Roads can drive your risk! A look at the importance of itinerants on roads in your consequence assessments.

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Currently there is little guidance available on how itinerants on roads should be included in a consequence assessment. The methods available are often subjective which can lead to itinerants on roads either being ignored or insufficiently considered. A fact that can in turn lead to consequence categories being inappropriately assigned to the asset being assessed or risks being under or over estimated. Consideration of these itinerants is especially important for smaller dams or retarding basins in urban areas where often the Potential Loss of Life (PLL) in buildings is small but there are major roads carrying a large Population At Risk (PAR) through the inundation extent, which experience flooding of sufficient severity to pose a threat to life.

This paper looks at how the method used to assess itinerants on roads can affect the consequence category assigned to an asset and/or the risk of the dam or retarding basin. It will draw on a number of recent assessments undertaken for retarding basins within Melbourne and make comment on a possible approach to consider itinerants on roads in the future.

\textbf{Keywords:} Itinerants, PAR, PLL, Roads, Consequence Category, Risk

\section{Introduction}

In early 2016 GHD was commissioned by Melbourne Water to undertake a consequence and risk assessment for a number of retarding basins (RBs). During this process GHD explored a number of key factors which could influence the outcomes of the risk assessment, namely, itinerants (in particular on roads), blockage of the outlet structures and the fatality rates applied to non-break floods. This paper explores one of these aspects, itinerants on road.

Currently there is no definitive guidance on how itinerants on roads should be included in consequence assessments, except for a recommendation to consider them in sufficient detail to determine their impact on the consequences assigned to the asset (ANCOLD, 2012). There are currently a few methodologies that have been proposed or considered to address this need, but these are generally subjective and/or overly coarse which can lead to assets being assigned inappropriate consequence categories and/or under or over stated risks. Consideration of itinerants on roads is especially important for smaller dams or retarding basins in urban areas where the Potential Loss of Life (PLL) in buildings is small, but there are major roads passing through the inundation extent.

Roads should be included in these assessments if they meet the following basic criteria:

- Experience flooding of sufficient severity to pose a threat to life; and
- Carry a significant portion of non-local traffic through the inundation extent (i.e. PAR that do not live within the inundation extent).

These criteria ensure that the calculated PAR is not overly conservative by double counting some of the PAR and minimise the number of roads to be considered separately in these assessments. Although important, the selection of roads is not discussed further as part of this paper.

This paper provides a brief overview of a number of methods used to estimate the potential loss of life (PLL) on roads including a method developed by GHD and tested on the project mentioned above. It then compares the PLL estimates for each of the methods for a number of RBs and looks at the impact of the PLL estimates on the Consequence Category and risk associated with some of the basins. Lastly, it makes a comment on a possible way forward.

\section{Current PLL Approaches for Itinerants on Roads}

A number of studies have shown that a large proportion of all flood related fatalities in Australia relate to motor vehicle use. Fitzgerald et al (2010) assessed the 73 recorded flood deaths in Australia over the 12-year period from 1997 to 2008. This assessment indicated that approximately 50% of deaths relate to motor vehicle users. The study concluded that “the vast majority of deaths in Australia (~90%) that occur as a result of floods occur because of the choices made by the individuals; choices to engage in inappropriate risk-taking behaviour or to enter flooded waterways either by foot or in a vehicle”. It follows that the estimation of Potential Life Loss (PLL) for the failure of dams (including retarding basins) ought to involve careful consideration of the danger posed to road users. It is also important that a consistent,
objective and repeatable method be adopted so that a comparison can be made between different retarding basins when assessing their risk and prioritising them for upgrade works.

In regards to the estimation of itinerants on roads, the ANCOLD (2012) Guidelines on the Consequence Categories for Dams suggests that “the risk posed to vehicle traffic arise from a number of possible hazards including:

- being present in the flood inundation zone at the time that the dam break flood wave passes through
- driving into the flooded area during or after the flood wave passes through.”

Furthermore, the Guidelines mention that they are “not intended to cover every possible scenario and where the inclusion of itinerants in the assessment of PAR has the potential to influence the Consequence Category, it is recommended that adequate studies be undertaken to properly assess their contribution.”

As part of the consequence assessment undertaken on the 48 RBs, Melbourne Water requested that all RBs be assessed in line with a Guidance Note (HARC, 2016). In the Guidance Note, three methods were mentioned for estimating PLL on major roads which experienced flow that could pose a threat to life:

- Campbell et al (2013);
- Graham (2008); and
- Alternate methods, such as GHD (2016).

