Report – Takitimu North Link Stage 2 Specimen Design – Downstream Flood Effects Investigation

Review by Graham Macky, Macky Fluvial Consulting Ltd

Included are the response from the designer and subsequent comments from the reviewer

Comment Reviewer: First, a general point applicable in multiple locations covered by this report and others: what should be said generally throughout the project about increased peak flows due to upgraded SH2 culverts.

As well as potential flooding, the increased flow would very likely have an adverse effect on channel stability. In principle, this change is significant. However, all that is proposed is restoring (more or less) the pre-SH2 hydrology, and the channel changes are likely to be relatively minor.

This report and your other reports all assume that any adverse effect on downstream channels is negligible compared to the positive effects on upstream flooding and upstream ecology. There is a good case for that argument, although BoPRC may want some mitigation of the more severe effects.

Do you feel able to address this point at the outset in the report accompanying the consent application? You could state then that you see the upgrading of the SH2 culverts as a nett positive. Consenting then becomes simpler if BoPRC accept the premise, as I think they largely will.

Response Designer: The downstream channel stability was outside the scope of this investigation, however it was evaluated as part of the overall effects of the project. The upsizing of the culverts has a range of effects on the downstream channels, depending on the existing condition and its location and these are not all negative. A summary is given below.

The upstream flooding causes a large upstream head and hence a large pressure on the flow in the culvert. Due to the small sizes of the culvert, the flow exits the culverts at high speed. As an example, flow exits culvert SH2-5380 at nearly 7m/s for period of about 8 hrs. This would cause significant erosion at the downstream ends of the existing culverts. Upsizing the culverts or replacing them with bridges, reduces the velocity of the flow immediately downstream of the culverts/bridges (peak velocity at SH2-5380 is 2.4m/s), thereby significantly reducing the scour potential. In addition, appropriate scour countermeasure will be implemented as part of the project should they be required, minimizing any remaining scour potential at those locations.

Of the nine existing culverts to be upsized, five discharge directly into proposed stream realignments (this includes culvert SH2-2900 whose flow is rerouted in a stream realignment). The stream realignments themselves discharge the flows into tidally influenced waters. The stream realignments will be designed to convey the 100yr ARI design flow without causing flooding or erosion and hence the upsizing of these culverts has no negative effect on the downstream channel.

Of the four remaining culverts, two are located within the Oturu Creek catchment. The downstream culverts underneath Borell Rd, Kiwirail and Armstrong Rd back water up during large storms. Of the 3.2km of stream downstream of the existing SH2, water is unaffected by the tailwater conditions for only the first km. During the 100yr ARI design storm, SH2 overtops in the existing condition at the time of peak rainfall intensity and hence the peak flow rate downstream of the culverts is similar as in the proposed condition. Therefore, the peak velocity results increase only by small amounts (i.e. from 2.73m/s to 2.77m/s or 1.65m/s to 1.71m/s).

The model was set up for the 100yr ARI storm, hence it should not be run for events that are much smaller and therefore only qualitative argumentation can be given for these events. During smaller storm events in the Oturu Creek Catchment, water backs up behind the culvert but does not overtop SH2 in the existing condition, while no water backs up in the proposed condition. For these events the peak flow rates in the proposed condition will be larger than in the existing condition and hence the peak velocities will increase as well. However, because stormwater is no longer held back by the culvert, the duration of high velocities in the channel downstream of the culvert may well reduce. In addition, sediment that is transported by the flow upstream of the culvert, may settle upstream of the culvert in the existing condition as water backs up in front of the culvert. In the proposed condition, the sediment will be transported with the flow through the culverts and hence more sediment will be present downstream of the culvert.

For the remaining two culvert, the velocities downstream of the culverts are higher. But the low flow rates in combination with the terrain means that during the 100yr ARI design storm, the velocities in the existing and proposed conditions are estimated to not be high enough to cause erosion.

The above highlights that for the majority of culverts (7 out of 9), the downstream channel stability is not adversely affected by the upsizing of the culverts, but the erosion risk immediately downstream of the existing culvert will be eliminated. This erosion risk is also eliminated from the 2 Oturu Creek catchment culverts. In addition, during the largest design storm, the increases in the velocities are minimal. Whether the upsizing of culverts results in degradation or aggradation of the channel during much smaller events will depend on the local parameters of the stream, such as the cross-sectional shape, grade, planting etc, and these can only be assessed quantitatively with a highly detailed model that includes sediment transport. However, our high-level assessment of the effects has not uncovered any reasons why this effect during the much smaller events will be more than minor.

Response Reviewer: I think that I didn't make my point clearly enough. What has struck me is that within the descriptions of runoff hydrographs there are many allusions to the flow changes being more or less a return to pre-1950s conditions. This is a good argument, I think, for BoPRC accepting the increased flows. I think that making the argument right at the beginning of the report would make matters much clearer.

Some of the points you've raised in response look to me like they belong in your report perhaps in a bit more detail.. However, I'm a bit puzzled by some of the arguments you've raised; I want to mention just two points:

First, I was a bit puzzled to read that one of your models might be inaccurate for lesser flows than the 100-year event. It would be an interesting debate as to which rainfall events are responsible for the hydrological parameters and Manning's n, but I'd argue that moderately significant events are those most likely to have been used to "calibrate" the recommended Horton values, for instance.

Second, I've re-read section 1.3, which defines the scope of this report. I'd rather rashly assumed that the downstream flooding effects included increased flow rates viz-a-viz both road overtopping and channel stability, but I can't really tell from the text whether that was intended. If the report is strictly about 100-year peak flood levels, that needs to be made clear. If so, are the flowrate issues covered elsewhere?

Response Designer: As mentioned in section 3.3 of the report, a limitation of the model is that the stream sections were based on representative cross-sections based on the available LiDAR and in many areas the LiDAR data did not identify the main channel of the stream, but only the floodplain. For very large storms, including the 100yr ARI storm, the impact of the flow within the channel of the stream on the routing of the flow is small. But when the storms become smaller, the impact of the flow within the channel of the stream on the routing of the flow increases and as this is not well resolved in the model, the model accuracy is expected to decrease as well. The actual impact of the flow within the channel of the stream on the routing of the flow is very difficult to quantify. For a significant length of the stream, the flow is backed up even in the 2yr ARI storm event and hence the impact over that length of stream will still be small. For the remaining length of the stream the impact will be dependent on the local channel parameters. We estimate that the model accuracy is still reasonable for the 2yr ARI storm event. The results from the 2yr-24hr rainfall event that took place on the 21st of Jan 2023 supported that reasoning. However, we would be hesitant to use the model for flows smaller than the 2yr ARI storm. It was these types of events that were referred to in the previous response when trying to explain the impact on the sediment transport potential of the stream in the proposed condition.

