Model Review Comments

| | |
|---|---|
| **Site Address** | Rangitoopuni Development Riverhead, Auckland |
| **Resource Consent Number** | BUN60449727 |
| **Files Reviewed** | Stormwater Management Plan Rev A, Maven Dated 30 April 25<br>Appendix AA.3 Stormwater Drawings, Maven<br>Flood Assessment Report, Maven, Rev A, Dated 5 May 2025 |

| Item Number | Comments | Descriptions of issues or concerns | Supporting Figures | Reason for request | Maven Response 251020 | Maven Response 251024 |
|---|---|---|---|---|---|---|
| | **HEC-RAS Model** | | | | | |
| 1 | 2D Model inflow boundaries | No hydrological model files have ben provided to support the inflow hydrograph used in the model. | | Justifications of the peak flow adopted. | The hydrological model files have been provided in the revised OneDrive link, which includes the hydrograph used in the model. | The hydrological model files have been provided in the revised OneDrive link, which includes the hydrograph used in the model. |
| 2 | Representation of the post development building platforms and roads in future development scenario | The model results indicate significant ponding with depths vary from 0.05m to 0.15m over large areas, possibly due to grading design issues. These pondings are unrealistic and can distort the peak discharge from these area. | Figure 1 | Excessive pondings can attenuate peak flow | As discussed in the meeting, the ponding on the platforms and/or within the Retirement Village is representation of what occurs to largely flat or low grade areas during periods of sustained rainfall in a 100-yr rainfall event. Ponding and sheet flow of surface water does occur in such areas during rainfall events. The surface within the HEC-RAS model is the actual surface which Maven has designed, including all platforms in the CSL, and the full retirement village, which includes the roads (which act as the CUTP routes within the village), whilst all lot areas have been graded so that external lots will shed towards the bush areas. Maven does not agree that the ponding shown in the HEC-RAS model is excessive, nor do we believe that this is skewing the results. Instead, we would argue that the suggestion of including a design rain-fall event before the 100-yr event would spue the results; and that such a scenario is neither reasonable or realistic to model. | Addional Modelling was completed and sent through on the 23/10/25 investigating the effects of the ponding on the building platforms on the peak flow. Two sensitivity runs were completed for the 100yrCC including<br>•Sensitivity 1: Terrain update to remove discussed ponding<br>•Sensitivity 2: Terrain update to remove discussed ponding and RV manning lowered to 0.03.<br>Update increased post development flows by approximately 2%, however flows were still found to be less than predevelopment. |
| 3 | Manning's n values used | The model adopted n value of 0.1 for all streams and general pervious area, 0.3 for building footpint and 0.03 for roads. Suggest more realistic n values to be used pervious area and stream based on land cover. Manning's n value of 1 should be used for building platforms. | | 0.1 for all pervious area can slow down the runoff and therefore reduce peak discharges modelled. | We believe that the use of 0.1 is acceptable throughout the site. The reasons behind this assumption is that logged forests are not reflective of pasture or grass land, and surface water flowing over the land has to pass through slash, logs and other debris. The use of 0.1 in the Retirement Village is also considered acceptable, as the retirement village features, fencing, retaining, landscaping and buildings of which is consistent with urban areas which the Code of practice requries the use of 0.1 for. Notwithstanding this, as was agreed in the meeting, we have undertaken a further model (uploaded in the OneDrive link) which changed the building platforms in the CSL to 0.035. This had no material difference to the outcome which further supports our orginal position. | We believe that the use of 0.1 is acceptable throughout the site. The reasons behind this assumption is that logged forests are not reflective of pasture or grass land, and surface water flowing over the land has to pass through slash, logs and other debris. The use of 0.1 in the Retirement Village is also considered acceptable, as the retirement village features, fencing, retaining, landscaping and buildings of which is consistent with urban areas which the Code of practice requries the use of 0.1 for. Notwithstanding this, as was agreed in the meeting, we have undertaken a further model (uploaded in the OneDrive link) which changed the building platforms in the CSL to 0.035. This had no material difference to the outcome which further supports our orginal position. |
| 4 | Downstream model boundary condition | A constant water level of 2.55m has been adopted at the junction with the Rangitoopuni River. Regional Rural Rapid Flood Model indicates an elevated tail water during extem events. Suggest the TS from the RFM to be used as a dynamic boundary condition. | Figure 2 and Tab DS WLTS | Downstream boundary can impact flood levels at Riverhead | Confirming Maven will run a 100-yr model with the dynamic heights of the downstream boundary condition.The results of this will be shared with Healthy Waters as soon as thsese are available. We remain of the view, that this scenario is not critical, as absolute levels downstream should not be a key concern, if our model continues to outline the reduction in peak run-off, which will deliver downstream benefits irrespective of the boundary condition modelled. | Addional Modelling was completed and sent through on the 22/10/25 investigating the effects of the using the provided dynamic height downstream boundary condition. Model confirmed that dynamic boundary did not have any effect on the peak flows and assessment. |
| 5 | Pre-development catchment runoff CN number | A pre-davleopment CN nuber of 74 has been adopted for the catchment area while a CN number of 70 is assumed for future pervious areas covenanted for native bush. Please note the existing ground has a top soil depth of 200-400mm. The catchment area was mostly covered by forest in the past on long term average basis. A curve number of 70 is considered to be more presentative of the long term avearage condition of the area. Minimum top soild depth of 300mm should be provided for all pervious area to | Figures 19,20 and 21 showing historic land cover | Assessment of effects from development requires appropriate representation of the existing condition. | As was noted in the meeting we do not agree with the sentiment that the pre-development condition should assume a CN value of 70 based on historic land cover. We are instead of the view that the pre-development assessment should be based on the current nature of the site, which for all of Lot 1 is recently logged. The existing catchment within Stages 6 and 7 which feature forest cover are also being logged in December 2025 - March 2026. Lot 2 features recently planted pines (4-5 years old) which also features minimal cover. These trees will be / can be removed without any consideration of downstream effects due to existing nature of the forest. A more robust planning and legal position relative to the effects based assessment will be provided to the panel in the forthcoming response on 24/10. If we assume a CN value of 70 for a plantation forest, this fails to consider the increased run-off effects that occur during after and for a time beyond the forest is harvested. On this basis, if a rainfall event was to occur after logging activties were done, the effects on Riverhead would not be increased. A value of CN 74 has been used in all of Council's modelling and PC100, and thus is further reasoning why we have used this as a basis for our pre-development assessment. | As was noted in the meeting we do not agree with the sentiment that the pre-development condition should assume a CN value of 70 based on historic land cover. We are instead of the view that the pre-development assessment should be based on the current nature of the site, which for all of Lot 1 is recently logged. The existing catchment within Stages 6 and 7 which feature forest cover are also being logged in December 2025 - March 2026. Lot 2 features recently planted pines (4-5 years old) which also features minimal cover. These trees will be / can be removed without any consideration of downstream effects due to existing nature of the forest. A more robust planning and legal position relative to the effects based assessment will be provided to the panel in the forthcoming response on 24/10. If we assume a CN value of 70 for a plantation forest, this fails to consider the increased run-off effects that occur during after and for a time beyond the forest is harvested. On this basis, if a rainfall event was to occur after logging activties were done, the effects on Riverhead would not be increased. A value of CN 74 has been used in all of Council's modelling and PC100, and thus is further reasoning why we have used this as a basis for our pre-development assessment. |
| 6 | Post development CN Number | There is no calculation and GIS file supporting the derivation of the composite CN number for each infiltration layer polygon. The covenanted bush area will be in the range of 170 ha and will take a very long time to establish. Therefore there will be a long time during and after the development, when the regenerated bush area will not be established. The increased flood risk during this period should also be assessed. The timing of the earthwork, housing development and native bush establishment should be provided to enable a clear understanding of this intermediate risk. | Figure 3 | Assessment of effects from development requires appropriate representation of the post development condition | Maven's position remains that the pre-development assessment is based on a conservative CN of 74, when we are of the view that the current CN should be 77. As such, we feel that this allows for the transition period when the bush is establishing. Given that modelling is based on long-term probabilities, we still feel that the approach is the best for the catchment. If this is an issue, we are open to introducing some interim mitigation which would see on-lot attenuation of roof and/or driveway areas being proposed. However, we do not believe that this is required for perpetuity and would suggest that such controls would only be required for the first 5years, or until canopy cover is achieved in the planted areas. We are happy to discuss how this could be conditioned, if this is an approach that we need to take. We are of the view, that this would only need to be considered for the eastern catchment. | Maven's position remains that the pre-development assessment is based on a conservative CN of 74, when we are of the view that the current CN should be 77. As such, we feel that this allows for the transition period when the bush is establishing. Given that modelling is based on long-term probabilities, we still feel that the approach is the best for the catchment. If this is an issue, we are open to introducing some interim mitigation which would see on-lot attenuation of roof and/or driveway areas being proposed. However, we do not believe that this is required for perpetuity and would suggest that such controls would only be required for the first 5years, or until canopy cover is achieved in the planted areas. We are happy to discuss how this could be conditioned, if this is an approach that we need to take. We are of the view, that this would only need to be considered for the eastern catchment. |
| 7 | Post development pervious area CN number | Geotechnical investigation indicate existing top soil depth from 0.2m to 0.4m at the catchment area. For the post development catchment area, if similar top soil depth can not be maintained then higher CN number should be used. | | Assesment of effects from development requires appropriate representation of the post development condition | For the CSL development, we are only going to be earth working the platform areas and roads. There is no wider earthworks proposed outside of these areas. Within the earthworked platform areas, the existing topsoil (which includes stumps / roots and vegetation) will be mulched in-situ down to a depth of 300mm (average) and then this material will be excavated and placed as bund around the cut/fill areas. Bulk cut and fill operations will then take place, before the topsoil is placed over the platform areas. We are aiming for a depth of 200-300mm topsoil which may be supplemented by additional mulch (pine chippings from onsite) in the planted areas directly around the platforms. On this basis, the CN values for future landscape areas is considered acceptable. | For the CSL development, we are only going to be earth working the platform areas and roads. There is no wider earthworks proposed outside of these areas. Within the earthworked platform areas, the existing topsoil (which includes stumps / roots and vegetation) will be mulched in-situ down to a depth of 300mm (average) and then this material will be excavated and placed as bund around the cut/fill areas. Bulk cut and fill operations will then take place, before the topsoil is placed over the platform areas. We are aiming for a depth of 200-300mm topsoil which may be supplemented by additional mulch (pine chippings from onsite) in the planted areas directly around the platforms. On this basis, the CN values for future landscape areas is considered acceptable. |
| 8 | Representation of Culverts proposed in the model | There are at least five very large culverts proposed which are not found the HEC-RAS Model, refer to Figure 4. Please explain | Figure 4 | Correct representation of all culverts proposed | These culverts have been added to the the model. (Western catchment model still undertaking minor update and will be made available tomorrow) | Addional Modelling was completed and sent through on the 21/10/25 and 22/10/25 with additional culverts added. Two of the mentioned culverts were located in the Western catchment and three in the easterncatchment.<br>Updated model included Culverts 13-4, 14-1, 6-6 and updated culvert 2 to 1.5m x 1.5m box shape culvert -addition of culvert 6-6, 14-1,13-4 results in peak flow at cross section (in figure below) increase of 0.1% from 142.48 to 142.62 m3/s, the peak flow is notably still 6.84 m3/s below predevelopment (149.46 m3/s). |