A brief explanation of each method including the pros and cons of each are given in the proceeding sections. The ‘Do Nothing’ (Buildings only) approach is also included to show the importance of including itinerants in the Consequence Category assessments.

2.2 ‘Campbell Method’ (Campbell et al, 2013)

The ‘Campbell Method’ calculates the PAR and PLL on each section of inundated road as a whole based on the following inputs:

- Location specific hazard (depth, velocity and depth x velocity or DV) for a given inundation extent;
- Location specific traffic volume (based on Average Annual Daily Traffic or AADT);
- Vehicle speed;
- Vehicle occupancy; and
- An assessment or calculation of the three factors below using guidance in Campbell et al, 2013:
  - \( P_{NE:T} \) - the probability of the driver of the vehicle taking no action to avoid the particular hazard.
  - \( P_{ANE} \) - the probability of an accident given that the driver of the vehicle has taken no action to avoid the hazard.
  - \( V_{DA} \) - the vulnerability (fatality rate) of the vehicle occupants given that an accident has occurred.

Using this data, the method involves the following steps for each road being assessed:

**Step 1: Assessing the chance of a vehicle being in the inundation extent**

The time a vehicle is in the flood inundation area \( (T_v) \) is estimated based on the length of inundation divided by the vehicle speed multiplied by the number of vehicles per hour \( (N_v) \). The number of vehicles per hour is calculated assuming a percentage of the vehicles per day are travelling during business hours and the remainder after hours.

**Step 2: Calculating the PAR**

The PAR within the flood inundation area is then estimated using the following formula for two potential PAR scenarios (being present in the flood inundation zone and driving into the flooded area during the flood) in two time periods and summed to give a total weighted PAR for the road:

\[
PAR = \frac{T_D}{24} \times P_{T:S} \times P_{NE:T} \times P_{ANE}
\]

Where:

\( T_D \) = Number of hours in assessed time period (i.e. day and night, or ‘Business Hours’ and ‘After Hours’)

\( P_{T:S} \) = Temporal spatial probability of car being present in inundation extent

\( = N_v \times T_v \) for scenario where vehicle is present in the flood inundation zone

\( = 1 \) in each direction for scenario involving cars driving into the flooded area

\( P_{NE:T} \) = Probability of the driver of the vehicle taking no action to avoid the particular hazard

(assumed to be 1 for scenario involving cars being present in the inundation extent)
$P_{A,NE}$ = Probability of an accident given that the driver of the vehicle has taken no action to avoid the hazard 
(calculated based on location specific hazard)

**Step 3: Determining the PLL**

The PLL is then calculated by multiplying the weighted PAR from above for each scenario by the factor $V_{D,A}$ and summing these to give a total weighted PLL for the whole section of inundated road being assessed.

The results of this process for each road assessed are then summed for a given dam break scenario and compared to the same assessment for the non-fail scenario to determine the incremental PLL (i.e. the PLL that can be attributed to dam failure). Although not explicitly stated, this comparison is inherently required to determine the loss of life attributed to the basin failure.

This method is highly dependent on the selection of the three key factors ($P_{NE,T}$, $P_{A,NE}$ and $V_{D,A}$), with the results being most sensitive to $P_{A,NE}$. For example, for a DV value of 0.44 m$^2$/s than a value of 0.1 is assigned to $P_{A,NE}$ (for speeds up to 50 km/h), but this increases to 0.8 if the DV is 0.45 m$^2$/s or greater.

An overview of the pros and cons of the Campbell Method are provided in Table 1.

<table>
<thead>
<tr>
<th>Table 1 Campbell Method Pros &amp; Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROS</strong></td>
</tr>
<tr>
<td>• Simple to implement in a spreadsheet.</td>
</tr>
<tr>
<td>• Considers different aspects of the hazard (e.g. probability of taking no action to avoid the hazard).</td>
</tr>
<tr>
<td>• Considers hazard at the road being assessed</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**2.3 Graham Method (Graham, 2008)**

It should be noted up front that the ‘Graham Method’ is currently an unpublished draft. The ‘Graham Method’ is an empirical relationship based approach developed using actual vehicle related fatalities as a result of a dam break. Although this method is an unpublished draft, as it was included in the Guidance Note provided by Melbourne Water, it has been included in this paper for comparison purposes only. The method is very simple and allows the user to consider itinerant road users without the need for detailed modelling or the selection of subjective criteria or probabilities. In order to calculate a PLL for roads, this method requires the following inputs:

• Road Usage Index (RUI) for all of the roads being assessed for a given dam break scenario. The RUI is broken into four categories based on its location (rural or urban), construction type (sealed or unsealed) and size (single or multi-lane);

• Peak outflow from dam failure – this is calculated using the equation developed by Froehlich (Froehlich, 1995); and

• Distance of the road being assessed downstream of the dam.