As part of defining the consent conditions for the project, it was agreed with Regional Council that a catchment-wide flood model was to be set up to determine the effects on the downstream properties during large storms due to the upsizing of the existing culverts. In terms of the results, the focus has been put on the one that has the largest impact on the existing downstream property-owners, i.e. the increase in the peak flood levels and the associated flood extents. It is the increased flow rates that cause the increased peak flood levels and increased velocities, however as the increased flow rates are not directly affecting the downstream properties, this was not the focus of the results presented in the report. Increased velocities have the potential to increase scour, but as mentioned in the previous response, the increases in the peak velocities were estimated to be small, and hence were estimated to not significantly change the scour potential of the flow during large storms. The road overtopping is an existing issue that has to be dealt with by the local TA. At the roads, the upsizing of the existing culverts results in a minor increase in the peak flow depths during large storms which does not significantly alter the existing high risk due to the overtopping. The impact of the upsized culverts on the risks due to road overtopping were not a major concern to the Regional Council. Hence these results have also not been the focus of those presented in the report.

Response Reviewer: Comment resolved.

Comment Reviewer: 2.1 TNL-5160 - On the off chance that you know it: you could note the year the SH2 culvert was constructed. The hydrology is being returned to before that year.

Response Designer: Unfortunately, we do not. From aerial photographs, the current alignment of the (majority) of SH2 was constructed between 1943 and 1953 and the road was sealed somewhere between 1953 and 1963. Some culvert replacements or upgrades may have taken place since construction of SH2, but upstream flooding issues, fish passage requirements, hydrology adjustment for climate change, and current dam regulations have changed the approach. Based on the latest requirements, calculations indicate that the existing SH2 culverts under sized and should be replaced.

Response Reviewer: No worries. However, if you need to argue in favour of upgrading the SH2 culverts, it helps to say that what is proposed is a return to the pre-1950 regime.

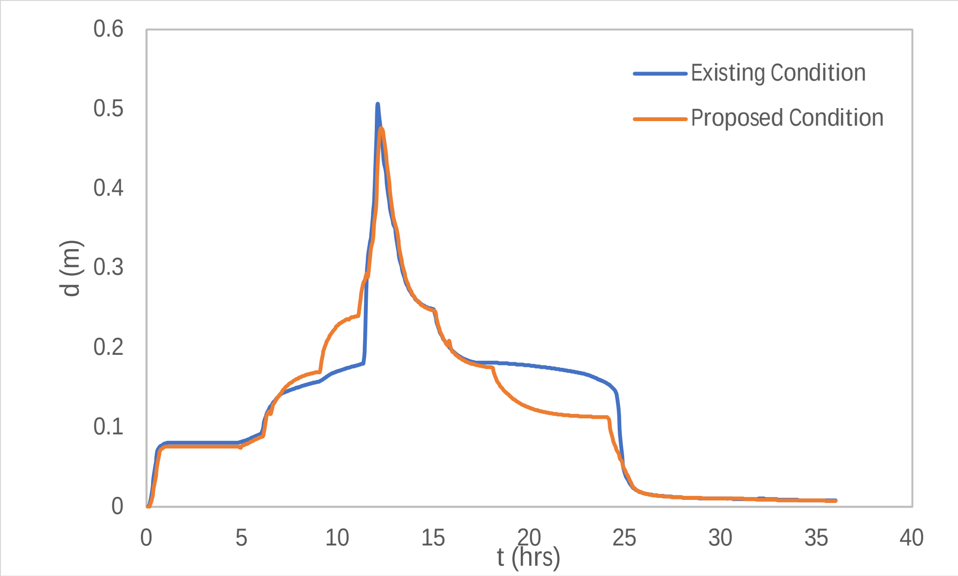
Response Reviewer: Comment resolved.

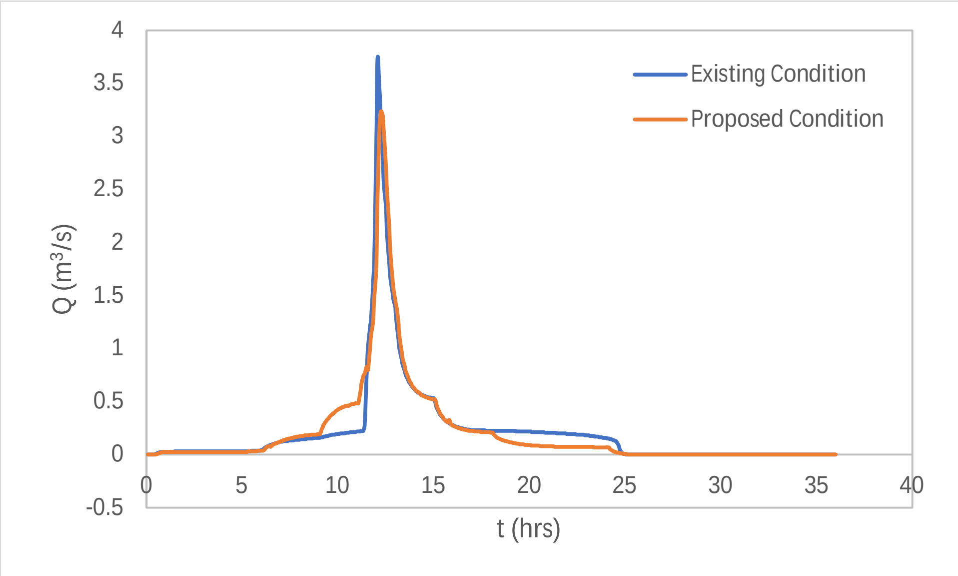
Comment Reviewer: 2.2 p8 - I'm a bit puzzled here, not by the actual works proposed but by the discussion of whether there are any adverse effects here from the project. The effect on peak flow and water level of a larger culvert OMK-60 may extend downstream of SH-270 because that culvert is also being upgraded. Pre- and post-development flow hydrographs and water level profiles would be helpful both for me and for later readers.

Response Designer: The water depth and the flow for the existing condition and proposed condition during the 100yr ARI design storm including climate change are presented in the figures below. Note that the peak flow rate downstream of the culvert is higher in the existing condition than in the proposed condition. In the existing condition, overtopping of the road begins before the time of peak rainfall intensity. Hence at the time of peak rainfall intensity, the flow through the culvert (small) plus the flow across the road (large) is equal to the runoff rate. In the proposed condition, flow only goes through the culvert. There is no overtopping. At peak rainfall intensity, the culvert does act as a flow control structure, hence the peak flow rate is slightly smaller than the peak runoff rate. Despite the smaller flow rate, the peak flow depth is slightly higher in the proposed condition. This is because the higher peak flow rate in the existing condition also results in higher peak velocities (2.2m/s versus 1.7m/s) as the road overtops.

