Indicators and trends

Monitoring climate change adaptation

climate change
Scotland's centre of expertise connecting climate change research and policy

Indicator name				Version
BT4 Flood events affecting the trunk road network				**10/03/16**
Indicator type:	**Risk/opportunity**	**Impact**	**Action**	
		X		

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Buildings and infrastructure networks	B1; B2; B3	FL8a Roads at significant risk of flooding TR1 Risk of traffic disruption

At a glance

- Flooding was the fourth most common recorded cause of trunk road incidents between January 2014 and March 2015
- Climate change is predicted to increase the frequency and extent of flood events and impacts
- Only a small proportion of recorded flood events during the period assessed were severe enough to result in full road closure
- Approximately half of the recorded flood events during the period assessed were located within National Flood Risk Assessment (NFRA) Potentially Vulnerable Areas (PVAs)

Latest Figure	Trend
January 2014 to March 2015: Flood Incidents recorded on the trunk road network: • Total number: **567** • 51.7% were on sections of the network within Potentially Vulnerable Areas (PVAs) as identified in SEPA'S National Flood Risk Assessment (NFRA) • A small proportion of incidents (8, or 1.41%) resulted in full road closure • Around one sixth (16.75%) resulted in flood depths of 3cm or more Flooding was the fourth most common cause of trunk road incidents – behind abandoned or broken down vehicles, road traffic collisions and damaged road or street furniture. Flooding was the most common cause of weather-related incidents and the most common cause of road closures.[1] [2]	

[1] It should be noted that incident data was not recorded for some trunk roads for all or part of the period January 2014 to March 2015 (see Limitations section)

[2] Incident data was not available for bridges managed by statutory bridge authorities (see Limitations section)

Why is this indicator important?

Flooding can disrupt the operation of the road network with knock-on consequences for many social and economic functions – e.g. delaying deliveries, preventing or delaying people from accessing employment or disrupting vital healthcare services. Communities located in remote areas are particularly vulnerable to road network disruption as they rely more heavily on road transport than those living and working in other parts of Scotland and alternative routes (where these exist) often require long diversions.

This indicator uses standardised trunk road incident data as reported by Scotland's trunk road Operating Companies (OCs) to assess flood events affecting the road network. The data is managed centrally by Transport Scotland through the Integrated Road Information System (IRIS). As explained further in the limitations section below, IRIS has only been fully operational since August 2014 meaning that the data presented in this section is incomplete (i.e. there are likely to be more flooding incidents than are reported here).

Related indicators:
BT2 Road network at risk of flooding
BT6 Road network benefitting from fluvial flood protection
BT17 Risk of traffic disruption as a result of flooding

What is happening now?

Table 1 presents current figures for each of the four metrics assessed for this indicator for the period January 2014 – March 2015. The location of all recorded trunk road flooding incidents during this period is shown in Figure 1.

Table 1 Trunk road network flood incidents (Jan 2014 – Mar 2015)

BT4 Metric	%	Figure
BT4a: Total number of reported trunk road flooding incidents	**-**	**567**
BT4b: Proportion of reported trunk road flooding incidents located within Potentially Vulnerable Area (PVAs)	**51.68%**	**293**
BT4c: Proportion of reported trunk road flooding incidents resulting in road closure	**1.41%**	**8**
BT4d: Proportion of reported trunk road flooding incidents where flooding is over 3cm depth	**16.75%**	**95**

Potentially Vulnerable Areas (PVAs), as identified in the National Flood Risk Assessment (SEPA, 2011), are locations where flood hazards could affect multiple receptors and therefore where the consequences of flooding are likely to be high[3]. Flooding events on transport links within such areas are likely to have important knock-on consequences for other socio-economic systems. In this respect it should be noted that just under half (48.7%) of the trunk road network itself is located within the PVAs, and that just over half (51.68%) of the trunk road flooding incidents recorded were located within PVAs. The spatial distribution of PVAs and trunk road flooding incidents within the PVAs is shown in Figure 1.