These three factors are then used to calculate the ‘Road-Usage-Danger-Factor’ (RUDF) for the dam failure scenario being assessed (i.e. for all inundated roads), which is then used to look up the number of expected vehicle related dam failure fatalities (or PLL) from a table based on the interpretation of the fatality database presented in Graham, 2008.

An overview of the pros and cons of the Graham Method are provided in Table 2.

<table>
<thead>
<tr>
<th>Table 2 Graham Method Pros &amp; Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROS</strong></td>
</tr>
<tr>
<td>• Quick and simple to implement in a</td>
</tr>
<tr>
<td>Spreadsheet</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>• Doesn’t require road specific hazard or traffic data.</td>
</tr>
</tbody>
</table>

### 2.4 GHD Method (GHD, 2016)

The ‘GHD Method’ calculates the PAR and PLL on each section of inundated road as a series of smaller independent sections based on the following inputs:

- Location specific hazard (depth, velocity and depth x velocity (DV)) for a given section of inundated road;
- Location specific traffic spacing (based on AADT, daily traffic distribution and average speed);
- Consideration of driver behaviour during flood events;
- Vehicle occupancy; and
- Assessment of potential for vehicles to be moved during the event into more hazardous areas.

The method endeavours to remove some of the subjectivity of the other approaches, whilst improving the method for determining the likely number of vehicles within the flood extent and the maximum hazard they could experience. The approach utilised existing research into driver behaviour, vehicle stability and flood severity to develop the following step-by-step approach for assessing each section of road.

**Step 1: Estimate the PAR**

This method uses the ‘no-failure’ flood extent to estimate where cars are likely to be during the dam break event. The fundamental assumption is that when the dam break occurs cars are in the same position they would be in the no failure scenario, or in other words, the flood event occurs first leading to a certain behaviour before the dam break comes through. This assumption is an approximation and when considering the many uncertainties associated with cars entering and leaving a flooded area throughout the duration of a flood, it was deemed an acceptable simplification for a consequence category and/or risk assessment process.

Using the available research on how motorists would behave during flood conditions, GHD identified four potential scenarios that may occur and be used to determine the PAR on any road affected by the dam break being assessed. These scenarios were largely based on a recent study titled “Motorist behaviour during the 2015 Shoalhaven floods” (Gissing et al. 2016), which found that most motorists underestimate the danger posed by flooded roads and enter floodwaters in spite of warnings and road closure signs. It was also observed as part of this study that drivers are likely to wait at the edge of the flood extent and cross when they see the vehicle in front make it through. The PAR scenarios identified apply to both day and night conditions, although some of the associated traffic parameters are different. The four potential PAR scenarios assumed are as follows (see also Figure 1):

- **Scenario 1 – ‘Business as Usual’**: The road is either not flooded or not inundated enough to impede traffic flow and traffic density is assumed to be a time weighted average.
- **Scenario 2 – Flooded without traffic queue**: Part of the road is flooded enough for drivers to change their behaviour, but cars still enter the inundated extent at the same or a similar rate as they leave so no queue forms.
- **Scenario 3 – Flooded with traffic queue**: Part of the road is flooded enough for drivers to change their behaviour, but cars cross slowly enough that a queue forms at the edge of the extent.
- **Scenario 4 – Flooded with a stopped car within the inundation extent**: During the no failure event, a car enters the flood extent and arrives at a hazard sufficient for it to become stranded within the extent. Based on conditions before the car got stuck, there may or may not be a queue. Once a car is stuck it is assumed that no other cars enter the extent.

These scenarios are affected by the nature of road, in that:

- if the road is one lane in each direction the behaviour of cars on one side of the road will influence those on the other.
- if the road is multi-lane, it is assumed that the carriageways operate independently of each other.