| 9 | Culverts representation inconsistencies | The 2.6m culvert under Deacon Road near the junction with Link Road is included in the pre-development model but not in the post development Model. Please explain. | | Correct representation of existing culvert | The 2.6m culvert is proposed to be upgraded to a bridge. Proposed development terrain modification has been used to model the reclaimed stream beneath the bridge. Refer to excel sheet "Response sheet 2". We note that this is consistent in all post-development scenarios modelled. | The 2.6m culvert under Deacon Road is proposed to be upgraded to a bridge. Proposed development terrain modification has been used to model the reclaimed stream beneath the bridge. Refer to excel sheet "Response sheet 2". We note that this is consistent in all post-development scenarios modelled. |
| 10 | Culverts representation inconsistencies | Culverts 1 to 7 in the post development model. Are there any existing culverts at the locations of Culverts 1-7 under the pre-development condition? Please explain | | Correct representation of existing culvert | The pre-development model does not include any of the existing culverts under Forestry Road, due to their condition and size. All existing culverts are listed under Appendix A of the flood modelling report. The largest culvert under Forestry Road (all of which have been surveyed) is 450mm. As such, given the existing state (poor condition and in some instances buried), and size ensures that the model is correctly represented with them being blocked. This also ensures that the pre-development state includes backwater effects to the west of Forestry Road. | The pre-development model does not include any of the existing culverts under Forestry Road, due to their condition and size. All existing culverts are listed under Appendix A of the flood modelling report. The largest culvert under Forestry Road (all of which have been surveyed) is 450mm. As such, given the existing state (poor condition and in some instances buried), and size ensures that the model is correctly represented with them being blocked. This also ensures that the pre-development state includes backwater effects to the west of Forestry Road. |
| 11 | Culvert size inconsistencies | Culvert 4 is 6m x 2m in the report, 6mx1.5m in the model and 4x2m on the design plans. Invert levels don't match. Culvert 5 Invert levels don't match. Please check | Figure 5, Figure 14 | Correct representation of existing culvert | Culverts 4 size is 6m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error, so this is why there is a difference in size between HEC Model and the desing plans. But this accounts for the embedment depth and details in the standard cross-section drawings. | Culverts 4 size is 6m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error, so this is why there is a difference in size between HEC Model and the desing plans. But this accounts for the embedment depth and details in the standard cross-section drawings. |
| 12 | Culvert size inconsistencies | Culvert 3 is 4mx1.5m in the model, 4mx2m in the report and plans. Invert levels don't match | Figure 6 | Culvert size inconsistency | Culverts 3 size is 4m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error, so this is why there is a difference in size between HEC Model and the desing plans. But this accounts for the embedment depth and details in the standard cross-section drawings. | Culverts 3 size is 4m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error, so this is why there is a difference in size between HEC Model and the desing plans. But this accounts for the embedment depth and details in the standard cross-section drawings. |
| 13 | Culvert size inconsistencies | Culvert 2 is a 1.5m Dia culvert, but a 1.5x1.5m box culvert on plan. Invert levels don't match | Figure 7 | | Culverts 2 size is 1.5m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error., so this is why there is a difference in size between HEC Model and the desing plans. But this accounts for the embedment depth and details in the standard cross-section drawings. | Culverts 2 size is 1.5m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error., so this is why there is a difference in size between HEC Model and the desing plans. But this accounts for the embedment depth and details in the standard cross-section drawings. |
| 14 | Culvert size inconsistencies | Culvert 6 is 2m x 1m in the report, 1.5mx1.5m in the model and on the design plans. Invert levels don't match. Please check | Figure 9 and Figure 4 | Culvert size inconsistency | Culverts 6 size is 1.5m x 2m (with 0.5m embedment). We have updated this to be a box culvert not 1500mm round.<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error. | Culverts 6 size is 1.5m x 2m (with 0.5m embedment). We have updated this to be a box culvert not 1500mm round.<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error. |
| 15 | Culvert size inconsistencies | Culvert 1 is 5m x 2m in the report, 5mx1.5m in the model and 4x2m on the design plans. Invert levels don't match between design and model. Please check | Figure 8 | Culvert size inconsistency | Culverts 1 size is 5m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error. | Culverts 1 size is 5m x 2m (with 0.5m embedment)<br>Modelled culvert in HEC RAS model does not include the embedment depth to avoid software error. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16 | | Culvert 7 included a blocked 1.5m box culvert. Design plan show a bridge not included in the model. | Figure 1 | | Culvert 7 is legacy culvert and shall be removed. | Culvert 7 is legacy culvert and shall be removed. |
| 17 | Culvert position in model | Many culverts in the HEC-RAS model has centre line station of 0, this leads to that half of the culvert opening is outside the embankment length. Please correct this to ensure appropriate representation of the model. | | Correct modelling of culvert positions | It it noted that HEC RAS only uses the digitised X,Y coordinates of culvert barrels when connected to 2D flow areas, therefore this shall have no impact on the computations | Is it noted that HEC RAS only uses the digitised X,Y coordinates of culvert barrels when connected to 2D flow areas, therefore this shall have no impact on the computations |
| 18 | Culvert sizes | It has been noticed that soft base for fish pass is proposed as a typical design for all box culvert. Has the lost cross section area and roughness of the soft base been considered in culvert hydraulic modelling? | Figure 15 | | Base of culverts have been modelled as the top of the embeded depth with a manning value of 0.035 to account for bedding roughness. | Base of culverts have been modelled as the top of the embeded depth with a manning value of 0.035 to account for bedding roughness. |
| 19 | Dry Detention Pond modelling | No outlet modelled for the dry detention pond. Please clarify how is the detention represented. Any initial water level? | Figure 12 | Correct modelling of dry detention pond | Outlet not included in 100yr model as assumed to be be fully blocked. No initial water level with pond base at mRL 32.0. | Outlet not included in 100yr model as assumed to be be fully blocked. No initial water level with pond base at mRL 32.0. |
| 20 | Terrain and Structure representation issues | Duke Road Bridge not included, and DTM errors in stream corridor require verifications | Figure 16 | Model representation of terrain and structures | Confirming Mawes will run a 100-yr model with the features included in the pre and post model. We endeavour to do this before Wednesday's meeting. We remain of the view, that this scenario is not critical, as absolute levels downstream should not be a key concern, if our model continues to outline the reduction in peak run-off, which will deliver downstream benefits. | Addional Modelling was completed and sent theough on the 22/10/25 with downstream stuctures listed in item 20 , 21 and 22.<br>Provided sensitivity check model confirmed that the downstream strucutre did not have any effect on the peak flows. Confirming mentioned downstream strcutures have no effect on relative water levels. |
| 21 | Structure representation issues | Private bridge to 17 Waitaiti Drive not included. | Figure 17 | Model representation of structures | Confirming Mawes will run a 100-yr model with the features included in the pre and post model. We endeavour to do this before Wednesday's meeting. We remain of the view, that this scenario is not critical, as absolute levels downstream should not be a key concern, if our model continues to outline the reduction in peak run-off, which will deliver downstream benefits. | Addional Modelling was completed and sent theough on the 22/10/25 with downstream stuctures listed in item 20 , 21 and 22.<br>Provided sensitivity check model confirmed that the downstream strucutre did not have any effect on the peak flows. Confirming mentioned downstream strcutures have no effect on relative water levels. |
| 22 | Structure representation issues | Private bridge to 22 School Road not included | Figure 18 | Model representation of structures | Confirming Mawes will run a 100-yr model with the features included in the pre and post model. We endeavour to do this before Wednesday's meeting. We remain of the view, that this scenario is not critical, as absolute levels downstream should not be a key concern, if our model continues to outline the reduction in peak run-off, which will deliver downstream benefits. | Addional Modelling was completed and sent theough on the 22/10/25 with downstream stuctures listed in item 20 , 21 and 22.<br>Provided sensitivity check model confirmed that the downstream strucutre did not have any effect on the peak flows. Confirming mentioned downstream strcutures have no effect on relative water levels. |
| 23 | HEC-RAS Model set up | There are too many models provided. All scenarios can be combined into one model for easy checking and comparisons. | | Too many models can cause inconsistencies and hard to compare results | As was noted in the meeting, due to the size and nature of the catchment, we have had to split the models so that we can run the model in a reasonable timeframe. Whilst we appreciate that this is not the usual approach, we are not able to combine all the models, as this becomes to labour and time intensive. | As was noted in the meeting, due to the size and nature of the catchment, we have had to split the models so that we can run the model in a reasonable timeframe. Whilst we appreciate that this is not the usual approach, we are not able to combine all the models, as this becomes to labour and time intensive. |
| 24 | Culverts for countryside living into Kaipara Harbour | These culverts and detention pond proposed have not been included in the model | | Need to verify the performance of the proposed detention at Culvert 1-1 | The crest height was adjusted slighlty in our formal response to the Panel; the model is currenlty been re-run to address this change as to ensyre the design and model is consistent. We are going to be in a position to share this model tomorrow for review / input before the meeting. | The crest height was adjusted slighlty in our formal response to the Panel; the model is currenlty been re-run to address this change as to ensyre the design and model is consistent. Model was sent through on the 22/10/25 |
| 25 | Provide a list of scenarios | The scenario name and relevant metadata should be included to enable effective review and interrogation of the model setup and results. | | | A list of scenarios run and the models to which they relate will be produced, including the additional modelled scenarios currently underway will be provided tomorrow with a list. The new models (n changes to platforms, and the 100-yr model with the amended culverts is included in the OneDrive link, refer to the folder marked yellow folder to the right | A list of scenarios run and the models to which they relate will provided. |
| 26 | Impact on existing dam at 49 Forest Road | Please assess the potential impact on the existing dam structure at No. 49 Forest Road, in terms of increase discharge, volume and flood duration. | Figure 22 | Failure of the dam structure can be detrimental to downstream properties at Rivehead | We have assessed the inflows (post-development) for the catchments which flow into the existing pond at No. 49 Forestry Road. In both instances, the flows are reduced from that of the pre-development modelled state, and the flood level has also reduced relative to depth in the pond area. As the peak flows are not increased in this catchment, no further assessment is warranted, or required in this instance. Whilst we appreciate that this part of the site is currently forested, the harvesting operation is going to occur December 2025 - March 2026. Thus, the pre-development state (as per all of Lots 1 and 2) will be clear felled, which will increase run-off from that off the pre development model assumed. As the vegetation matures within the planted and covenant areas, the proposal will deliver increased initial abstraction levels, and will progressively reduce runoff from the site. In comparison, if the rotation forestry was to occur, every 25years, the site will be deforested, and increased runoff will occur. On this basis, we don't believe any further assessment relative to this existing feature is required. | We have assessed the inflows (post-development) for the catchments which flow into the existing pond at No. 49 Forestry Road. In both instances, the flows are reduced from that of the pre-development modelled state, and the flood level has also reduced relative to depth in the pond area. As the peak flows are not increased in this catchment, no further assessment is warranted, or required in this instance. Whilst we appreciate that this part of the site is currently forested, the harvesting operation is going to occur December 2025 - March 2026. Thus, the pre-development state (as per all of Lots 1 and 2) will be clear felled, which will increase run-off from that off the pre development model assumed. As the vegetation matures within the planted and covenant areas, the proposal will deliver increased initial abstraction levels, and will progressively reduce runoff from the site. In comparison, if the rotation forestry was to occur, every 25years, the site will be deforested, and increased runoff will occur. On this basis, we don't believe any further assessment relative to this existing feature is required. |