[3] According to the approach taken by NFRA, trunk roads were regarded as high value receptors and hence the presence of a trunk road increases the likelihood of an area being designated a PVA

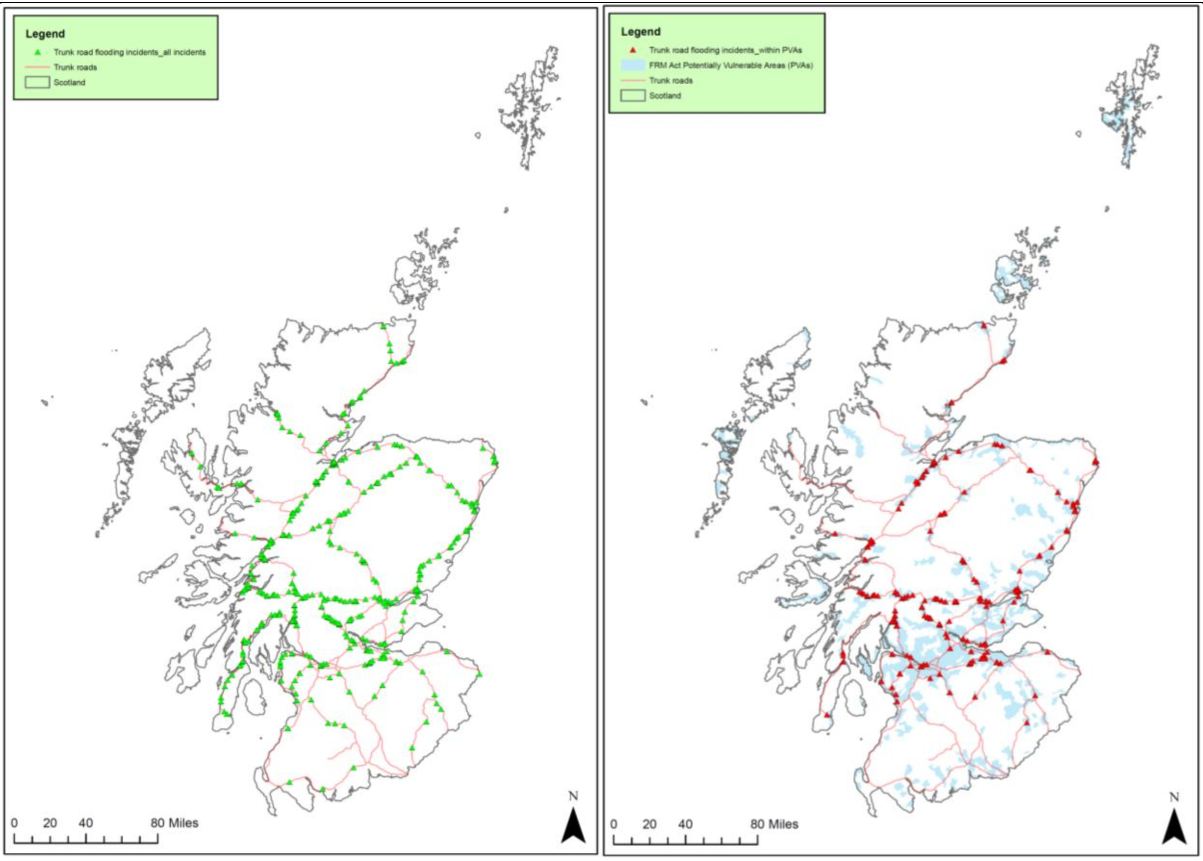
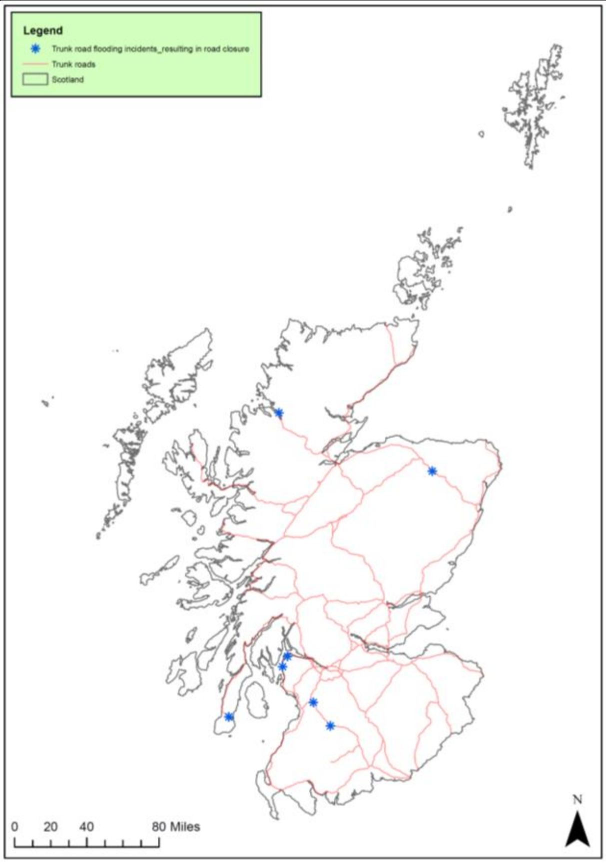


Figure 1. Location of all recorded trunk road flooding incidents (LH map) and all of those located within Potentially Vulnerable Areas (RH map) between January 2014 and March 2015 (IRIS, SEPA (2011)).