A significant consideration when estimating the PAR for the aforementioned scenarios is the tendency for people to remove themselves from perceived danger. Whether or not people will perceive the danger and how they will react is
very difficult to predict. However, some allowance for this is required to reduce the conservatism in the approach. GHD assumed that the reduction in PAR could be thought of as the difference between receiving no warning and some warning as detailed in the Graham, 1999 and USBR, 2014. The adopted proportion of people who are not trapped by the flood in their car that will take some action and remove themselves from danger, was selected as 70%. This was based on an interpretation of the variance in fatality rates between no warning and some warning (15 to 60 minutes) as documented in Graham, 1999.

For the relevant scenario, the likely PAR is then calculated for individual sections (or points) at a fine increment to pick up the variation in hazard within the inundation extent and the chance that cars could be at a number of locations along the inundated road. The total PAR is then a sum of all the assessed points along the section of inundated road.

**Step 2: Assign a Fatality Rate (FR) to the PAR**

Given the different nature of the risk to the PAR on roads compared to buildings, GHD developed a classification of flood severity based on depth and hazard (Depth x Velocity or DV), which is shown in Table 3. The criteria for defining what constitutes the flood severities for roads was derived from interpretations of information in Keller and Mitsch (1992, 1993), Australian Rainfall & Runoff (AR&R) and the Melbourne Water Land Development Manual (MW, 2016). Recent studies undertaken by the University of New South Wales in Manly Vale found that a small car like a Toyota Yaris, weighing 1.05 tonnes, could be moved by water only 0.15 meters deep and with a flow speed of 1 metre/second (or 3.6 km/h) (Daniel and Fogarty, 2016). They also found that a larger vehicle starts becoming unstable when the water is about 0.45 meters deep, when the water is moving past at “walking pace” (Daniel and Fogarty, 2016). The Fatality Rate (FR) ranges for the flood severity categories in Table 3 were based on Graham (1999) and USBR (2014). With the FR applied to the cars who are exposed to the flood.

**Table 3 – GHD Road Method Flood Severity Assumptions**

<table>
<thead>
<tr>
<th>Flood Severity</th>
<th>Depth Range (m)</th>
<th>DV Range (m²/s)</th>
<th>Fatality Rate (FR) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low*</td>
<td>0.3 - 0.4</td>
<td>0.35 - 0.6</td>
<td>0.00 - 0.01</td>
</tr>
<tr>
<td>Low</td>
<td>0.4 - 0.5</td>
<td>0.6 - 0.8</td>
<td>0.01 - 0.03</td>
</tr>
<tr>
<td>Medium</td>
<td>0.5 - 2.0</td>
<td>0.8 - 1.2</td>
<td>0.03 - 0.30</td>
</tr>
<tr>
<td>High</td>
<td>2.0 - 4.0</td>
<td>1.2 - 4.0</td>
<td>0.30 - 0.90</td>
</tr>
</tbody>
</table>

Note: * indicates that for depth and DV less than the lower limit in this category the fatality rate is assumed to be 0.00.

The probability of a fatality due to flooding on the road is not related solely to depth or DV on the road, but also the proximity of the vehicle to a more hazardous location (such as a waterway) and its likelihood of more severely impacted. In order to account for this, GHD developed a method for considering the potential movement of cars during floods based on research into vehicle stability. The vehicle stability research GHD used is summarised in the AR&R literature review “Appropriate Safety Criteria for Vehicles” (AR&R, 2011) for various vehicle types and sizes. For this process it was assumed that a car could only be pushed off the road if the following criteria were met:

- Car will float if depth is greater than or equal to 0.4 m; and
- Car will move if DV is greater than or equal to 0.45 m²/s.

These criteria were based on research for ‘large passenger vehicles’ as they were considered to represent an average vehicle size for the purpose of a risk assessment. In reality vehicle sizes are highly variable, and it may be desirable in the future to use vehicle data to calculate a more representative average size.

Using the above movement criteria, GHD mapped the movement of the identified PAR points, using the two dimensional outputs, over a specified distance and assigned a fatality rate to the PAR points based on the range in Table 3 and the maximum depth and DV the point experiences over its journey. This approach means that if a PAR point starts in a low flood severity location, but ends up in a high flood severity location it will be assigned an FR based on the location in the high category.
Figure 1  Example of PAR Scenarios used in GHD Method
(theoretical car shown in black and flood extent shown in blue)
**Step 3: Calculate the Potential Loss of Life (PLL)**

The PLL was then calculated by multiplying the PAR in Step 1 by the by FR in Step 2 for each point along the roads being assessed. The result for each road was then summed to give the total PLL for the dam break or flood scenario being assessed. These results are then compared to the same assessment at Step 2 and 3 for the non-fail scenario to determine the incremental PLL (i.e. PLL that can be attributed to dam failure).

