to allow direct comparison of participant responses where the sign was active (i.e. flashing), not active, and removed from the scene. Additional survey questions were asked. The face-to-face survey sought to answer the following research questions:

1. What is the effect of installing a landslide wig-wag sign on drivers’ self-reported behaviours?
2. What effect does the type of sign (e.g. landslide wig-wag sign versus other wig-wag warning signs) have on drivers’ behaviours?
3. What do drivers report they would do if they passed a wig-wag sign when the lights are flashing?
4. What do drivers think they should do if they pass a wig-wag sign when the lights are flashing?
5. Do drivers think the signs make the road safer and do drivers take the precautions that Transport Scotland publicised?
6. Are there differences between local and non-local drivers?

Overall results indicate that there is no effect on drivers’ speed choice resulting from the presence of an inactive landslide wig-wag sign, and that the effect of activating the flashing lights on a landslide wig-wag sign is a reduction in chosen speed. This is a desirable outcome as it suggests that the installation of the signs has not resulted in any unexpected behavioural response from drivers and that drivers are responding as anticipated when the signs are activated (i.e. they are taking more care). This result was apparent for both local and non-local drivers, although non-local drivers’ speed reductions to flashing landslide wig-wag signs are more pronounced. It should be noted that the pattern of responses to the flashing wig-wag landslide signs is not entirely consistent across all settings; in one of the four settings, speed choice was shown to increase with the presence of the landslide wig-wag sign with flashing lights. It is not clear why this setting would lead to such a behavioural response and further elucidation of the finding by testing a wider range of sign settings could be considered.

While the overall findings suggest that drivers’ behavioural response to landslide wig-wag signs is in the desired direction (i.e. drivers reduce speed in response to a flashing landslide wig-wag sign) results indicate that the reduction in speed is not to the same magnitude as the reduction in speed to other wig-wag warning signs. Drivers’ reduction in stated speed to both flashing ice warning and school wig-wag signs was found to be greater than that of landslide wig-wag signs. In addition, the pattern of data was less consistent by sign location and by questionnaire order for the landslide signs. These differences by sign type could be for a number of reasons. For example it might suggest that drivers are uncertain of the correct response to a flashing landslide wig-wag sign and do not consider the risk of a landslide to be as immediate as that of either ice on the road or school children being present. This interpretation is supported by what drivers report they would do if they passed a wig-wag sign when it was flashing. Almost every respondent reported that they would reduce their speed upon seeing a flashing school wig-wag sign, and 85% of respondents would slow down in response to a flashing ice warning wig-wag sign. In comparison, only 68% of respondents reported that they would slow down for a flashing landslide wig-wag warning sign. Interestingly, 13% of
respondents reported that they would turn around or stop upon seeing a flashing landslide wig-wag sign and 2% of respondents reported that they would speed up. The lower consistency in stated responses for flashing landslide wig-wag signs suggests that the link between the risk factor being signalled (landslides) and the desired behavioural response (slow down) is not as obvious as it is for the ‘ice’ and ‘school’ risk factors. Presumably this is due to the immediacy of the threat in the landslide setting being less obvious than in the ‘ice’ and ‘school’ settings.

A similar pattern is present in the beliefs drivers stated about what they thought they should do when seeing a flashing landslide wig-wag sign. One-hundred per cent of drivers reported that they should slow down when passing a flashing school wig-wag sign. This drops to 92% of drivers for a flashing ice warning wig-wag sign and drops further to 83% for a flashing landslide wig-wag sign. A proportion of drivers believe that the correct response to passing a flashing wig-wag sign is to continue at the same speed (5%), turn around (5%), stop (5%) or speed up (1%). This is consistent with the proportions who report that this is what they would do and suggests that some drivers are unaware of the desired response, specifically for the landslide wig-wag signs. Further analysis revealed that this group of drivers are largely non-locals and may have therefore missed out on any marketing material disseminated when the signs were installed. It is possible that their behavioural response is a result of a lack of knowledge of the desired response rather than a deliberate act of non-compliance.

Of participants who drove the road regularly, the majority (71%) reported that they agreed that the signs had made the road safer (34% strongly agreed) although 18% disagreed with this statement (7% strongly disagreed). Over half of these drivers also reported following Transport Scotland’s guidelines when using the A83 to check the weather forecast, allow extra time for their journey and listen to travel updates on the radio.
5 Conclusions and Recommendations

This report presents an evaluation of a trial of the use of wig-wag signs as a temporal warning of a higher risk of rainfall-triggered debris flow events on the A83 in the area centred on the Rest and be Thankful. This locality is known for the frequency with which debris flow events occur, much more than any other part of the trunk road network in Scotland. It is thus well-suited to the use of this type of temporal warning. The potential application of this approach to other parts of the network is limited and any proposals should be the subject of detailed location-specific assessment.