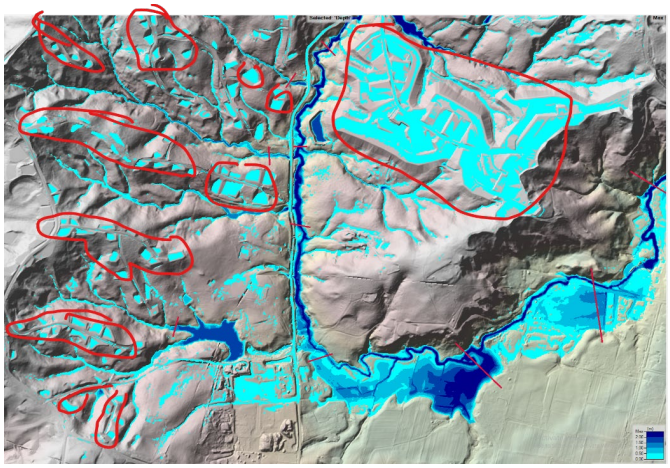


Figure 2 - RFM Rangitoopuni Water Level TS

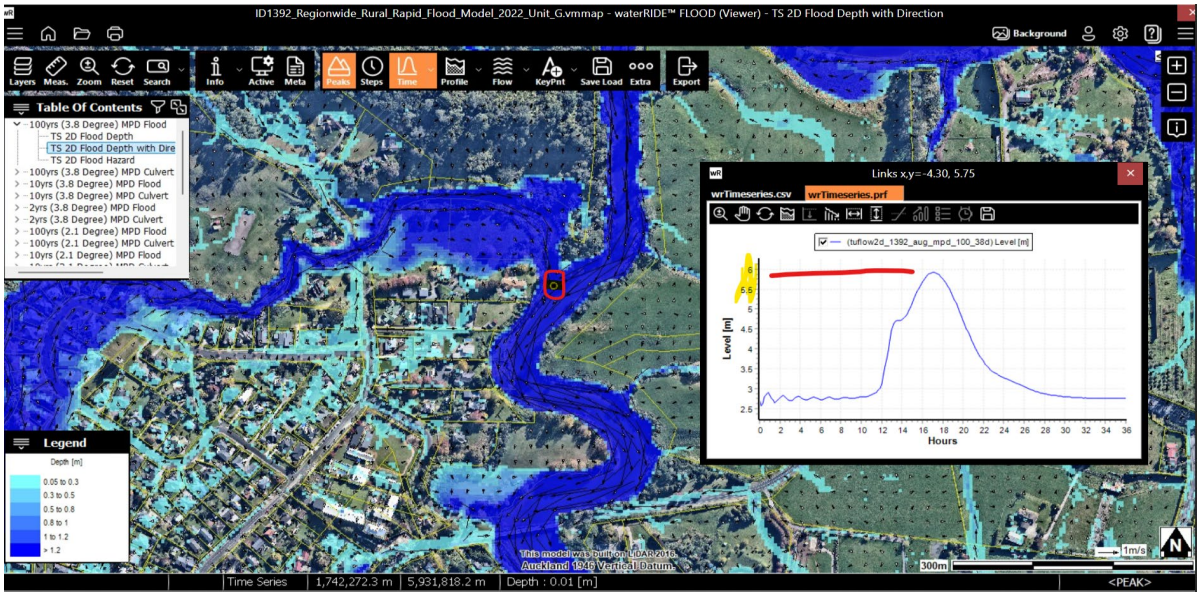
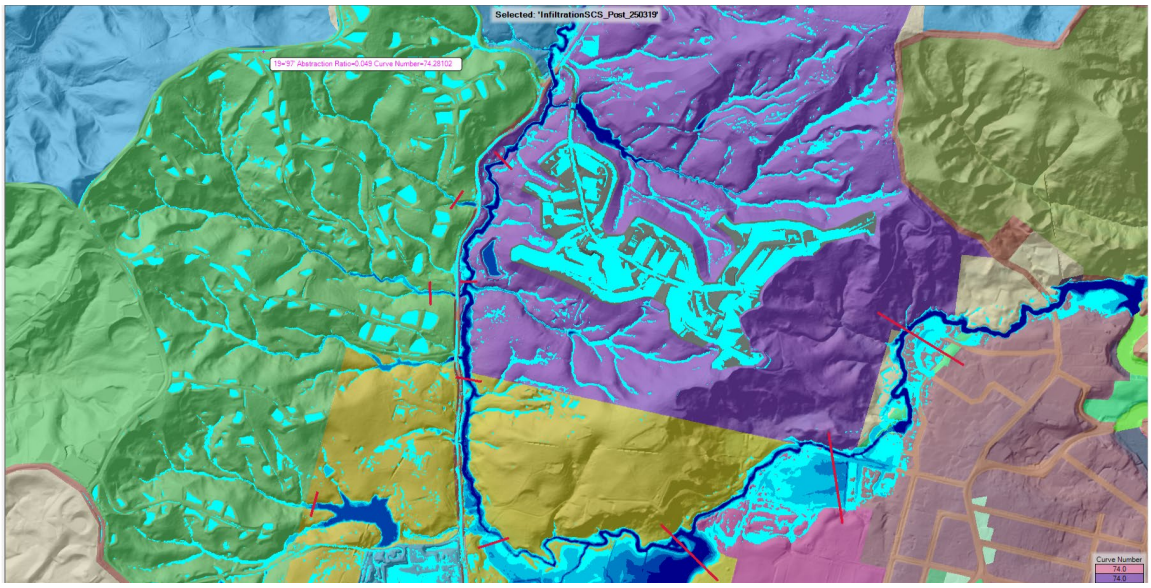