Also, please note that the detailed hydrodynamics shown in the graphs do depend significantly on the proposed design, i.e., what will be the invert levels of the proposed culvert be (the proposed road embankment will be wider, hence the upstream invert level will likely increase as there is no room for drop structures), what will the length of the proposed culvert be, what will the culvert size be, etc. In this case, the downstream invert level of the existing culvert is also unknown at this time as no survey data could be obtained to verify. However, any changes in the detailed hydrodynamics will not change the assessment of the downstream effects due to the upsizing of the culvert, i.e., no design will result in effects that are more than minor because of the approximately 8m depth of the gully that the stream flows through. This is the main reason why most of these details have not been included into the downstream effects report.

It is agreed that the changes to culvert OMK-60 will affect the flow past culvert SH2-270. The paragraph was meant to point out that the changes downstream of OMK-60 include a small increase in flow depth in the upper part of the downstream gully and a large decrease in flow depth in the lower part of the downstream gully. Text has been updated to avoid confusion.





Response Reviewer: I presume (1) that the 2nd of these graphs in fact shows flow rate through + over OMK60 and (2) that the roadway will be raised. I think your report should include this flow hydrograph.

The section heading should make it clear that this section covers down to SH2 only, with further downstream covered in 2.3.

However (and I may be missing something basic here) despite your explanation I can't see why the lower flow gives a higher water level immediately downstream.

Response Designer: Apologies for the confusion. The label on the y-axis of the 2nd graph was indeed wrong and should have been the flow rate immediately downstream of the culvert. In addition, there was an error in the roughness applied to the downstream section of the proposed condition model. The updated results are shown above, confirming that the lower flow rate also results in a lower flow depth.

Note that the roadway will not be raised, but the proposed road makes a bend at the location of the existing culvert and as a result, the proposed embankment reaches further upstream than the existing embankment. This also results in a higher invert elevation of the culvert at the inlet.

A line has been included in the text to clarify that the downstream effects investigated within this section only cover the stream length between culvert OMK-60 and culvert SH2-270.

Comment Reviewer: 2.3 p9 - It would be helpful to see the channel cross-section and the 100-year flow it is to contain. I appreciate that the design might not yet have been done, though the flow rate will be known

Response Designer: At the time of preparing this report, those details were indeed not available. However, Specimen Design details of the downstream stream realignment, SR3A, have been included in the "Takitimu North Link Stage 2 – Specimen Design – Culvert Bridges and Streams" report. These can be found in Tables 5-1 and 5-2 in the main text, Appendix G.2 and drawing 144702-00-2303 in Appendix H. The stream realignment has been designed for a flow rate of 10.7m^3/s. References to the information in the Culvert Bridges and Streams report have been added to the text.

Response Reviewer: That should do at this stage. I think there's enough detail of the proposed design process in Section G2.

Response Reviewer: Comment resolved.

Comment Reviewer: 2.4 p9 - Could the realigned stream from SN-530 be more clearly shown on Figure 5? Or perhaps refer not only to Fig 5 but also to 144702-00-2227 or a similar drawing, which could be appended. Could you please indicate in Figure 5 which way is North? I'm getting a bit confused!

This all sounds fine, but again the design peak flow and an indicative channel cross-section would help confirm that.

Response Designer: The stream realignment replacing the existing culvert and the stream immediately downstream of the existing culvert is stream realignment SR3B. The stream realignment has been designed for a flow rate of 11.5m^3/s. As this stream realignment is beneath a proposed bridge, the analysis as part of Specimen Design has focused on the bridge requirement, although it was ensured that the cross-sectional area below the bridge was more than sufficient for a channel containing the 100yr ARI design flow. Detailed analysis of the stream realignment will be carried out during detailed design. Flow rate has been included in the text, Figure 5 has been updated clarifying location of SR3B and North indicator.

Reviewer Response: I'm happy to accept your assurance that a 100-year ARI channel can be specified. Something I may have brought up re a different report, though, is the 200m or so of channel running to the salt marsh. I think it needs to be specified as more of stream realignment SR3B. Regardless of its land zoning status, the downstream flood effects on it need to be considered.

The channel, which is very minor, disappears into a floodplain that appears from Google Maps to be borderline between pasture and swamp. In practice there might indeed be no major effects from an increase in peak flow.

Response Designer: The salt marsh is included in the mitigation design as part of the project and hence the salt marsh is within the proposed project designation. Changes in flood levels within the project designation are allowed. Regional Council is not going to be worried if flooding effects caused by NZTA only effect NZTA. There is no effect on any adjacent landowners or stakeholders. Hence this has not been investigated further.

Response Reviewer: Comment resolved.

Comment Reviewer: 2.5 - Again, can you show the re-aligned stream more clearly in Fig 5? Is it really re-aligned or just engineered for the higher peak flow? If there is a remnant of natural stream, does its erosional state need consideration?

I presume that the increased flow peak will be more or less the pre-SH2 condition of decades ago.

Response Designer: As the stream realignment (SR4A) will be located where the existing culvert is and its length will be the length of the existing culvert, it is slightly difficult to display both clearly in Figure 5. The Figure has been updated to make it as clear as possible.

As we are not moving the alignment of the stream, calling it a stream realignment may be slightly misleading. However, we have been using the term 'stream realignment' for any of the proposed works whereby stream reaches are altered, so this includes those stream sections that are realigned, stream sections that are replacing existing culverts and stream sections that reconnect existing streams to inlets or outlets of proposed culverts. There are remnants of the natural stream left, including downstream of the existing culvert. This is the reason why bridge TNL-7240 is proposed to be built to take the expressway over this stream section. Its erosional state has not been considered during Specimen Design. However, the existing culvert is a reasonable size (1.5m by 1.5m box) so that the channel forming discharge is able to flow through the culvert with relatively little temporary storage upstream (the culvert needs to be replaced because the large upstream catchment means that during the 10yr ARI and 100yr ARI, the volume of water temporarily stored upstream of the culvert is very large). Hence, it is expected that the culvert has had less impact on the sediment transport within the stream than some of the other culverts.

A main difference with the runoff during pre-SH2 condition is likely to be the effect of climate change. There is more impervious area and fewer trees in the upstream catchment than during the pre-SH2 time, however the impact on the runoff due to the additional impervious area and continued tree loss is estimated to be small.

Response Reviewer: I don't think I was rigorous enough in reviewing this section, and now realise that you have quoted the "existing conditions" peak flow but not the post-TML value. I'm somewhat confused about whether the channel between TML and the estuary is natural channel, part of SR4A or a bit of both. Will it all be managed or reconstructed to accommodate post-development flood flows?

As it happens, the present channel is a straight ditch cut through a floodplain that appears from Google Maps to be borderline between pasture and swamp. Almost any effort at creating a suitable "realigned" channel would be an improvement.

Response Designer: Just as for the previous comment, the channel between TNL and the estuary is included in the mitigation design. Hence the flood effects on this land due to the upsizing of the upstream culvert has not been investigated further.

Response Reviewer: Comment resolved.