Eight debris flow events occurred during 2011 and 2012 in the Rest and be Thankful area. Six of those occurred during periods when a Heavy Rainfall Warning was in force and the wig-wags were switched on and a seventh was most likely contained within that group, albeit that there is some doubt about the precise timing of the event.

The eighth event occurred during a period when there was no Heavy Rainfall Warning in force and the wig-wag signs were switched off (‘false negative’). There may be good reasons for this and some modification to the period during which the wig-wags remain switched on after the Heavy Rainfall Warning ceases to be in force may be needed.

Nevertheless, there was a significant number of ‘false positives’. These are to be expected with a system of this nature, particularly one that is under trial and subject to ongoing development. The wig-wags were activated during 2011 and 2012 on 11% and 15%, respectively, of the days of the year when the switch-on period was not associated with a debris flow event. There seems little doubt that given time the forecast values used to initiate switch on of the wig-wag signs can be improved as set-out in Section 3.4, albeit that this will take some time.

There were also some periods when the wig-wags were not switched on despite a heavy rainfall warning being in force and there is a rational explanation for the majority of these.

It should be noted that, work to further develop the currently tentative rainfall intensity-duration debris flow threshold is ongoing. That work is an important part of Transport Scotland’s continuing programme of work on landslides for reasons that go beyond the operation of wig-wags. As part of this work a review of the post-Heavy Rainfall Warning period during which the wig-wags signs remain switched on should be undertaken. At the appropriate time the activation of the flashing lights on the wig-wag signs should be tied to the intensity-duration threshold rather than the Met Office Heavy Rainfall Warnings.

The results of the survey undertaken to evaluate driver perception of the wig-wags signs have established that overall, the installation of landslide wig-wag signs on the A83 does not appear to have had any negative effect on drivers’ behaviour (as measured by speed choice) overall. However, for one sign scenario, speeds were found to increase slightly and this, along with other patterns in the data may warrant more specific investigation.

Both local and non-local drivers who have experience of driving the A83 reported slower speed choice on average when landslide wig-wag signs are flashing, with non-local drivers reducing their speeds more than local drivers on average. For all drivers, the reduction in speeds to flashing landslide wig-wag signs was not as pronounced as that for flashing ice warning or school wig-wag signs. In addition a small proportion of drivers (largely non-local drivers) was found to report increased undesirable responses to flashing landslide wig-wag signs (as compared with the rate of such undesirable
responses to school and ice warning signs) and this may require targeted interventions to further promote the desired behavioural response. These undesirable responses appear to be due to a lack of understanding rather than deliberate non-compliance.

It is proposed that this may be the result of the link between the risk factor and required behaviour being weaker in the ‘landslide’ setting than in the ‘ice’ and ‘school’ settings, where the immediacy of the threat may be more obvious. The majority of those who drive the A83 regularly, reported that they believed the signs had improved safety on the A83 and more than half undertook precautions supported by Transport Scotland’s previous marketing material.

The three aspects of the operation of the wig-wag signs were set out as follows:

1) The standard fixed-plate rockfall/landslide warning red triangle sign which is used internationally to indicate risks of both rockfall and other types of landslide.

2) The flashing lights that are activated during periods of heavy rainfall.

3) The notifications that are posted on the Traffic Scotland website and thus picked up and promulgated more widely by the media.

The evidence from both the technical and perceptual evaluations indicated that the wig-wag signs trial has a satisfactory outcome and that the flashing lights prompt generally desirable behaviours in the majority of cases. Notwithstanding this, there are areas for improvement and specific recommendations are made below.

That the wig-wag signs have prompted diverse views from road users and local residents is beyond doubt. However, the message that ‘mid-Argyll is effectively closed for business’ when the signs are flashing does not seem to be borne out by the perceptual evaluation in which a relatively small proportion of respondents suggested that they would turn around on encountering a flashing landslide wig-wag sign. Indeed, over 70% of participants in the survey stated that they agreed with the statement that the signs made the road safer, albeit that 18% disagreed with the statement. It does thus seem that this message, erroneous as it is, is most likely a result of media reports focussed on the fact that the wig-wag signs are operating. Such reports originate from the notifications that are placed on the Traffic Scotland website when the signs are activated.