In terms of the severity of impact, only 1.41% of trunk road flooding incidents resulted in full road closure. The location of these incidents is shown in Figure 2.

Flooding of over 3cm depth provides another proxy assessment of flood incident severity (see Appendix 1, Table 4 Indicator Methodology below). 16.75% of trunk road flooding incidents recorded during the period assessed were incidents where flood depth was over 3cm. The location of these incidents is also shown on Figure 2.

To put these metrics in context, Table 2 summarises the number of different types of reported trunk road incidents and the proportion of incidents which resulted in a road closure. Flooding was the fourth most common type of incident overall and occurred more frequently than other incident types directly associated with climate change risk, namely high winds, landslides and severe weather. Also, the number of flooding incidents resulting in a complete road closure occurred more frequently but with the same order of magnitude as road closures associated with other potential climate change risks, i.e. high winds, landslides and severe weather.



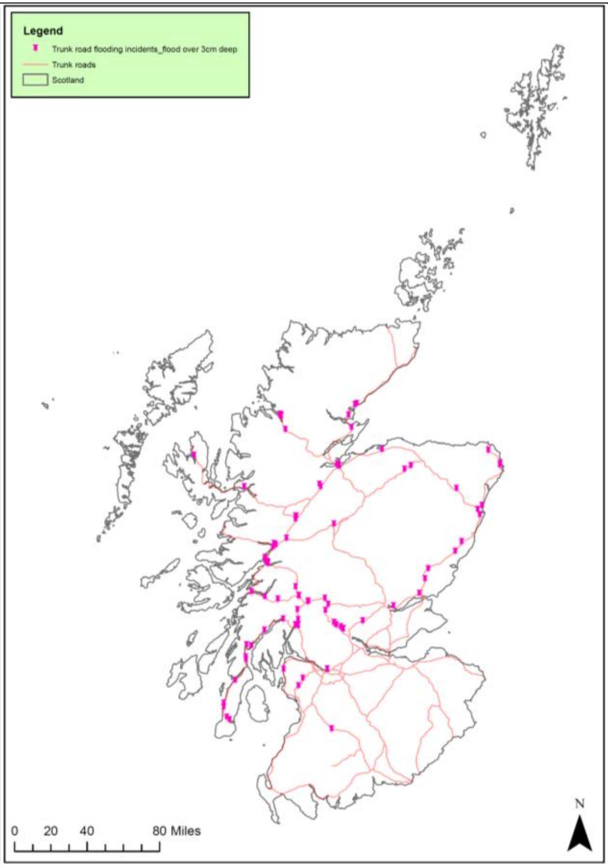


Figure 2 Location of trunk road flooding incidents that resulted in road closure (LH map) and those incidents where flooding was over 3cm depth (RH map) between January 2014 and March 2015

Table 2 Comparison of trunk road network incidents January 2014 – March 2015

Incident type	Total number of reported incidents	Incidents resulting in road closure (% in brackets)
Abandoned or broken down vehicles	**1,768**	**100 (5.66)**
Road traffic collisions (RTC)	**1,015**	**68 (6.70)**
Damaged road / street furniture	**906**	**1 (0.11)**
Flooding	**567**	**8 (1.41)**
Landscaping and fallen / overhanging branches	**131**	**2 (1.53)**
Obstruction or damage from vandalism	**79**	**0**
High winds	**16**	**4 (25.0)**
Rock fall	**13**	**0**
Landslide	**12**	**5 (41.7)**
Severe weather (snow, fog and rain)	**4**	**2 (50.0)**
Subsidence	**2**	**0**

Note: Incidents have been listed in order of frequency of occurrence, highest to lowest.

What has happened in the past?

Historic flooding incident data is not available prior January 2014 to assess these metrics over time (i.e. to determine any trends in flood events affecting the trunk road network). However historic climate data shows how key aspects of climate (rainfall) have changed leading to impacts on biophysical systems (e.g. hydrological response of Scotland's catchments and watercourses) and ultimately changes to the scale and magnitude of relevant climate risks (i.e. risk of traffic disruption as a result of flooding). Overall there is a clear upward trend in winter precipitation as well as increasing heavy rainfall in winter (Sniffer, 2014). It is expected that these climatic changes will have contributed to increased frequency and extent of pluvial and fluvial source flooding and associated impacts on the trunk road network.[4]

What is projected to happen in the future?