Figure 3 - Post Development CN Number - Infiltration layer



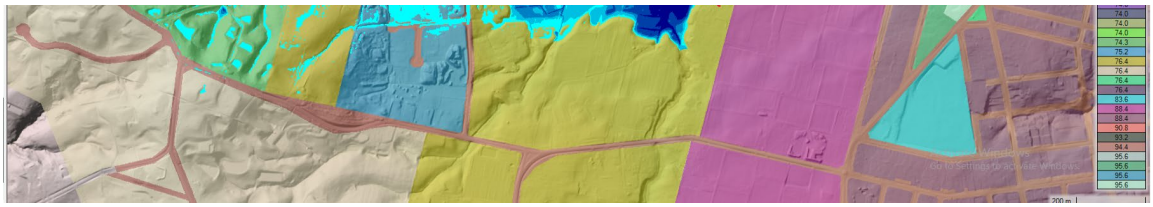


Figure 4 - Culverts Proposed - Not in the HEC-RAS Model

| HY-8 CULVERT RESULTS SUMMARY | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CULVERT No. | TYPE | SIZE | CULVERT LENGTH (m) | Flow (m3/s) | VELOCITY (m/s) | RIP-RAP THICKNESS (m) | POOL LENGTH (m) | APRON LENGTH (m) | BASIN LENGTH(m) | BASIN WIDTH (m) |
| 1 | BOX CULVERT | 5m x 2m | 13.57 | 15.67 | 3.65 | 0.30 | 15.00 | 5.00 | 20.00 | 18.30 |
| 2 | BOX CULVERT | 1.5m x 1.5m | 12.43 | 1.56 | 3.46 | 0.45 | 4.50 | 1.50 | 6.00 | 5.50 |
| 3 | BOX CULVERT | 4m x 2m | 14.84 | 9.33 | 3.17 | 0.45 | 12.00 | 4.00 | 16.00 | 14.67 |
| 4 | BOX CULVERT | 6m x 2m | 14.16 | 16.69 | 4.15 | 0.45 | 18.00 | 6.00 | 24.00 | 22.00 |
| 5 | BOX CULVERT | 2m x 1m | 15.82 | 1.68 | 2.65 | 0.15 | 6.00 | 2.00 | 8.00 | 7.33 |
| 6 | BOX CULVERT | 1.5m x 2m | 14.99 | 7.52 | 3.66 | 0.45 | 12.32 | 6.16 | 18.49 | 13.82 |
| 7 | PRIMARY-CIR-CULVERT | 0.6mø | 29.08 | 1.22 | 4.34 | 0.45 | 4.57 | 2.28 | 6.85 | 5.17 |
| | | | | | | | | | | |
| COUNTRYSIDE | | | | | | | | | | |
| 13-4 | CIR-CULVERT | 1.20mø | 14.33 | 1.58 | 3.35 | 0.30 | 5.58 | 2.79 | 8.36 | |
| 14-1 | BOX CULVERT | 1.5m x 1.5m | 13.31 | 4.07 | 5.28 | 0.45 | 9.11 | 4.56 | 13.67 | 10.61 |
| 6-6 | CIR-CULVERT | 1.05mø | 13.41 | 1.26 | 3.13 | 0.36 | 3.15 | 1.46 | 4.61 | 4.12 |
| 1 | PRIMARY-CIR-CULVERT | 1.20mø | 15.09 | 3.41 | 3.89 | 0.36 | 3.60 | 1.20 | 4.80 | 4.40 |
| 1-1 | SECONDARY-BOX-CULVERT | 4m x 1.5m | 12.36 | Specific energy dissipation arrangement to be confirmed for the secondary culvert | | | | | | |

Figure 5 - Culvert 4

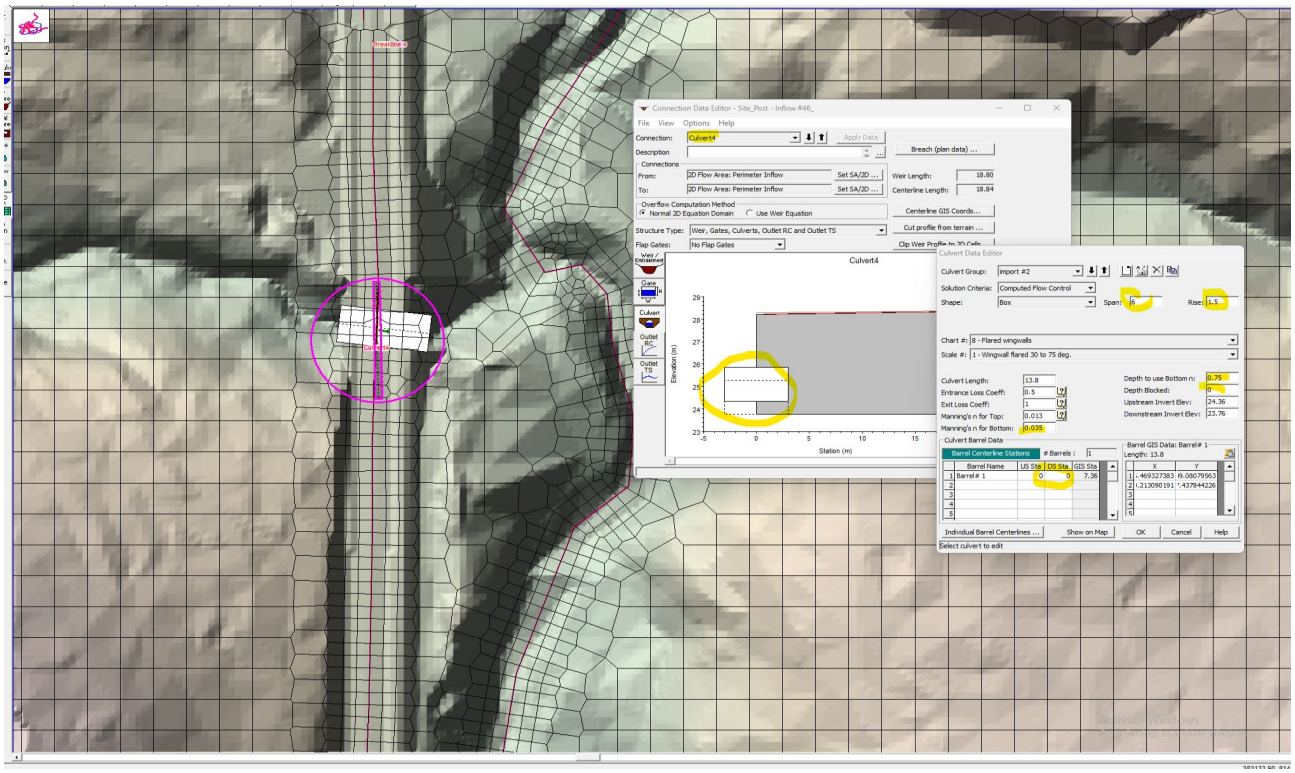
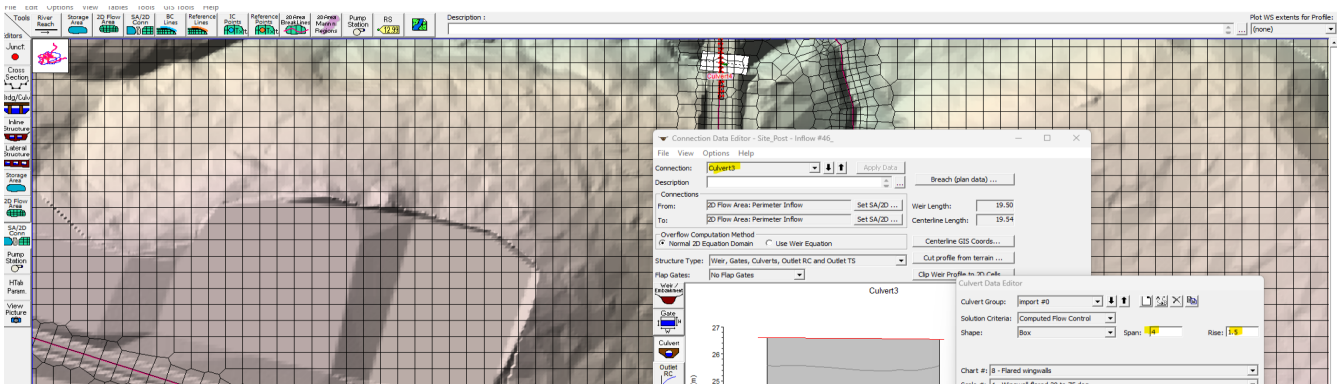