Comment Reviewer: Suggested extra words: "a new outfall into Te Puna Stram upstream of both the TNL and SH2"

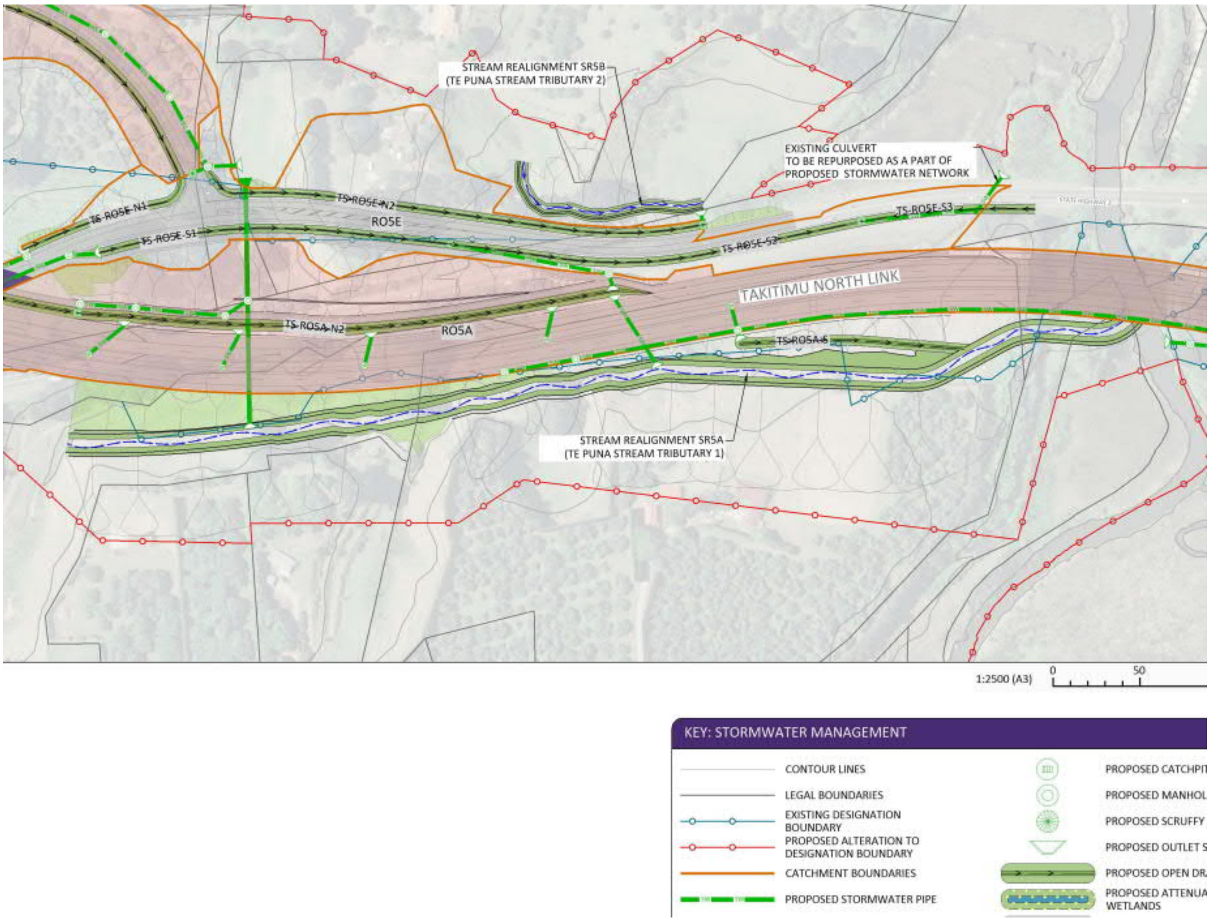
Can you indicate on Figure 6 the small sub-catchment that will still flow through the culvert, or refer to a plan that does show that?

Response Designer: Text has been updated with additional words and links to relevant section in the "Takitimu North Link Stage 2 – Specimen Design – Stormwater Management" report, Appendix B, drawing 144702-00-2216. Please note that in the last version of this report that was forwarded to you, this drawing did not show the correct proposed connection between the swales next to SH2 and culvert. The proposed pipe is to connect a proposed treatment swale alongside SH2 with the existing culvert from the side. The upstream end of the existing culvert is to be blocked off. This has now been updated. A snip of the updated drawing is shown below.

In addition, Figure 6 has been updated to include a representation of the existing culvert that was missing from the earlier figure.

Response Reviewer: I'm still not certain but presume that the treatment swales are to be the sole catchment of SH2-2900. It doesn't matter anyway.

Response Reviewer: Comment resolved.



Comment Reviewer: 2.7 p11 - I am a bit confused by these two paragraphs. The first paragraph describes the status quo conditions (for the 100-year event? Could you quote the ARI?). It's not clear here (but may be explained elsewhere) why improving these longstanding conditions is essential rather than desirable.

The 2nd paragraph is an options analysis, but it is difficult for the reader to tease out the options. Those options appear to be:

- *Designing the TNL culvert to throttle the flow just enough to retain the present peak runoff, leaving the SH2 culvert as it is;*
- *Designing the TNL culvert to avoid any flow detention, but leaving the SH2 culvert as it is;*
- *Designing both the TNL culvert and a replacement SH2 culvert to avoid any flow detention.*

Was there ever a 4th option, to engineer some limited detention to moderate peak flows?2.7 above

The last of these three options was then modelled. That's all good, as you've explained why the first two options are not ideal. However, it could all be set out more clearly.

Response Designer: The first paragraph describes the existing condition, i.e. without the construction of Takitimu North Link Stage 2, which highlights the existing issue of flooding due to the undersized culvert. The numbers provided are indeed for the 100yr ARI storm including climate change (text has been updated).

The second paragraph describes a single option where Takitimu North Link Stage 2 was to be built, including a suitably sized culvert, but no modifications were carried out to the existing SH2 culvert. This option is described to give the reasoning why the existing culvert must be upsized as part of the project. I.e., because the embankment of the proposed expressway would be located upstream of the existing culvert, within the area that floods in the existing condition. The available volume for flooding upstream of the existing SH2 culvert would be significantly reduced. This would cause the depth of the flooding upstream of the existing SH2 culvert to increase and hence result in uncontrolled overtopping of SH2. The construction of the embankment will therefore make the existing flooding issue significantly worse. To mitigate the effect of Takitimu North Link Stage 2 on the existing flooding issues, the existing culvert is proposed to be upsized. The text in the second paragraph has been rewritten to clarify the above.

When looking at potential design options for the proposed Takitimu North Link culvert and the upsized SH2 culvert, it became clear that the embankments of the two roads will be too close together for there to be an open channel between the outlet of the TNL culvert and the inlet of the SH2 culvert (SH2-4070). Hence a single culvert consisting of three pipes that crosses both TNL and SH2 was the only option investigated. For clarity, this has also been added to the text at this point in the report.