The UK Climate Change Risk Assessment (HR Wallingford et al, 2012a; Thornes et al, 2012) assessed changes in flood risk to road infrastructure as a result of anticipated climate changes. Whilst this assessment was only undertaken for England and Wales (due to data availability) it provides a broad indication of what might happen in Scotland in the future given anticipated climate changes. Given this, transport specific aspects from the UK CCRA can be used in conjunction with general aspects from the Scotland CCRA (HR Wallingford et al, 2012b) to understand how flooding related impacts to road infrastructure might change in the future.[5]

The following projected changes are anticipated for the future:

- The proportion of the road network located in areas at risk of flooding is projected to increase
- Road infrastructure that is already located in the floodplain is expected to be affected by flooding more frequently
- Increased incidence of intense summer rainfall events may result in more frequent pluvial (surface water) flooding

The last two projected changes are of particular relevance. Any increase in the frequency of flood events affecting the road network (fluvial, pluvial or coastal) may also increase the number of flooding related incidents on the trunk road network recorded and managed by the OCs. Crucially, any flooding incident recorded by the OCs (with the exception of minor incidents perhaps) is likely to be of a severity such that it causes significant traffic disruption (Transport Scotland, undated). In summary therefore, anticipated climate changes are likely to increase the number of flooding incidents on the trunk road network and increase traffic disruption (though note that this does not account for any action that might be taken, such as increasing drainage capacity).

Patterns of change

No patterns of change have been identified.

Interpretation of indicator trends

No trends identified for BT4 due to lack of historical data.

[4] A fuller account of historic climate trends is provided in indicator BT2.

[5] Indicator BT2 provides a detailed description of the assessment undertaken.

Limitations

The limitations to the assessment of this indicator are summarised below:

1. Transport Scotland's Integrated Road Information System (IRIS) has only been fully operational since August 2014. In particular, IRIS has been collecting OC data for the west of the country since late 2013 but only since August 2014 for the east (Ramage, 2015). As such, the assessment presented here is based on incomplete data and the number of flood events affecting the road network will be higher than that recorded. Also, it will not be possible to draw any conclusions as to the spatial distribution of flood events (e.g. to account for possible variations in climate and associated climate impacts between west and east Scotland).
2. Some trunk roads are not covered under IRIS as they are not managed by the OCs (Ramage, 2015). This will also affect the accuracy of this indicator's metrics but the number of flood events affecting the trunk road network is likely to be higher in reality as a result.
3. Some major bridges which connect parts of the trunk road network were managed by separate statutory authorities during the period of assessment and thus did not form part of the trunk road network. Bridge closures due to high winds were not included in the IRIS data.
4. Some data recording is not mandatory for the OCs and the consistency of data recording year-to-year may change (Ramage, 2015), especially given the somewhat qualitative nature of the trunk road incident classification system (Traffic Scotland, undated). As a result, the accuracy of the absolute figures / metrics assessed as part of this indicator may not be consistent.
5. The projections of what might happen in the future in terms of flood events affecting the road network are based on English and Welsh data only from the UK CCRA. Whilst this provides a useful broad indication of possible future risks, the accuracy of any quantitative assessment is limited and the 'future risk assessment' / trends assessment is based on climate projections data only, as per the Scotland CCRA.

References

HR Wallingford, AMEC Environment and Infrastructure, The Met Office, Collingwood Environmental Planning, Alexander Ballard Ltd, Paul Watkiss Associates, & Metroeconomica (2012a). *UK Climate Change Risk Assessment* [online]. Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report [accessed 22/05/15]

HR Wallingford, AMEC Environment and Infrastructure, The Met Office, Collingwood Environmental Planning, Alexander Ballard Ltd, Paul Watkiss Associates, & Metroeconomica (2012b). A *Climate Change Risk Assessment for Scotland* [online]. Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report [accessed 22/05/15]

Ramage, A (2015) *Personal communication with Alex Ramage*, Transport Scotland Head of Management Information Systems, April 23, 2015)

SEPA (undated). *Flood Risk Management (Scotland) Act 2009 – Appraisal Method for Flood Risk Management Strategies*. [not available online]