**Application of Method and Assumptions**

The process for undertaking the method above was largely automated with the ability to change the key parameters, as listed in Table 4.

The traffic spacing under the ‘business as usual’ scenario would normally be a variable based on traffic volume, traffic distribution and average speed. However, for the Melbourne Water project used as the basis of this paper the traffic spacing was calculated based on the road type (i.e. inner or outer and freeway, divided arterial or undivided arterial), average speed and daily traffic distribution information available from VicRoads on their monitored network (VicRoads, 2014a; VicRoads, 2014b). The Melbourne Water project also assumed a 6% reduction in average speed due to the wet weather (US DoT, 2013).

<table>
<thead>
<tr>
<th>Parameter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Car movement DV limit</td>
<td></td>
</tr>
<tr>
<td>Car movement depth limit</td>
<td></td>
</tr>
<tr>
<td>Percentage difference in departure and arrival rate required for a traffic queue to form</td>
<td></td>
</tr>
<tr>
<td>Car speed through inundated water</td>
<td></td>
</tr>
<tr>
<td>Car spacing through inundated water</td>
<td></td>
</tr>
<tr>
<td>Depth criteria for road to be considered inundated</td>
<td></td>
</tr>
<tr>
<td>Percentage of non-trapped motorists who leave the floodplain</td>
<td></td>
</tr>
<tr>
<td>Car Occupancy</td>
<td></td>
</tr>
</tbody>
</table>

An overview of the pros and cons of the GHD Method are provided in Table 5.

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Considers hazard at the road being assessed</td>
<td>• Results depend on availability of traffic volume and average speed data (available for Melbourne, but may not be available everywhere)</td>
</tr>
<tr>
<td>• Considers driver behaviour, which affects traffic spacing (including potential for queuing)</td>
<td>• Need to have a 2D hydraulic model</td>
</tr>
<tr>
<td>• Considers potential movement or cars to more hazardous areas</td>
<td>• Requires more than just spreadsheet assessment.</td>
</tr>
<tr>
<td>• Easily test sensitivity of parameters and/or update to remain in line with current research</td>
<td></td>
</tr>
</tbody>
</table>

2.4 **Do Nothing (Buildings Only) Method**

The ‘Do Nothing’ method simply involves not assessing the risk to itinerants on major roads, which means that the PLL only considers the PAR in the buildings. An overview of the pros and cons of this approach are provided in Table 5.
Table 5  Do Nothing Pros & Cons

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Simple – as no additional work on top of current assessment for buildings.</td>
<td>• No allowance for itinerant road users being affected and may underestimate the consequences and/or risk posed by the retarding basin.</td>
</tr>
</tbody>
</table>

3  Method Comparison

To compare the impact on the Consequence Category of the methods described in Section 2, each method was applied to six (6) example retarding basins of various sizes. The retarding basins used were taken from the consequence and risk assessment project recently completed for Melbourne Water. A summary of the key statistics for the six basins used in this report are presented in Table 6. Table 6 also shows the PAR/PLL for the buildings only and the associated ‘Severity of Damage and Loss’, which are required to calculate the Consequence Category.

A comparison of the methods is presented in Figure 2 and Table 7. The results shown are for the Dam Crest Flood event. The results highlight the following:

• It is important to consider itinerants on roads as they can significantly change the Consequence Category assigned to the basin. This is especially important for retarding basins where in general PAR in buildings are much less vulnerable than itinerants on roads;

• Depending on the method adopted, the difference in incremental PLL estimates on roads for the six example RB cases varied between 0.64 and 8.07. This indicates that the results are basin and/or catchment specific;

• The method for determining PLL on roads can affect the Consequence Category assigned to the basin.

For the project undertaken for Melbourne Water, the priority of upgrade works on the RBs was based on a risk assessment. To assess the potential impact of the different methods for determining PLL on roads on this prioritisation, the results of a risk assessment for a couple of the example basins is explored below.