Figure 6 - Culvert 3 size



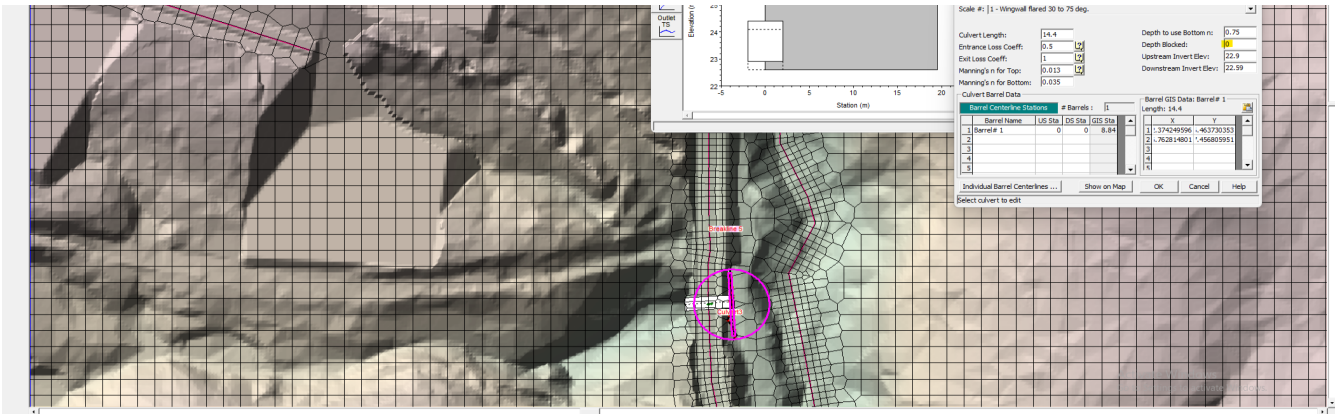


Figure 7 - Culvert 2

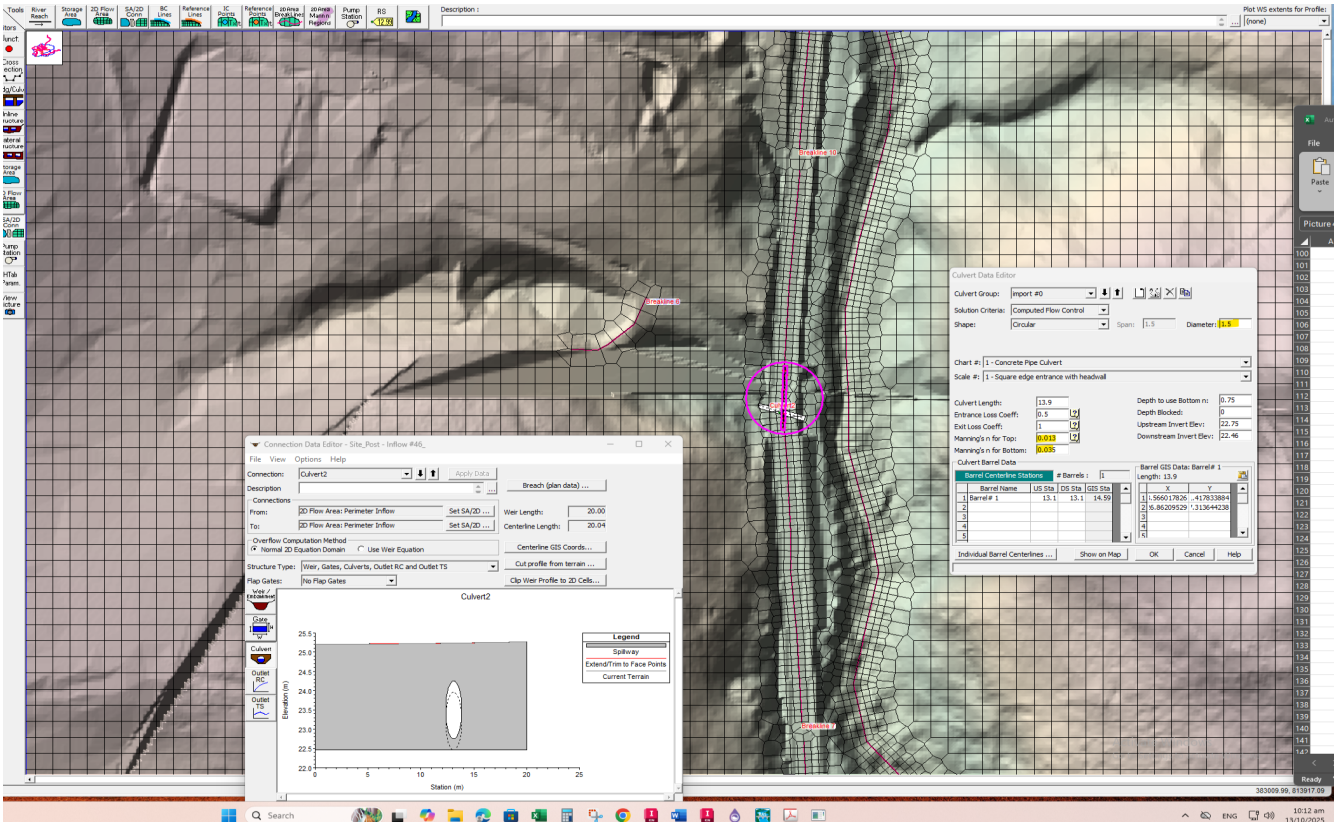
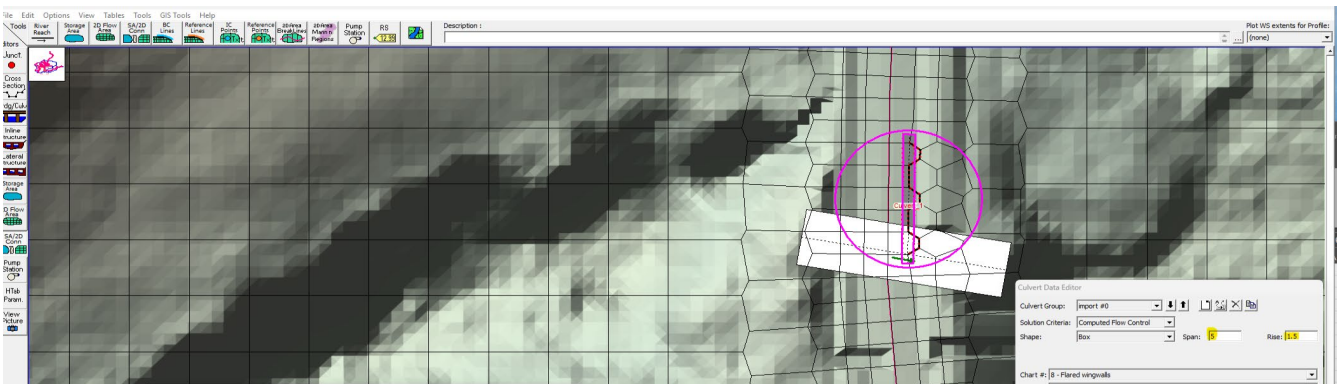


Figure 8 - Culvert 1 Size



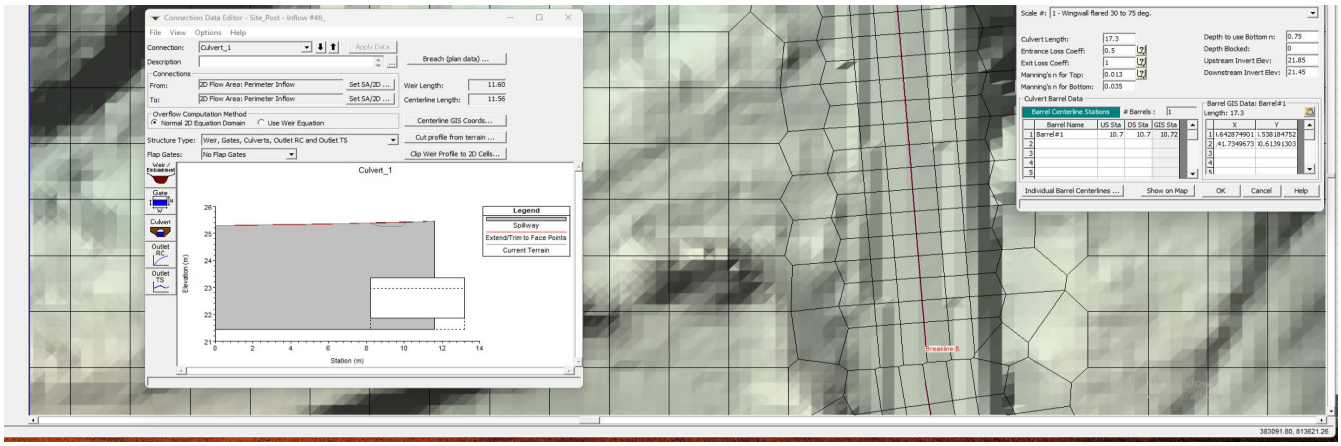



Figure 9- culvert 6

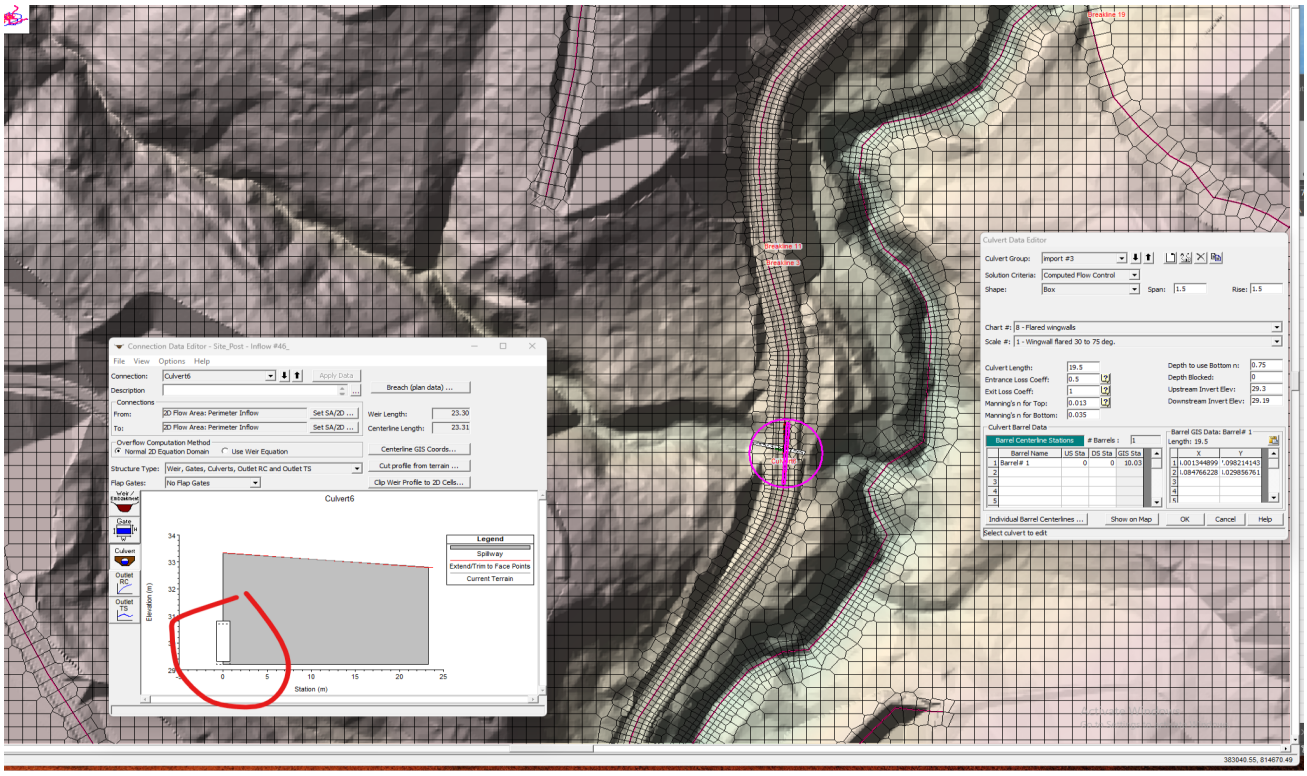



Figure 10
No culvert for the main stream channel under Forestry Road for Post Development Scenario