SEPA (2011). *The National Flood Risk Assessment* [online]. Available at: http://www.sepa.org.uk/environment/water/flooding/flood-risk-management/national-flood-risk-assessment/ [accessed 27/05/15]

Sniffer (2014). *Scotland's Climate Trends Handbook* [online]. Available at: http://www.environment.scotland.gov.uk/climate_trends_handbook/index.html [accessed 21/05/15]

Thornes, J., Rennie, M., Marsden, H., & Chapman L (2012). *Climate Change Risk Assessment for the Transport Sector* [online]. Available at: https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report [accessed 22/05/15]

Transport Scotland (undated). *4th Generation Term Contract for Management and Maintenance of the Scottish Trunk Road Network North East Unit* [online]. Available at: http://www.transportscotland.gov.uk/system/files/documents/tsc-basic-pages/NE%20-%20S7P3.pdf [accessed 27/05/15]

Transport Scotland (2015). *Operating Companies pages* [online]. Available at: http://www.transportscotland.gov.uk/road/maintenance/operating-companies [accessed 27/05/15]

Further information

ClimateXChange (2016) Adaptation to Climate Change: Context and Overview for Transport Infrastructure Indicators. Available online at: http://www.climatexchange.org.uk/adapting-to-climate-change/indicators-and-trends/

Acknowledgements

The analysis and development of this indicator was undertaken by Dr Neil Ferguson (University of Strathclyde) and Dr Peter Phillips (Collingwood Environmental Planning Limited), utilising National Flood Risk Assessment Potentially Vulnerable Area (PVA) data provided by SEPA and trunk road incident data provided by Transport Scotland.

Katherine Beckmann, Heriot-Watt University / CXC contributed to this indicator.

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	BT4 Flood events affecting the trunk road network
Indicator contact: Organisation or individual/s responsible for the indicator	ClimateXChange
Indicator data source	• **Transport Scotland** – IRIS trunk roads incident data • **SEPA** – National Flood Risk Assessment Potentially Vulnerable Area (PVA) data
Data link: URL for retrieving the indicator primary indicator data.	Transport Scotland: data not available online (request only) SEPA: data not available online (by request only)

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	Data presented in this iteration of this indicator is for the period January 2014 – March 2015
Frequency of updates: Planned or potential updates	IRIS trunk roads incident data is updated at least annually It is not clear if and when the NFRA will be updated
Spatial coverage: Maximum area for which data is available	Scotland wide
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	See 'Limitations' section
Spatial resolution: Scale/unit for which data is collected	The spatial resolution of incident data is unknown
Categorical resolution: Potential for disaggregation of data into categories	
Data accessibility: Restrictions on usage, relevant terms & conditions	IRIS trunk road incident data available on request from Transport Scotland. NFRA PVA data is available under license from SEPA.

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
IRIS trunk road incident data: [not available online] SEPA NFRA PVA data: [not available online]

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Individual methodologies have been provided for each of the four metrics in BT4. *Introduction to the approach* BT4 presents metrics on flood events affecting the trunk road network. The assessment of BT4 is based on trunk road incident data provided by Scotland's trunk road Operating Companies (OCs), in accordance with their contractual agreements (Transport Scotland, 2015). The OCs are required to report on major, critical and minor incidents (Transport Scotland, undated). Major incidents are the most severe and minor the least (ibid). The OCs are contractually required to collate and report a range of data on trunk road incidents as recorded by the Integrated Road Information System[6] (IRIS), which is managed by Transport Scotland (ibid). Data to be recorded by OCs includes: 1) type of incident – e.g. flooding, landslide, road traffic collision; 2) disruption type – includes full road closure; and 3) road surface conditions – includes flood over 3cm deep. Based on this data, the sub-section below lists the metrics assessed as part of BT4. This and other data is used to assess specific BT4 metrics as outlined below. Metric BT4b assesses the proportion of trunk road flooding incidents located within Potentially Vulnerable Areas (PVAs). PVAs were identified through the National Flood Risk Assessment (NFRA) and represent areas where the potential impact(s) of flooding are sufficient to justify further assessment and appraisal of flood risk management actions (SEPA, 2011). In line with the NFRA therefore, it is useful to track the number of flood events that occur in PVAs as this is where flooding impacts to transport infrastructure could have important knock-on consequences for other socio-economic systems (e.g. commuter journeys, logistics, health service related journeys). It should be noted that according to the approach used by NFRA, the presence of a trunk road increases the likelihood of an area being designated a PVA. Metric BT4c assesses the proportion of trunk road network flooding incidents resulting in road closure. Full road closure in this context is considered to be the most severe type of flood incident

[6] IRIS has only been fully operational since August 2014 – i.e. there is only a full dataset of trunk road incidents for the whole of Scotland from August 2014 onwards. However, IRIS data for the west of the country is available for the whole of 2014. As such, the BT4 data presented to date is incomplete and does not capture all flood events affecting the trunk road network (Alex Ramage – Transport Scotland Head of Management Information Systems, personal communication, April 23, 2015).