Response Reviewer: That 2nd paragraph is still difficult to follow, but the need for the one culvert is hard to argue with.

Can that culvert pass the 100-year event with little or no heading up, and does it have to?

Response Designer: The model indicates there is minimal heading up at the culvert inlet.

Response Reviewer: Comment resolved.

Comment Reviewer: 2.8 p12 Same comments as 2.7 above.

Response Designer: The text in the second paragraph of section 2.8 has been rewritten as per the response to the previous comment. An option to engineer some limited detention to moderate peak flow was not investigated as such an option would likely not meet the fish passage requirements.

Response Reviewer: Comment resolved.

Comment Reviewer: 2.9 p13 Same comments as 2.7 above.

Response Designer: The text in the second paragraph of section 2.9 has been rewritten as per the response to the previous comment. An option to engineer some limited detention to moderate peak flow was not investigated as such an option would likely not meet the fish passage requirements.

Response Reviewer (2.8 and 2.9): That's fine, with the same reservation about readability

Response Reviewer: Comment resolved.

Comment Reviewer: 2.10 p14 - Just to be clear (because I was confused at fist) can you start by saying "The existing culvert was constructed recently as part of TNL Stage 1".

Yes, it seems almost self-evident that the longer culvert now needed won't significantly change the hydraulics.

Response Designer: It has not been constructed yet, but construction is expected to begin on the associated stream realignments next January (2024). Culvert construction will begin after preloading of the subgrade is complete. Text has been updated accordingly.

Response Reviewer: That's fine

Response Reviewer: Comment resolved.

Comment Reviewer: 3.2 2nd para p17 - I'd rather the 2005 and 2130 rainfall intensities were referred to as "present day" and "post climate change" or similar.

Response Designer: Text has been updated to 'present day (2005) and climate change affected (2130) rainfall intensities'.

Comment Reviewer: 3.2 4th para - Can you say anything about how the "decay rate" was determined? It and the final infiltration rates are the important parameters.

Response Designer: In the SWMM there is some guidance as what to use for the decay rate, it gives a typical range of 2 to 7. This is based on the original work done by Horton (1939). In that paper Horton obtains estimates for the parameters in the Horton equation from experimental data of rainfall and runoff rates from various soils. The soil that best matched those in the relevant areas in the Bay of Plenty had a decay rate of 3.57. In the model we used a value of 3. However, please note that this value has very minimal impact on the runoff rates because irrespective of the value used within the typical range, the final infiltration rate is reached well before the peak in the rainfall intensity as shown in Figure 14.

Response Reviewer: That sounds fine, but could you please insert the above explanation into the method description?

Response Designer: The text has been expanded the include explanation for decay rate value.

Response Reviewer: Comment resolved.

Comment Reviewer: 3.3 p21 - I agree that being unable to include the "main" channel in the cross-sections won't make much difference to the calculations.

The choices for Manning's n are reasonable. With unlimited resources I'd recommend one or two sensitivity tests, but it's perhaps best not to add uncertainty when consenting is involved!

The approach to volume storage sounds sensible.

Response Designer: Noted.

Response Reviewer: Comment resolved.

Comment Reviewer: p22 - It is not clear to me here whether the outlet structure is in fact a series of weirs or just behaves like one. I don't suppose it matters as long as you are confident of your hydraulic description of it.

Response Designer: The reference in the text referred to the outlet structure containing one or more weirs. However, these are not set up in series as may be interpreted from the text. Text has been updated to avoid confusion.

The specifics of the outlet structure will depend on the attenuation required to match the existing condition flow rates. But a typical outlet structure includes an orifice at the permanent level (for controlling the outflow up to the 2yr ARI design flow), a weir at the peak water level of the 2yr ARI design flow in the wetland (for controlling the outflow up to the 10yr ARI design flow) and a weir at the peak water level of 10yr ARI design flow (for controlling the outflow up to the 100yr ARI design flow). The design of the outlet structure would likely also include an emergency overflow for flows more than the 100yr ARI design flow or if other parts of the outlet structure are blocked. However, these scenarios are not typically modelled.

Response Reviewer: That sounds fairly standard practice now, although in my experience it is much more common to build one weir with a varying crest level that provides the required responses to various flow events.

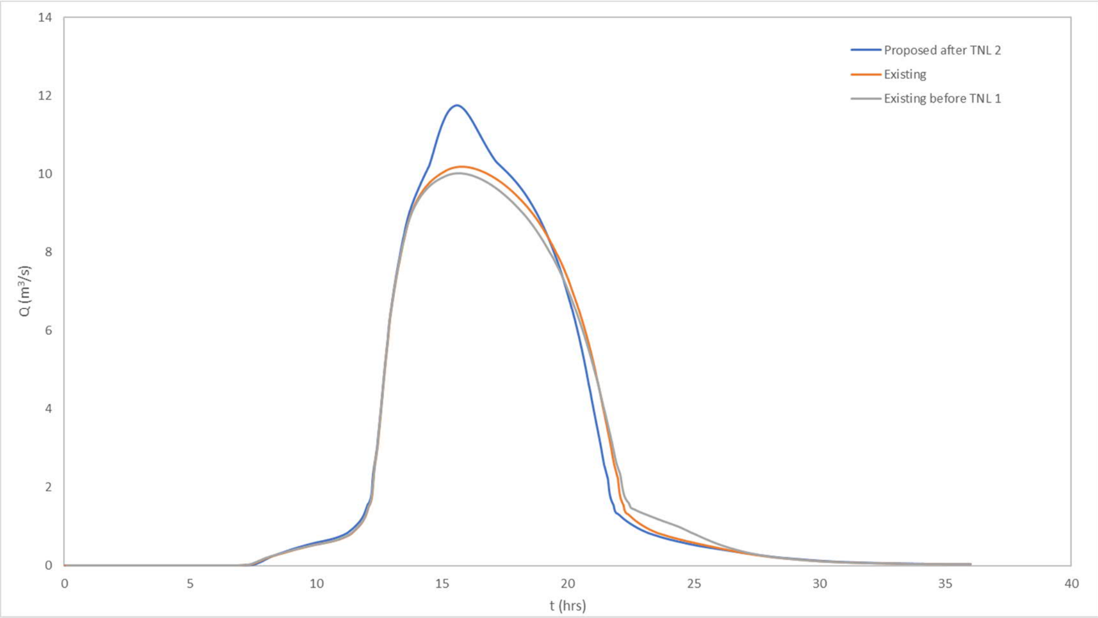
Response Designer: The description of the weir by the reviewer is likely the method used for creating the weir, but in the model this is set up as per the description in the previous response.

Response Reviewer: Comment resolved.

Comment Reviewer: P23 - If there were any concern about the project causing channel erosion just upstream of the coastal marine area, then you'd also need to model the design rainfall event coinciding with low water.

