Inverness City
Trunk Link Road – West Link

Flood Modelling Input to Options Assessment Report

Consultation Draft - September 2011

Prepared for

Highland Council

Inverness West Link – Flood Modelling Input to Options Assessment Report (September 2011)

Baseline Model Development and Results

Introduction

This document represents a summary of the flood modelling undertaken for the Inverness West Link project to define the existing flooding baseline in the reach between the SEPA Gauging Station at Ness-side and the western tip of the Ness Islands.

Hydrology

No new hydrological analysis of the River Ness was carried out for this study given the extensive work previously completed for The Highland Council by Mott MacDonald in regard to the River Ness, namely: -

- River Ness Flooding Review (January 2004),
- River Ness Flooding – Inverness, Pre-feasibility Study, Flood Protection (June 2005),
- Proposed Highland Archive Centre, Bught Park, Inverness - Flood Risk Assessment - Final Report (March 2007)

Therefore, the flows used in this study are extracted from the above reports, as follows: -

Return Period	Flow (m^3/s)	Source
1:200yr	972	River Ness Flooding Review (January 2004)
1:200yr + climate change allowance at 20%	1167	Scott Wilson Inverness West Link Modelling (2008)
1:1000yr	1386	Proposed Highland Archive Centre, Bught Park, Inverness - Flood Risk Assessment - Final Report (March 2007)

This approach was agreed with SEPA in 2008. However, it is noted that revised flow estimates were provided by SEPA after this modelling work had been completed (October 2011) and these flows will be adopted for the future modelling of the preferred option. These revised flow estimates are anticipated to affect all the options investigated in this report similarly, and the relative differences in flood risk between the options are not anticipated to be significantly affected from what is reported herein.

Hydraulic Model Development

The hydraulic model was developed in the HEC RAS software package, and extends from the SEPA Gauging Station at Ness-side (some 650m upstream of Holm Mill Weir) to the upstream tip of the Ness Islands (some 1100m downstream of Holm Mill Weir).

The cross section data used in the model has been gathered from the following sources: -

- 2008 river cross section survey (including survey of Holm Mill Weir) by Aspect Surveys (undertaken specifically for this study),
- Digital Ground Model from aerial survey data provided by The Highland Council for the study area,
- 2007 river cross section survey and topographic survey for the Highland Archive Centre FRA by Stuart Ross,
- Past and current river cross section data for the SEPA Gauging Station at Ness-side provided by SEPA,
- 1991 river cross section survey by Property & Land Surveys,

The 2008 river cross sections were used to model the weir and the areas immediately upstream and downstream of the weir (i.e. the original site considered for a crossing of the River Ness). The 1991 survey data was reviewed against equivalent data from the 2007 and 2008 surveys to ensure the 1991 sections were still a reasonable representation of the river channel, and could therefore be used to extend or interpolate the model where necessary. Where necessary the river cross sections were extended out into the surrounding land using

the data from the Digital Ground Model. Holm Mill Weir was also included in the model based on specific survey sections upstream, on top of, and downstream of the weir.

Historical Flooding and Model Calibration

The upstream end of the model was calibrated to known flood levels for specific flood flows at the SEPA Gauging Station at Ness-side (see table below), and the downstream end of the model was calibrated to the modelled flood levels from the Flood Risk Assessment for the Highland Archive Centre.

Event	Flow (m^3/s)	Calibration
7 February 1989	792	Upstream end of model to SEPA recorded flood level
6 February 1989	763	Upstream end of model to SEPA recorded flood level

The resultant baseline flood mapping is shown on the attached figure ("Inverness Trunk Link Road: Predicted pre-development flooding envelope").

Assessment of Options

There are nine potential options for the proposed Inverness West Link, but a number of these options have very similar bridge crossings and therefore in terms of potential effects on flood risk some of these options have been grouped together for the purposes of this assessment. In the following sections a brief description of the justification for grouping various options together has been provided.