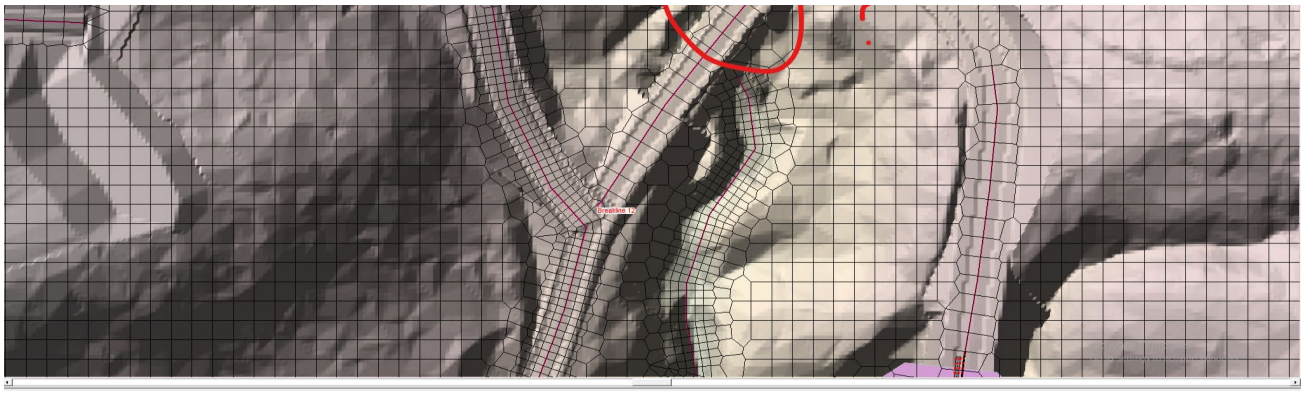
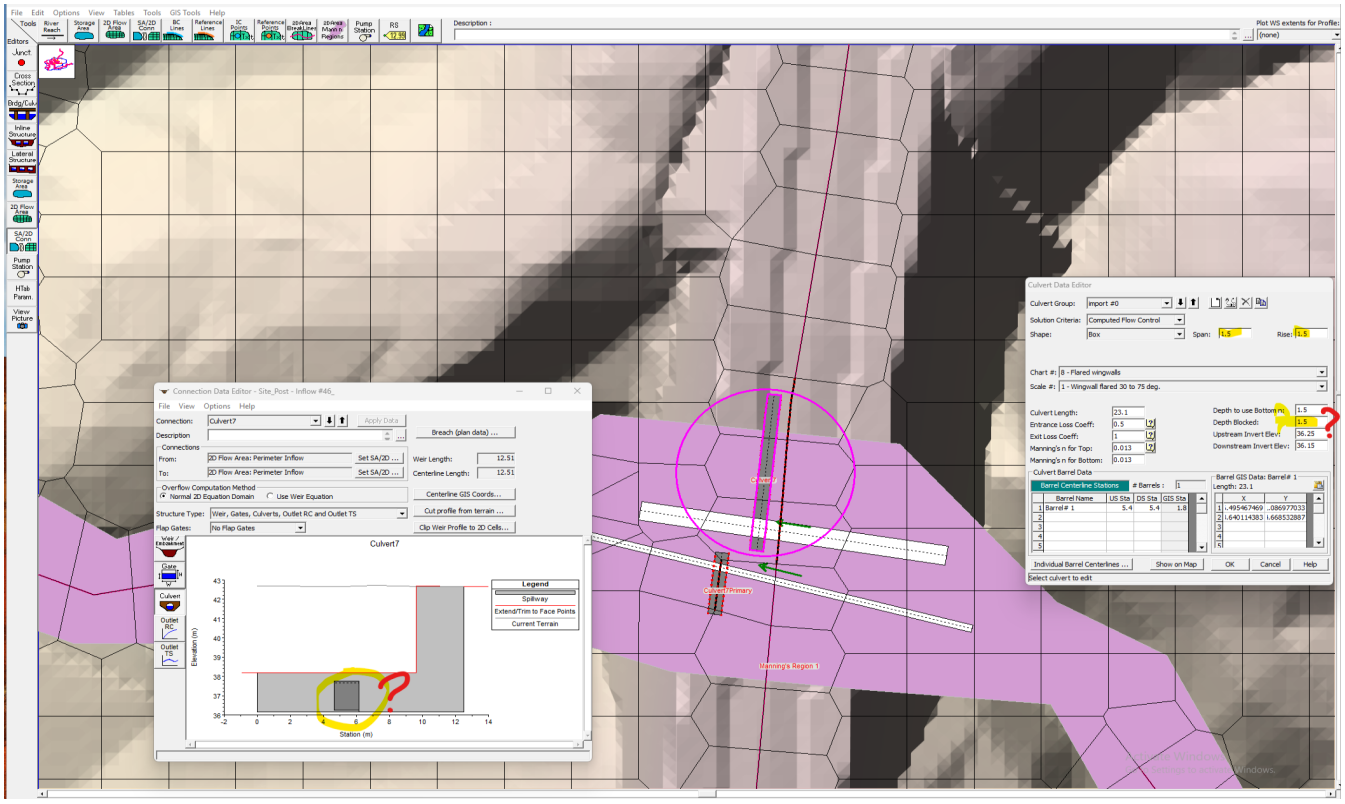
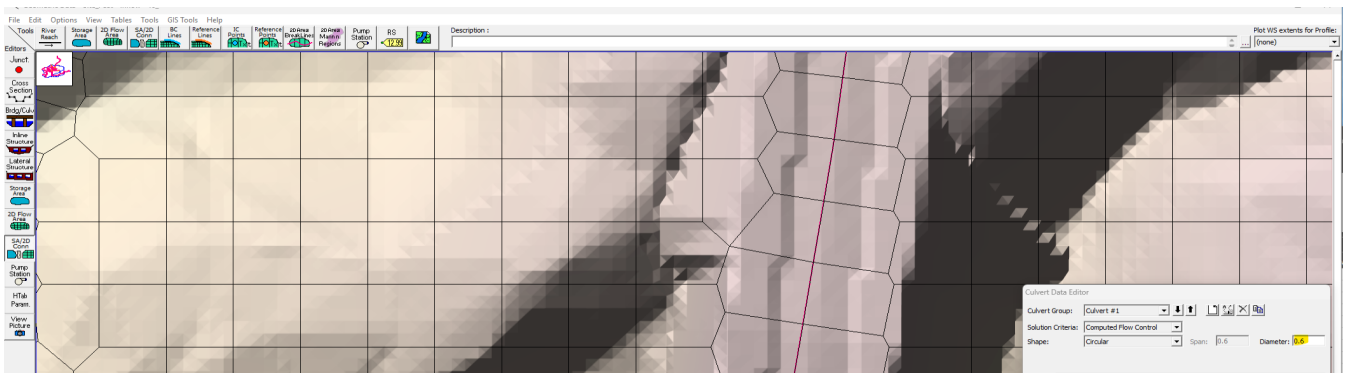


Figure 11
Culvert 7 - Blocked completely?