Response Designer: Because the flow is controlled by the KiwiRail culvert and the KiwiRail embankment does not overtop, changes in the hydrodynamics downstream of the KiwiRail culvert, due to the upsizing of the SH2 culverts are small. The plot of 2-year hydrographs below provides a comparison of the flows under three conditions (existing,

existing after TNL-1, and TNL-2 proposed). The results are based on 2130 climate adjusted rainfall and low tide with no sea level rise.



High tide and sea level rise will increase the tailwater at the downstream end of the stream enough to negate any significant change in velocity within the channel due to the flooding from the harbour. As can be seen in the graph, the small increase in peak discharge in the proposed condition has a short duration and the existing conditions indicate a slightly longer duration within the range of typical channel forming discharges. While some inference could be made around the increase or decrease in potential erosion in the downstream reach of the stream, the effect would be minor regardless.

Response Reviewer: This graph should go into the report, I think, or the 100-year equivalent (or is this information already there as the green lines in Figure 20?). As you say, downstream of the railway we get a minor increase in flow rate, limited to about 5 hours. Thus the downstream effects here are moderate, both for channel stability and for closure of Borell Road.

Response Designer: As Borrell Road already closes due to flooding and the difference in flow is small (and thus, the difference in depth will be very small, 0.05m without climate change or 0.02m with climate change as per Table 9 in the report), the effect will be minor or less than minor. The width of the floodplain and the dense vegetation will keep erosion or scour at minor or less than minor as well.

Response Reviewer: Comment resolved.

Comment Reviewer: 4.1 p24 - I find part of para 1 confusing, but take it that "Existing Conditions" means post-TNL Stage 1.

Response Designer: That is correct. For clarity, reference to the existing condition being after the completion of TNL Stage 1 has been added to the text, references to situation pre-TNL Stage 1 have been removed, references to TNL Stage 1 documents have also been removed.

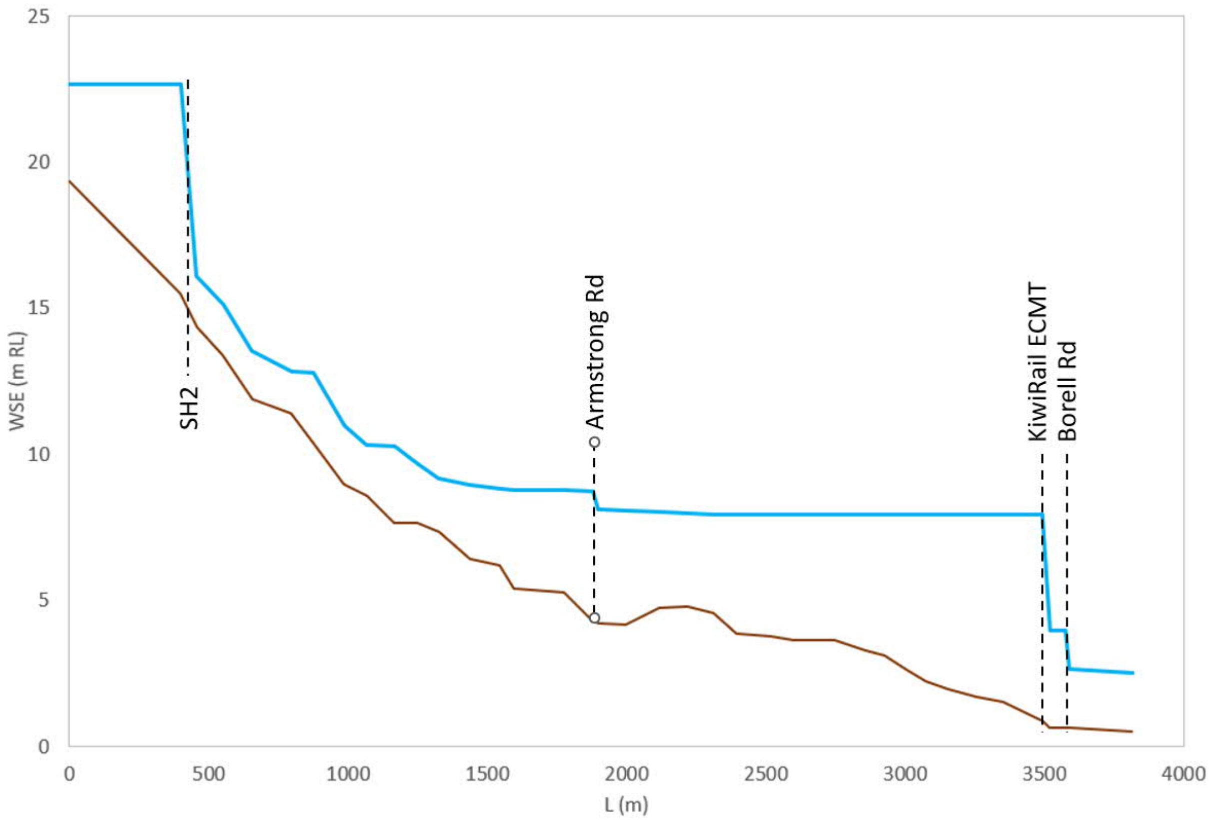
Response Reviewer: Comment resolved.

Comment Reviewer: 4.1 5th para: "… the model results suggest that [4 crossings] are major control structures". They no doubt are, but neither Fig 15 nor Table 6 demonstrates this really. Could you add a peak water level profile from upstream of SH2 to the sea? Or instead include in Table 5 water levels downstream of the culverts?

Response Designer: The following figure has been added to the text:

Response Reviewer: The profile is useful! I'm not sure how important it is, but the figure suggests that SH2 and the railway are indeed major control structures, but probably not the other two roads.

Response Reviewer: Comment resolved.



Comment Reviewer: p44 -"4.2 p25 & p28 (applicable to both the Te Pua tributary and Oturu Creek

Again, a long profile of peak water levels (existing vs proposed) would be instructive. So would be one or two flow hydrographs (existing and proposed for a particular location plotted together) which would show the existing storage in action.

I think flow hydrographs upstream and downstream of each attenuation wetland would be very helpful" an immediate demonstration to BoPRC that the wetland performs as intended.

But the effects you describe all sound very credible.