It is noted that the bridge designs provided were at a concept design stage and therefore the modelling should also be considered as concept design modelling. Whilst the modelling of the options has been completed in sufficient detail to determine the relative differences in flood risk for the various options, further detailed modelling of the preferred option/s would be required using the full design details of the preferred bridge crossing to confirm any variations in flood level and extent compared to the predicted pre development case. In addition, during the detailed modelling stage it is recommended that the preferred bridge design is optimised to reduce changes to flood risk where possible, by considering the position and width of the piers, the location of the approach embankments, the creation of openings in the approach embankments, etc.

Options 1 & 2

Description of option/s
Both options would cross the River Ness at the upstream end of Whin Island with a roundabout either side of the river. Both options comprise of a bridge crossing with three spans (50 m / 65 m / 50m) with two piers situated within the main channel and approach embankments at either side. The only difference between the two options is the location of the Queen's Park Roundabout, the alignment of the road between the Queens Park Roundabout and the Weir Roundabout, and where the proposed road would cross the Caledonian Canal. However, since both options are very similar in relation to how they would effect the existing baseline flooding conditions (i.e. obstructions within the main channel and on the adjacent banks), they have been represented as a single option in the model.

Representation in model
As the engineering design for the bridge options is currently at concept stage, all the options modelled have been represented based on the concept design sketches provided i.e. with soffit levels situated above the baseline 1:1000yr flood levels and a standard bridge pier width. However, the likely effect of the bridge crossing, with piers included where applicable and the road embankment where it would pass through the floodplain, have been represented in the model to a sufficient level of detail to indicate the likely effect on the flooding regime.
For Options 1 and 2 the geometry of the bridge has been represented as three spans (50m / 65m / 50m), pier widths of 2.5m, and deck depth varying across its length but the minimum deck level (at the piers) has been estimated from the concept design as 10.3mAOD. Since both options would comprise three openings, a multiple opening analysis has been undertaken to model the proposed bridge crossings.

Results of analysis
The modelling predicts that both options would increase flood levels upstream between the proposed crossing and the weir by 50 – 80mm for the 1:200yr + climate change event and by

60 – 90mm for the 1:1000yr event. There are no predicted effects on the flood levels downstream of the proposed bridge or upstream of the Holm Mill Weir, which still has the dominant hydraulic effect on upstream river levels. The modelling also indicates that for both the 1:200yr + climate change and the 1:1000yr events, that the bridge could increase water levels locally by around 250-300 mm immediately upstream of each pier (e.g. for distance of around 2-3 m).

The modelling also indicates that the 1:200yr + climate change flow would be contained within the openings of the proposed bridge and would not significantly flow overbank to flow against the bridge abutments assuming these are set just out with the existing 1:200yr + climate change flood extents. For the 1:1000yr event, flows would not be contained within the openings of the proposed bridge and would flow out of bank against the approach embankments (particularly on the Whin Park side where the ground slope is shallower). If one of these options is to be developed as the preferred option, then it is recommended that consideration is given to moving the bridge abutments back slightly to keep them out with the predicted 1:1000yr flood extent for the "with scheme" condition.

Options 3 and 4

Description of option/s

Both options would cross the River Ness downstream of Whin Park, with the crossing falling from Dores Road to the corner on Bught Road and then rising up towards the Queen's Drive Roundabout. Both options comprise of a bridge crossing with three spans (60 m / 60 m / 60 m) with two piers situated within the main channel and approach embankments at either side.. The only difference between the two options is the location of the Queen's Park Roundabout, but this is located out with the predicted baseline flood extents in both options so is not considered relevant in this assessment. Therefore, since both options are very similar in relation to how they would affect the existing baseline flooding conditions, they have been represented as a single option in the model.