Table 6  Key Statistics of Basins for Comparison

<table>
<thead>
<tr>
<th>Basin</th>
<th>Storage Volume (ML)</th>
<th>Embankment Height (m)</th>
<th>Peak Breach Flow (m³/s)</th>
<th>Number of Affected Roads (AADT - vehicles/day)</th>
<th>Incremental PLL Buildings</th>
<th>Severity of Damage and Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6000</td>
<td>5</td>
<td>310</td>
<td>111 (38,000)</td>
<td>0.08</td>
<td>Medium</td>
</tr>
<tr>
<td>2</td>
<td>164</td>
<td>5.5</td>
<td>101</td>
<td>1 (17,800)</td>
<td>0</td>
<td>Minor</td>
</tr>
<tr>
<td>3</td>
<td>130</td>
<td>2.9</td>
<td>49</td>
<td>2 (25,000 / 32,000)</td>
<td>0.26</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>119</td>
<td>8</td>
<td>116</td>
<td>3 (24,000 / 31,000 / 29,000)</td>
<td>2.39</td>
<td>Medium</td>
</tr>
<tr>
<td>5</td>
<td>66</td>
<td>1.6</td>
<td>5</td>
<td>1 (34,000)</td>
<td>0.02</td>
<td>Minor</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>4</td>
<td>20</td>
<td>2 (24,000 / 31,000)</td>
<td>0.6</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Figure 2  Summary of Incremental PLL from Roads for assessed basins

Table 7  Summary of variation in Consequence Category for assessed basins

<table>
<thead>
<tr>
<th>Basin</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do Nothing (Buildings only)</td>
<td>Low</td>
<td>Very Low</td>
<td>Significant</td>
<td>High C</td>
<td>Very Low</td>
<td>Significant</td>
</tr>
<tr>
<td>Campbell Method</td>
<td>High C</td>
<td>High C&lt;sup&gt;1&lt;/sup&gt;</td>
<td>High B&lt;sup&gt;2&lt;/sup&gt;</td>
<td>High B&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Significant</td>
<td>High C</td>
</tr>
<tr>
<td>Graham Method</td>
<td>High C</td>
<td>Significant</td>
<td>High C</td>
<td>High B&lt;sup&gt;2&lt;/sup&gt;</td>
<td>High C&lt;sup&gt;1&lt;/sup&gt;</td>
<td>High C</td>
</tr>
<tr>
<td>GHD Method</td>
<td>High C</td>
<td>Significant</td>
<td>Significant</td>
<td>High B&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Very Low</td>
<td>High C</td>
</tr>
</tbody>
</table>

Note:

1<sup>1</sup> indicates that this was set to “High C” as ANCOLD, 2013 states where total incremental PLL is > 1 the Severity of Damage and Loss is unlikely to be ‘Minor’

2<sup>2</sup> indicates that this was set to “High B” as ANCOLD, 2013 states where total incremental PLL is in the range of 5 to 10, the category can be reduced from ‘High A’ to ‘High B’.

To look at the impact the road PLL method has on the results of a risk assessment, FN plots were produced for Basin 3 and 5 in accordance with the methodology in GHD, 2016. These basins were selected for this paper because they have the largest range in PLL estimates between each of the methods.

To produce the FN plots, the PLL assessment for each method was also carried out for two additional failure scenarios (an overtopping failure scenario and a part full piping failure scenario) and interpolated to produce consequences at all the required flood partitions from the risk assessment process.

The results of this assessment are presented in Figure 3 and Figure 4. These figures show that depending on the method adopted to calculate PLL on the roads, the result of the risk assessment can be significantly different and could lead to basins being prioritised incorrectly and/or not targeted for upgrade.
Figure 3  Basin 3 FN Plot using various Road PLL Methods
5 Conclusion and Recommendation

Given the outcome of this assessment, it is concluded that itinerants on roads can form a significant portion of the PLL for a retarding basin. Therefore, when considering retarding basins, itinerants on major roads need to be carefully considered in any consequence or risk assessment where major roads are affected. Based on the comparison of methods, the difference in results indicates that there is a need to reach a consensus on the method adopted for assessing this form of itinerants. This is particularly the case for a Portfolio Risk Assessment carried out by an asset owner to assist in the appropriate prioritisation of works. All of the methods discussed have advantages and disadvantages, but the GHD Method is considered to generate the most representative risk for a given road because it considers all of the following:

- Variable hazard across the inundation extent;
- PAR could be located at numerous points within the inundation extent;
- Driver behaviour during floods, which alters the flow of traffic and may cause queuing of traffic; and
- Potential movement of cars into more hazardous areas.

Considering this, going forward GHD would like to work with the ANCOLD community to further develop a tool that can be used by the industry to generate PLL estimates for major roads.

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References