It is recommended that the wig-wag sign installations continue to be maintained and operated, but that the practice of notifying, on the Traffic Scotland website, the periods when the signs are activated be ceased.

A review of the activation procedures is necessary to ensure that periods when the wig-wags remain switched off (or un-activated), despite a heavy rainfall warning being in force, are minimised.

It is also recommended that efforts to promulgate the message about desired behaviours should continue and even be increased to the non-local driver target audience.
References


APPENDIX A: PERCEPTION EVALUATION QUESTIONNAIRE

DATE ______/_____/2012

INTERVIEWER
INITIALS ______________________

LOCATION ________________

Survey of Road Scenes

Questionnaire

Introduction

Are you currently driving in this area?

<table>
<thead>
<tr>
<th>Yes=continue</th>
<th>No=do you regularly drive in this area?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes=continue</td>
</tr>
<tr>
<td></td>
<td>No=Thank decline and</td>
</tr>
</tbody>
</table>

We are conducting research into drivers’ views of different road scenes and would appreciate your response. We are simply seeking your honest opinion in response to a series of road scenes that we show you. We will then ask a few further questions. The interview will take 10 to 15 minutes and you are free to stop at any time.

Do you agree to take part?

<table>
<thead>
<tr>
<th>Yes=Start</th>
<th>No=Thank and move on</th>
</tr>
</thead>
</table>

39 PPR664
We are going to show you pictures of road scenes. For each scene we would like you to estimate the speed at which you would choose to drive, when driving your usual car. There are no ‘right’ or ‘wrong’ answers – we want you to answer honestly with respect to your own driving (in your usual car):

To be answered in response to viewing each show card:

(If questioned regarding repeated scenes, just state “The important thing is that for each picture, you estimate the speed at which you would choose to drive, when driving your usual car. Just do this for each picture we show you.”)

<table>
<thead>
<tr>
<th>At what speed would you choose to drive in this scene?</th>
<th>mph</th>
<th>Or kmph (if preferred)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
43  [use show card page 43 to show sign]

a  What would you do if you were driving and passed this sign when the lights were NOT flashing?
[present as an open question. If necessary, ask “would you alter the speed you were driving at?”]
Interviewer: please code participant’s response using the following:
   1. Continue at same speed
   2. Slow down
   3. Speed up
   4. Turn around
   5. Stop / Pull over
   6. Other (please note)________________

b  What would you do if you were driving and passed this sign when the lights WERE flashing?
[present as an open question. If necessary, ask “would you alter the speed you were driving at?”]
Interviewer: please code participant’s response using the following:
   1. Continue at same speed
   2. Slow down
   3. Speed up
   4. Turn around
   5. Stop / Pull over
   6. Other (please note)________________
c  What do you think you are supposed to do when the lights are flashing?
[present as an open question]
Interviewer: please code participant’s response using the following:
   1. Continue at same speed
   2. Slow down
   3. Speed up
   4. Turn around
   5. Stop / Pull over
   6. Other (please note)______________

44  [use show card page 44 to show sign]

a  What would you do if you were driving and passed this sign when the lights were NOT flashing?
[present as an open question. If necessary, ask “would you alter the speed you were driving at?”]
Interviewer: please code participant’s response using the following:
   1. Continue at same speed
   2. Slow down
   3. Speed up
   4. Turn around
   5. Stop / Pull over
   6. Other (please note)______________

b  What would you do if you were driving and passed this sign when the lights WERE flashing?
[present as an open question. If necessary, ask “would you alter the speed you were driving at?”]
Interviewer: please code participant’s response using the following:
   1. Continue at same speed
   2. Slow down
   3. Speed up
   4. Turn around
   5. Stop / Pull over
   6. Other (please note)______________
c What do you think you are supposed to do when the lights are flashing?
[present as an open question]
Interviewer: please code participant’s response using the following:
1. Continue at same speed
2. Slow down
3. Speed up
4. Turn around
5. Stop / Pull over
6. Other (please note)______________