Culvert 7 - Primary



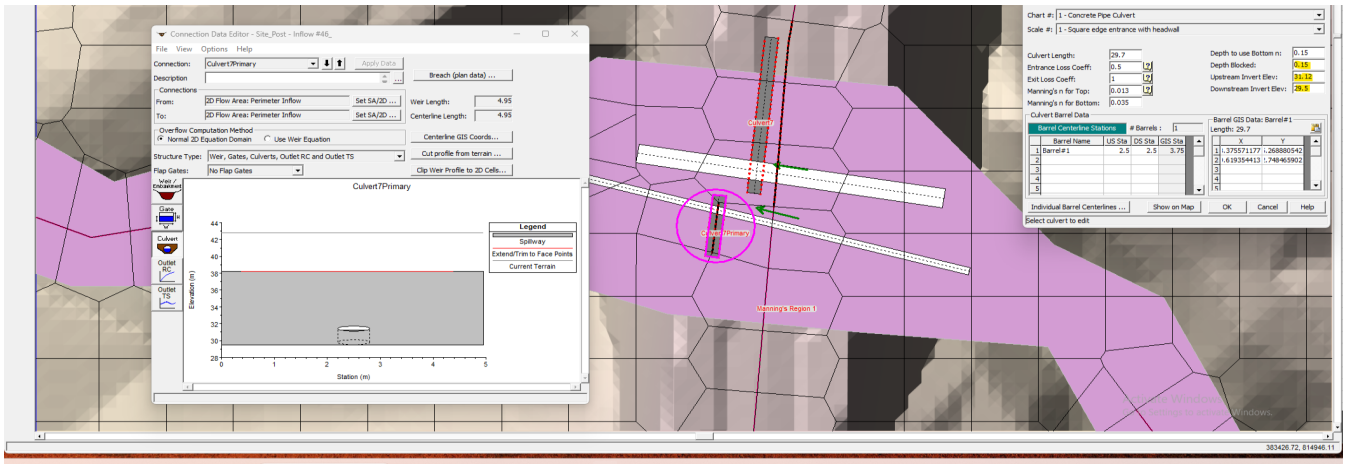



Figure 12
No Outlet from dry detention Pond

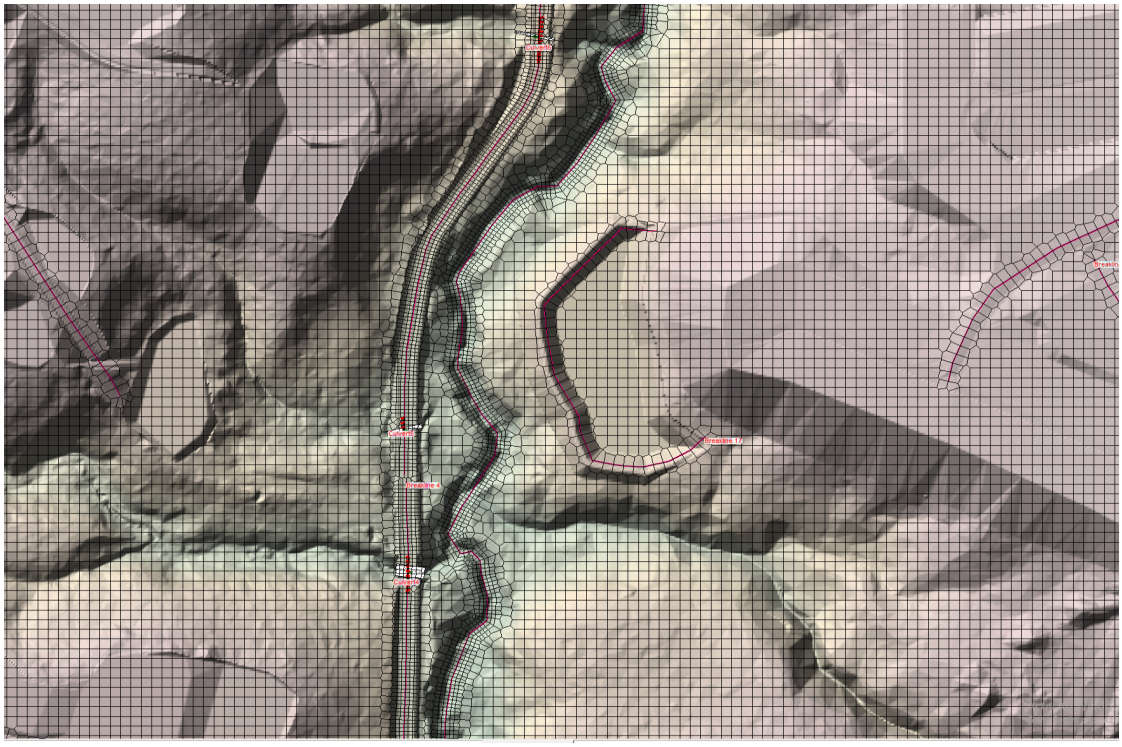
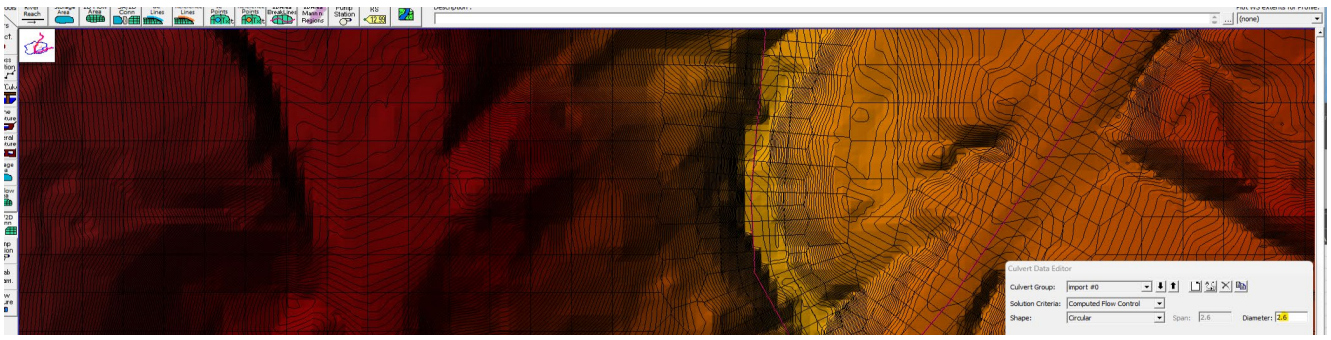


Figure 13
Pre-Development only one Culvert inlcuded in the model



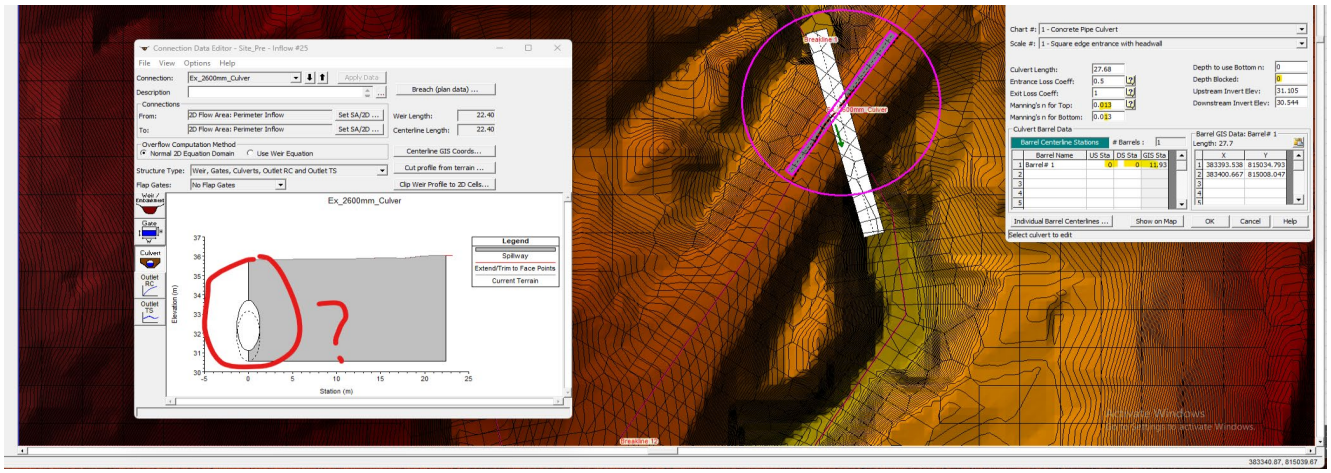



Figure 14
Culvert 5

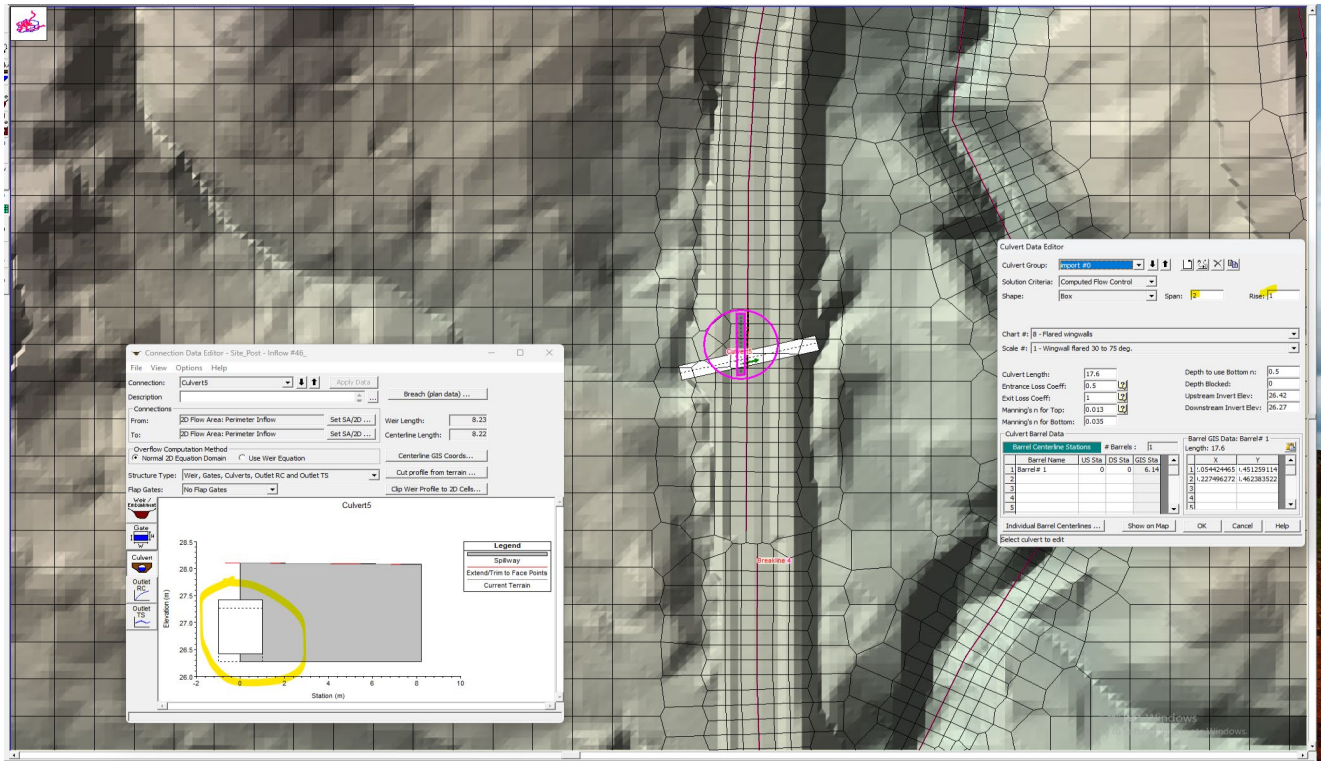
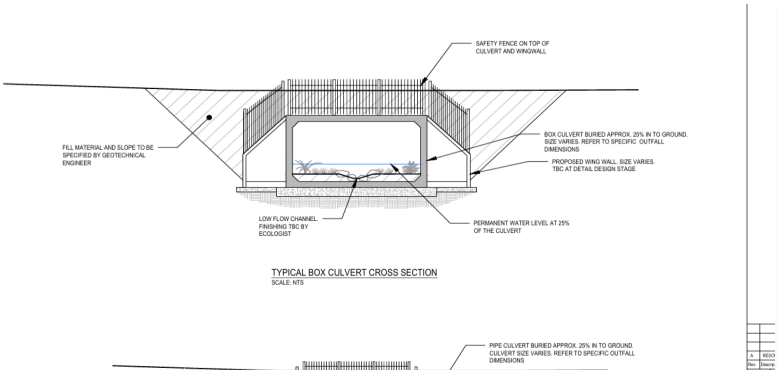