Representation in model

For Options 3 and 4, the geometry of the bridge has been represented as a 60 m / 60 m / 60 m span arrangement. Similarly to Options 1 and 2, the crossing has also been modelled in this location using a multiple opening analysis. Based on the concept design, the bridge deck has been modelled at a height of around 14.5mAOD at the southern bank falling to 11.94mAOD at Whin Park bank. The rising geometry of the road deck from this low point towards the Queen's Park Roundabout has also been included in the model. The geometry for Options 3 and 4 differs from this point towards the Queen's Park Roundabout, but this is not considered relevant to this assessment as in either case the proposed road would still be above the existing 1:1000yr flood level.

Results of analysis

The modelling predicts that both options would increase flood levels upstream between the proposed crossing to the upstream end of the weir by 20–90mm for the 1:200yr + climate change event and by 30 – 90mm for the 1:1000yr event. There are no predicted effects on the flood levels downstream of the proposed bridge or upstream of the Holm Mill Weir, which still has the dominant hydraulic effect on upstream river levels. In the existing baseline case floodwater flows across Whin Island, and although not shown in the modelling results, it is anticipated that the proposed approach embankment may come into contact with the sheet flow across Whin Island and would have a detrimental effect on the movement of floodwater in this area.

Option 5

Description of option/s

Option 5 is similar to Options 3 and 4 as it would cross the river at the same location downstream of Whin Park. For this option the proposed Queen's Park Roundabout would be located next to Whin Island and remain outwith the 1:1000 flooding envelope. However this option also comprises a proposed road leading from the roundabout to the Canal, and a section of this road would pass through the predicted existing flooding envelope for the 1:200yr & 1:1000yr events. Therefore from a flood risk point of view this option has been considered separately from Options 3 and 4.

Representation in model
The crossing for this option has been represented at the same location as Options 3 and 4 with the same dimensions modelled in regards to the bridge crossing. However, the section of the proposed road heading northwest from the roundabout which would pass through the predicted flooding envelope has been represented in the model as an 'obstruction' within the flood plain.

Results of analysis
The modelling predicts that this option would have a slightly more detrimental effect on flood levels than Options 3 and 4, predicting increases in predicted flood levels in the order of 20 - 90mm between the proposed bridge crossing and the weir for the 1:200yr + climate change event and 30 – 90mm for the 1:1000yr event. It is noted that the change in water levels from the baseline is similar to that of Options 3 and 4, however the model results do predict for Option 5 that the section of road would uplift flood levels by an additional 10mm adjacent to the road. In comparison to Options 3 and 4 however, these results show that the effect of the road crossing through the floodplain on the northern bank is negligible.

Option 6

Description of option/s
Option 6 is similar to Options 1 and 2 as it would cross the river at the same location with the same span dimensions as well as having roundabout junctions in the same locations. However, part of the road embankment on the southern side of the river between the Ness-side and Holm Mains roundabouts would marginally come into contact with the predicted flooding envelope for the 1:200yr + climate change and 1:1000yr events. Therefore, this option has been modelled as a variant of Options 1 and 2.

Representation in model
This option has been represented the same as Options 1 and 2 in the model with regard to the bridge crossing, however the modelling of this option has also accounted for the potential effect of the road embankment encroaching onto a small part of the floodplain on the southern bank at Ness-side by representing this as an obstruction in the relevant cross sections.

Results of analysis
The results show that this option would have a similar effect on flood levels to Options 1 and 2, predicting increases in the order of 60-80 mm between the weir and the proposed bridge crossing for the 1:200yr + climate change event and 80 - 90mm for the 1:1000yr event. The modelling shows that the road embankment to the south of the river would have a negligible effect on flood levels with no change predicted for the 1:200yr + climate change event and a small increase predicted flood level for the 1:1000yr event of around 10mm adjacent to where the embankment would come into contact with the River Ness flood extents. Similar to Options 1 and 2, the modelling predicts that the bridge piers would locally cause flood levels upstream of the bridge to increase by 250-300mm for a short distance upstream. As per Options 1 & 2, if Option 6 is to be developed as the preferred option, then it is recommended that consideration is given to moving the bridge abutments back slightly to keep them out with the predicted 1:1000yr flood extent for the "with scheme" condition.