45 [use show card page 45 to show sign]

a What would you do if you were driving and passed this sign when the lights were NOT flashing?
[present as an open question. If necessary, ask “would you alter the speed you were driving at?”]
Interviewer: please code participant’s response using the following:
1. Continue at same speed
2. Slow down
3. Speed up
4. Turn around
5. Stop / Pull over
6. Other (please note)______________

b What would you do if you were driving and passed this sign when the lights WERE flashing?
[present as an open question. If necessary, ask “would you alter the speed you were driving at?”]
Interviewer: please code participant’s response using the following:
1. Continue at same speed
2. Slow down
3. Speed up
4. Turn around
5. Stop / Pull over
6. Other (please note)______________
c  What do you think you are supposed to do when the lights are flashing?  
[present as an open question]

Interviewer: please code participant’s response using the following:

1. Continue at same speed
2. Slow down
3. Speed up
4. Turn around
5. Stop / Pull over
6. Other (please note)__________________

46  Do you drive regularly on this section of the A83 (Rest and be Thankful)?
[show map on page 46 of the show cards and read out options]

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 1</td>
<td>□ 2</td>
</tr>
</tbody>
</table>

Go to 47a  Go to 47b

47a  If Yes: how often do you drive on this section of the A83 (Rest and be Thankful)

<table>
<thead>
<tr>
<th>Less than once or twice a month</th>
<th>Once or twice a month</th>
<th>Once a week</th>
<th>Few times a week</th>
<th>Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
</tbody>
</table>

Go to Q48

47b  If No: Have you driven on this section of road in the last 12 months?

<table>
<thead>
<tr>
<th>No</th>
<th>Yes, I have driven on it as a visitor to the area</th>
<th>Yes, I have driven it as I am local but I do not drive it regularly</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
</tr>
</tbody>
</table>

Go to Q49
48 Using scale A, please rate your response from 1 (Strongly Disagree) to 5 (Strongly Agree) to the following statements

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>I think these signs make the road safer</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>b</td>
<td>I check the weather forecast before driving on the A83 (Rest and be Thankful)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>c</td>
<td>I allow extra time for my journey because I was driving on the A83 (Rest and be Thankful)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>d</td>
<td>I think drivers pay attention to these signs</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>e</td>
<td>I listen to traffic updates on the radio when I was driving/drive on the A83 (Rest and be Thankful)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>

49 What is your age? _______________ years

50 Gender? Male □ 1 Female □ 2

51 Are you a UK citizen? Yes □ 1 No □ 2

If No, what is your nationality? ____________________________

52 Would you consider yourself a local to this area or are you a visitor?

Local □ 1 Visitor □ 2
53 Please state the postcode or town where you usually live.

Postcode ___________ or Town ___________

54 Do you hold a valid UK driving licence?  
Yes □ 1  No □ 2  

55 How long have you had a driving licence (from any country)?

_______________ months  or  ___________ years

56 Approximately, how many miles or kilometres do you drive each year?

_______________ miles  _______________ kilometres

57 [show page 48 on show card]  
Using Scale B, please rate how frequently you:

<table>
<thead>
<tr>
<th></th>
<th>Very infrequently</th>
<th>Very frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Drive fast</td>
<td>1  2  3  4  5  6</td>
</tr>
<tr>
<td>b</td>
<td>Exceed the speed limit in built up areas</td>
<td>1  2  3  4  5  6</td>
</tr>
<tr>
<td>c</td>
<td>Exceed the speed limit on motorways</td>
<td>1  2  3  4  5  6</td>
</tr>
</tbody>
</table>

58 Finally, have you seen these signs in the media or on leaflets?  
[show show card page 43 or 47]

Yes □ 1  No □ 2

If yes, where have you seen them? (select all that apply):

- In an article in a newspaper or magazine □ 1
- In an item on the TV □ 2
- On an information leaflet □ 3

Do you have any further comments?

_____________________________________________________________________________
_____________________________________________________________________________

Thank respondent for their participation and time
APPENDIX B: QUESTIONNAIRE SHOW CARDS

In this Appendix Show Card Pack A is presented. The pictures were presented as show cards in two packs (Pack A and Pack B). Both packs started with the same three filler pictures to give participants a chance to practice and clarify instructions with the interviewer. Pack A then presented pictures 4-42 in a pseudo-randomised order (the order was initially randomised, researchers ensured that no pictures of the same scene were adjacent). Pack B presented pictures 4-42 in the reverse of the order used in Pack A.
Wig-Wag Evaluation
### Wig-Wag Evaluation

<table>
<thead>
<tr>
<th>Scale A</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Scale B</td>
<td>Very infrequently</td>
<td>Very frequently</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------</td>
<td>-----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>