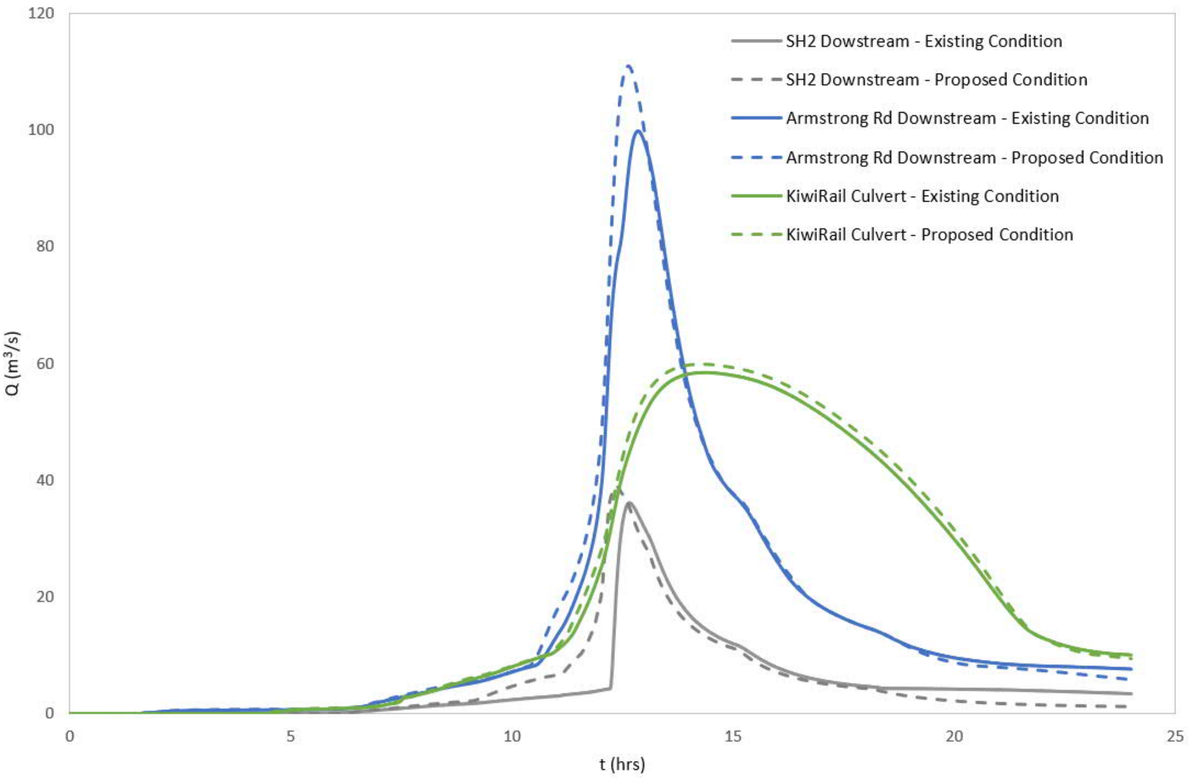
Response Designer: As stated in reply to similar comment on the report "Takitimu North Link Stage 1 – Downstream Effects Investigation", profiles of the peak water levels that compare existing versus proposed do not clearly show the effects because of the length of the profile as well as the peak depths at more than 6m. Instead, also in response to a comment on the report "Takitimu North Link Stage 1 – Downstream Effects Investigation", tables of the peak flow depths comparing existing and proposed (for the scenarios without and with climate change) have been included (Tables 5 and 6) as well as table of the peak culvert flow and overflow (Tables 7 and 8).

A hydrograph of the flow rates downstream of the three main flow control locations within the catchment, i.e., SH2, Armstrong Rd and KiwiRail culvert, is shown below. It compares the flow rates in the existing and proposed conditions. It confirms the slightly larger peak flow rates (as per Tables 5 and 6). It also highlights that the peaks are delayed in the existing condition as water fills the volume upstream of the SH2 culvert, before overtopping, which results in a very rapid increase in the flow rates downstream of the culvert.

To confirm the performance of the attenuation wetlands, the peak flow rates in the existing and proposed conditions were compared in report "Takitimu North Link Stage 2 – Specimen Design – Stormwater Management". A comparison of the hydrograph for the attenuation wetland RO8 in the existing and the proposed condition was included the response to the reviewer's comments on report "Takitimu North Link Stage 2 – Specimen Design – Stormwater Management".

Response Reviewer: Figure 20 and Tables 5-8 are helpful. I see from Tables 5 and 7 (but not 6 and 8) that flooding of Armstrong Road will be significantly worse. That also implies more frequent flooding in lesser events. However, BoPRC may well note that it's a return to pre-1950s (more or less) and perhaps no more than an inconvenience.

Does the Stormwater Management report now contain the graph showing the attenuation provided by the wetland?



Designer response: At the roads, the upsizing of the existing culverts results in a 0.15m increase in the peak flow depths during large storms which does not significantly alter the existing high risk due to the overtopping. The impact of the upsized culverts on the risks due to road overtopping were not a major concern to the Regional Council.

Response Reviewer: Comment resolved.

Comment Reviewer: P29 - Water level and flow hydrographs upstream and downstream of the Oturu Creek rail culvert would also be helpful, and should at some stage be seen by Kiwirail. They may consider a culvert upgrade there someday, and might need to address dam stability with the increased depths due to this project and (particularly) climate change.

Response Designer: Details of the effects of TNL 1, 2 and climate change have independently been shared with Kiwirail for their further assessment.

Reviewer response: That's good. I presume that Tables 5-8 essentially provide the peaks of these hydrographs.

Designer response: That is correct.

Response Reviewer: Comment resolved.

Comment Reviewer: 5 Modelling the Waipapa Stream tributary

This all looks to be sound modelling. I'd say that Manning's n right now, with the tangle of exotic weeds, would be more than the .045 assumed, especially for higher flows. However, the weeds could easily be cleared anytime, so no need to change anything.

Response Designer: Noted.

Response Reviewer: Comment resolved.

Comment Reviewer: 6 Waipapa Stream tributary HECRAS Results

P 37 I found this all a bit confusing; it is sometimes hard to work out what's being compared with what. However, it seems the results are sound and what one might expect.

Could you possibly insert a couple of flow hydrographs into the report? For instance, you could put all the "present climate" hydrographs on one plot (existing & proposed scenarios, 6 lines) and the "future climate" ones on another plot. Or if that looked too cluttered, just the 2-year and 100-year ARIs. The hydrographs should illustrate nicely how the existing upstream storage is quickly taken up in larger events.