Option 7

Description and analysis of option/s
This option would be situated approximately 300m upstream of the weir and would cross both the River Ness and the Canal in 5 separate spans. It is recognised that a pier supporting the span over the River Ness would be placed partly within the southern side of the channel and would have a substantial width. The pier to north of the channel span would be placed between the canal and the river and based on the concept design would not come into contact with extreme flood flows. This option has been modelled separately to consider the effect of the pier situated within the southern part of the channel.

Representation in model
The modelling of this option considers the effect of the pier on flood levels in the River Ness. Since the approach embankments and soffit of the structure would not come into contact with extreme flood flows, the modelling of Option 7 is more simplistic and the modelling of the bridge only takes into account the loss of flow conveyance area imposed by a pier within the channel. In the model the pier was modelled as a 5m wide obstruction.

Results of analysis
The results show that this option would have a negligible effect on flood levels along the modelled reach of the River Ness. The model predicts no change in flood levels for the 1:200 + climate change event and an increase of 10mm for the 1:1000yr event near the Ness-Side gauging station.

Option 8

Description of option/s
Option 8 is similar to Option 1 and 2 in terms of the proposed road geometry over the river with roundabout junctions situated at the same locations on both banks of the river. However, this option would differ as the Queen's Park Roundabout would be located closer to Whin Island. Although the proposed Queen's Park Roundabout would be situated outwith the predicted flooding envelope for the 1:1000yr event, part of the proposed road between this roundabout and the Weir Roundabout would pass through the predicted flooding extents. Therefore, Option 8 has been modelled as a separate option to assess the effect of the road through the floodplain in the Whin Park area.

Representation in model
In terms of the proposed bridge crossing, this would have the same dimensions as Options 1 and 2, therefore the crossing has been modelled the same. However, using the concept design information the road between the Weir Roundabout and the Queens Park Roundabout has been represented as an obstruction in the flood plain.

Results of analysis
The results of Option 8 are similar to that of Options 1 and 2 in terms of the influence of the option on predicted flood levels (i.e. +50 – 80 mm for the 1:200yr + climate change event and +60 – 90 mm for the 1:1000yr event between the weir and the proposed bridge crossing) and the section of proposed road through the predicted floodplain is predicted to have little additional effect on the flooding regime. Using model results for the Option 1 and 2 run as the baseline event, the modelling predicts that the road section through the floodplain would have no further detrimental effects on flood levels for the 1:200yr + climate change event, with some change predicted for the 1:1000yr event (+10mm). This is logical since the proposed road would only pass through an area of relatively shallow flooding for the 1:1000yr event. As per Options 1 & 2, if Option 8 is to be developed as the preferred option, then it is recommended that consideration is given to moving the bridge abutments back slightly to keep them out with the predicted 1:1000yr flood extent for the "with scheme" condition.

Although, it has no effects on the existing flood risk, it is noted that the crossing underneath the Caledonian Canal may potentially be flood liable unless specific measures are put in place to ensure that flood waters cannot run down the proposed road towards the canal crossing.

Conclusion

In terms of effects on flood risk, the options have been grouped below in order from least / no affect to greatest affect: -

- Option 9 'Do Nothing'.
- Option 7
- Options 1 and 2,
- Options 6 and 8,
- Options 3 and 4,
- Option 5

Option 7 is the most preferable design since from a flood risk point of view since it would only have a negligible effect on altering the existing flooding regime. Options 1 and 2 are the next most desirable from a flooding point of view as they would only marginally change flood levels within the River Ness between the bridge & Holm mill Weir during extreme flood events. Options 3-5 are the least preferred of all the concept designs as although they would have a similar effect on flood levels as Options 1, 2, 6 and 8, they would however produce an effect on flood levels along a greater length of reach.