(Graham Edmond – Transport Scotland Head of Network Maintenance, personal communication, March 6, 2015), thus BT4c provides a useful proxy of trunk road network flood event severity.

Metric BT4d assesses the proportion of trunk road network flooding incidents where flooding is over 3cm deep. Although flood depths of over 15cm (0.15m) are required to impede safe driving (SEPA, undated), OCs record data on flood events where flood depth is over 3cm which is considered to provide another useful proxy of trunk road network flood event severity.

Metrics assessed under indicator BT4

Box 1. Metrics assessed under indicator BT4

- **BT4a Metric:** Total number of trunk road flooding incidents
- **BT4b Metric:** Proportion of trunk road flooding incidents located within Potentially Vulnerable Areas (PVAs)
- **BT4c Metric:** Proportion of trunk road flooding incidents resulting in road closure
- **BT4d:** Proportion of trunk road flooding incidents where flooding is over 3cm deep

Methodologies adopted in the assessment of BT4 metrics

This section provides details of the methodology adopted to assess each BT4 metric. The methodologies include steps that are undertaken in a GIS indicated in pale green and steps that are undertaken in Microsoft Excel indicated in dark green. A separate metric calculation template has been created in Microsoft Excel.

Assessment methodology for BT4 Metric No.1 – total number of trunk road network flooding incidents

Assessment Step	Method
1	Select flooding incidents only from the IRIS trunk road incidents data using the following query: “INCIDENT_T” = ‘FLOODING’
2	Sum the number of flooding incidents in the Assessment Step **No.1** output

Assessment methodology for BT4 Metric No.2 – proportion of trunk road network flooding incidents located within Potentially Vulnerable Areas (PVAs)

Assessment Step	Method
1	Select flooding incidents only from the IRIS trunk road incidents data using the following query: “INCIDENT_T” = ‘FLOODING’
2	Sum the number of flooding incidents in the Assessment Step **No.1** output
3	Clip the output of Assessment Step **No.1** to the FRM Act PVA layer
4	Sum the number of flooding incidents in the Assessment Step **No.3** output
5	Divide the output of Assessment Step **No.4** by the output of Assessment Step **No.2** and multiply by 100. This produces a figure for BT4 Metric No.2: *Proportion of trunk road network flooding incidents located within Potentially Vulnerable Areas (PVAs)*

Assessment methodology for BT4 Metric No.3 – proportion of trunk road network flooding incidents resulting in road closure

Assessment Step	Method
1	Select flooding incidents only from the IRIS trunk road incidents data using the following query: “INCIDENT_T” = ‘FLOODING’
2	Sum the number of flooding incidents in the Assessment Step **No.1** output
3	Select flooding incidents resulting in road closure only from the output of Assessment Step **No.1** using the following query: “DISRUPTI_1” = ‘ROAD CLOSED’
4	Sum the number of flooding incidents in the Assessment Step **No.3** output
5	Divide the output of Assessment Step **No.4** by the output of Assessment Step **No.2** and multiply by 100. This produces a figure for BT4 Metric No.3: *Proportion of trunk road network flooding incidents resulting in road closure*

Assessment methodology for BT4 Metric No.4 – proportion of trunk road network flooding incidents where flooding is over 3cm depth	
Assessment Step	**Method**
1	Select flooding incidents only from the IRIS trunk road incidents data using the following query: “INCIDENT_T” = ‘FLOODING’
2	Sum the number of flooding incidents in the Assessment Step **No.1** output
3	Select flooding incidents where flooding is over 3cm depth only from the output of Assessment Step **No.1** using the following query: “ROAD_CONDI” = ‘FLOOD OVER 3CM DEEP’
4	Sum the number of flooding incidents in the Assessment Step **No.3** output
5	Divide the output of Assessment Step **No.4** by the output of Assessment Step **No.2** and multiply by 100. This produces a figure for BT4 Metric No.4: *Proportion of trunk road network flooding incidents where flooding is over 3cm depth*