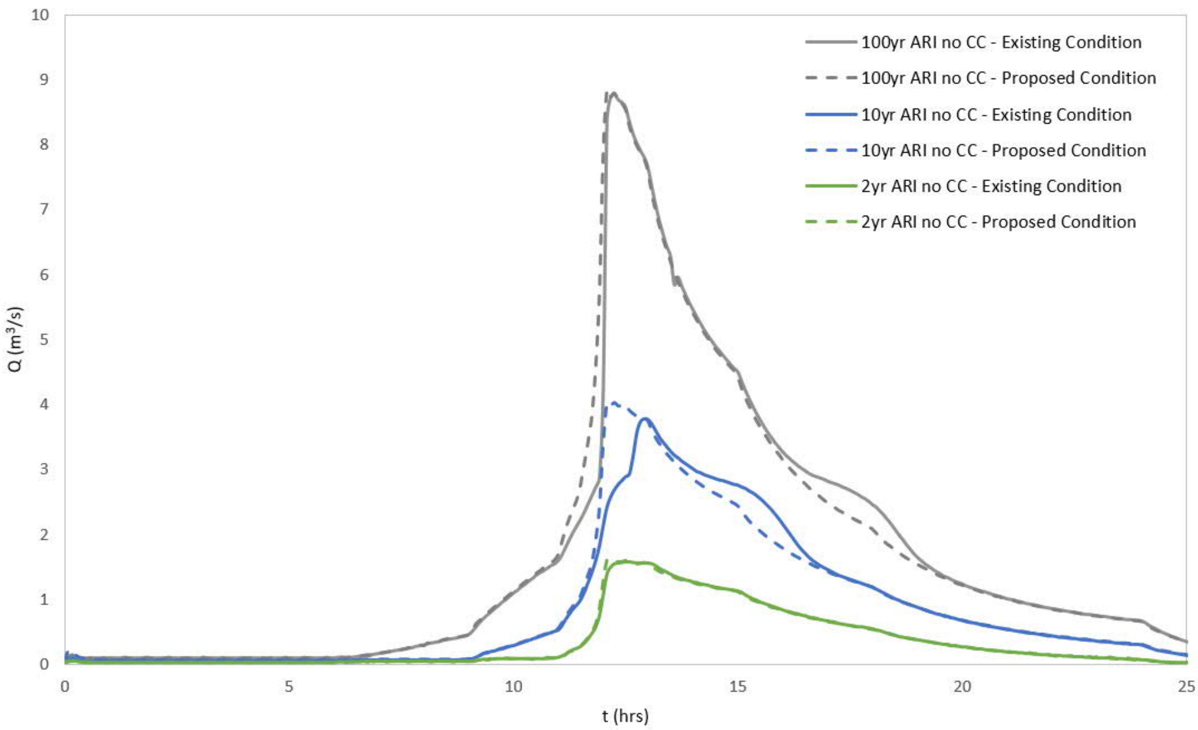
- *P38 I agree with the conclusion that any effects are minor. However, there will be a range of events where the storage upstream of the culvert has a significant effect downstream. The hydrographs I've suggested will show whether that storage effect is really significant - I suspect not.*

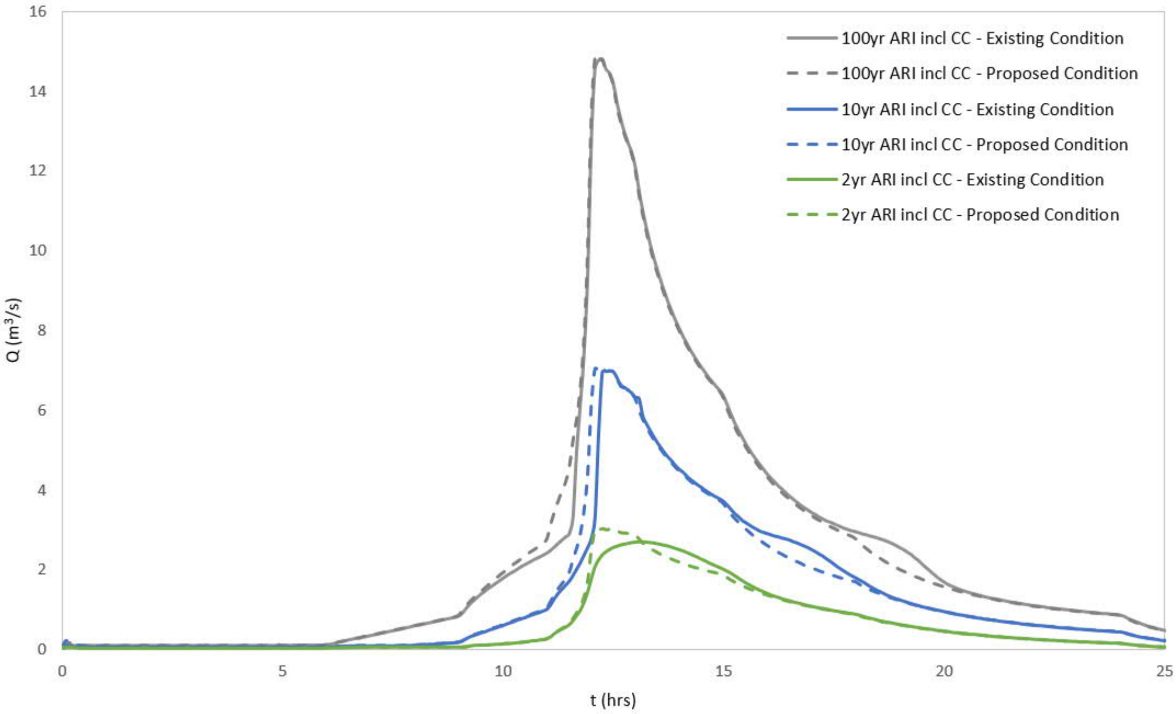
Response Designer: The hydrographs for the flows immediately downstream of the culvert for the existing condition and proposed condition for the 2yr ARI, 10yr ARI and 100yr ARI design storms without climate change and including climate change are shown below. These confirm that the peak flow rates during the 10yr ARI including climate change and 100yr ARI without and with climate change are very similar as the flow overtops the road in the existing condition during the time of peak rainfall intensity. For the 10yr ARI without climate change, the road does overtop, but after the shortly after the time of peak rainfall intensity, hence the downstream flow rate during the existing is slightly smaller than the proposed condition. For 2yr ARI design storm including climate change, the flow does not overtop in the existing condition, but does storage a significant amount of water upstream of the culvert. Hence the downstream flow rate during the existing is still slightly larger than for the proposed condition. For the 2yr ARI design storm without climate change, the storage upstream of the culvert in the existing condition is no longer significant. Hence the downstream flow rates are again the same in the existing and proposed conditions. Figures have been added to the text. Text has also been updated to clarify the above details.

The data indeed indicates that somewhere between the flow rate of the 10yr ARI design storm including climate change and without climate change, the proposed condition starts affecting the peak flow rate downstream of the culvert. And this continues to be the case down to somewhere between the flow rate of the 2yr ARI design storm including climate change and the 2yr without climate change.

Response Reviewer: It's good to see these graphs in the report, and pleasing for BoPRC no doubt that peak flow rates here will be little changed.

Response Reviewer: Comment resolved.


100yr ARI no CC - Existing Condition
100yr ARI no CC - Proposed Condition
10yr ARI no CC - Existing Condition
10yr ARI no CC - Proposed Condition
2yr ARI no CC - Existing Condition
2yr ARI no CC - Proposed Condition
Q (m³/s)
t (hrs)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25


100yr ARI incl CC - Existing Condition
100yr ARI incl CC - Proposed Condition
10yr ARI incl CC - Existing Condition
10yr ARI incl CC - Proposed Condition
2yr ARI incl CC - Existing Condition
2yr ARI incl CC - Proposed Condition
Q (m³/s)
t (hrs)
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25