Figure 15 - Softbase for ecology design for all culverts



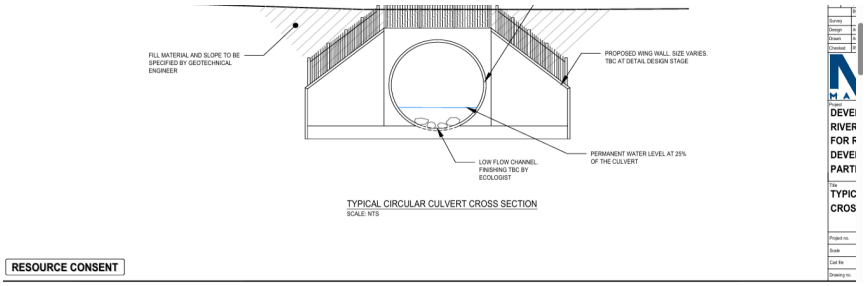



Figure 16 -Duke Road Bridge not included & DTM Issues with Stream corridor

Figure 17 - Private bridge to 17 Wautaiti Drive not included.

Figure 18 - Private Bridge to 22 School Road not included

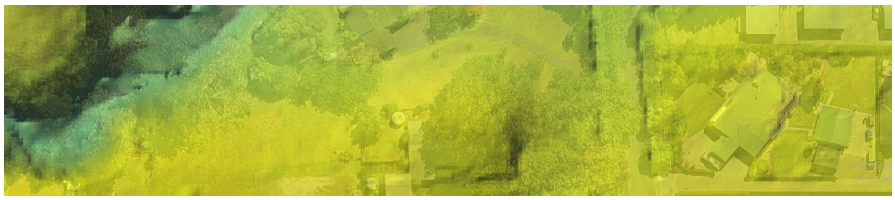


Figure 19 - Catchment Landcover 2011

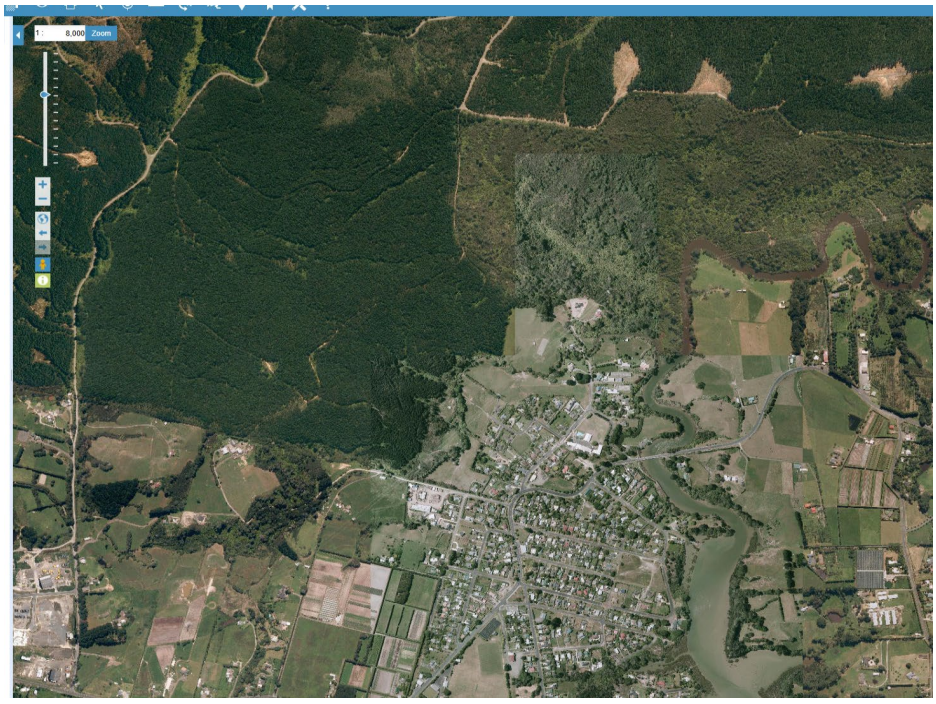



Figure 20 - Catchment Land Cover 2017

Figure 21 - Catchment Landcover 2024

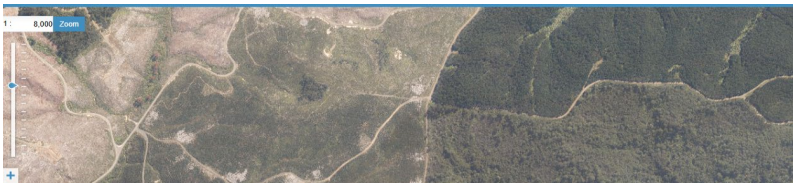
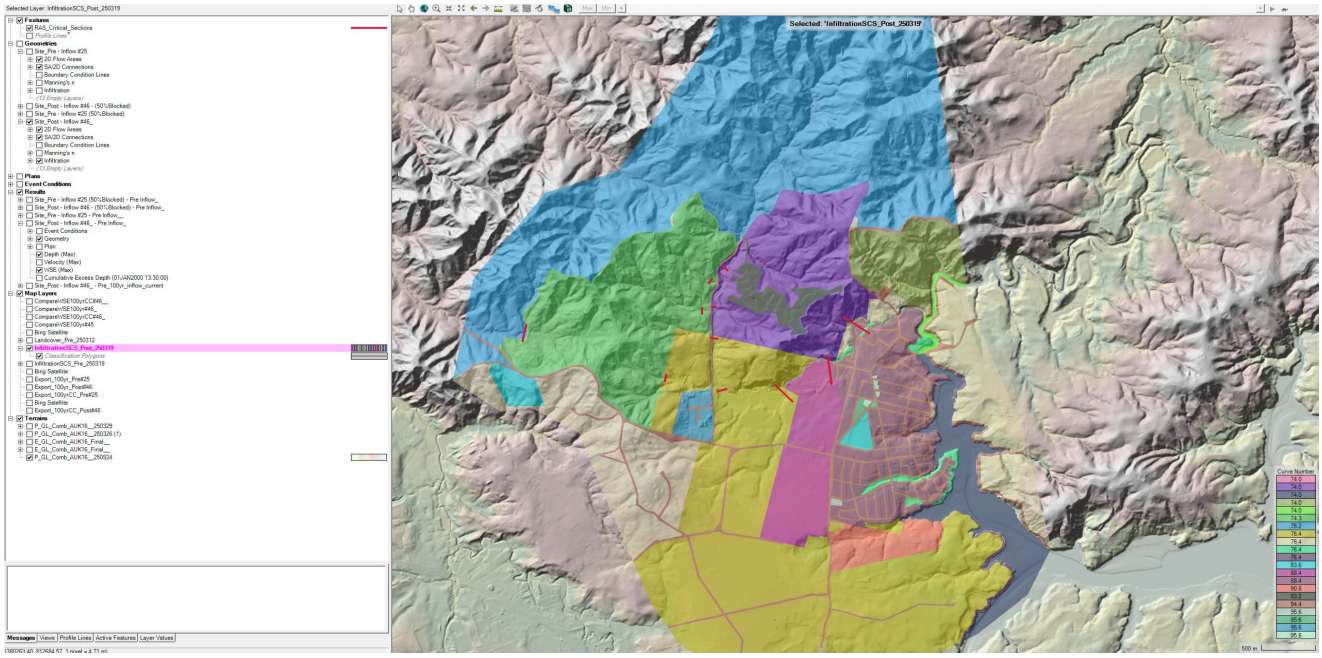


Figure 22 - Existing Dam Structure at No. 49 Forest Road

| 0 | NoData | | | Ia | | NoData | | | Ia |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 0.057 | 76.4 | 4.47226 | | 11 | 0.057 | 76.4 | 4.47226 |
| 10 | 19 | 0.06 | 88.4 | 1.99982 | | 3 | 0.057 | 76.4 | 4.47226 |
| 11 | 7 | 0.043 | 95.6 | 0.50269 | | 27 | 0.05 | 94.4 | 0.75339 |
| 12 | 30 | 0.056 | 74 | 4.99762 | | 44 | 0.043 | 95.6 | 0.50269 |
| 13 | 63 | 0.058 | 90.8 | 1.49267 | | 32 | 0.057 | 76.4 | 4.47226 |
| 14 | 17 | 0.043 | 95.6 | 0.50269 | | 33 | 0.06 | 83.6 | 2.98967 |
| 15 | 25 | 0.056 | 74 | 4.99762 | | 31 | 0.057 | 76.4 | 4.47226 |
| 16 | 15 | 0.056 | 74 | 4.99762 | | 59 | 0.056 | 74 | 4.99762 |
| 17 | 16 | 0.057 | 75.2 | 4.77466 | | 4 | 0.06 | 88.4 | 1.99982 |
| 18 | 12 | 0.043 | 95.6 | 0.50269 | | 19 | 0.06 | 88.4 | 1.99982 |
| 19 | 97 | 0.049 | 74.281 | 4.30929 | | 7 | 0.043 | 95.6 | 0.50269 |
| 2 | 3 | 0.057 | 76.4 | 4.47226 | | 30 | 0.056 | 74 | 4.99762 |
| 20 | 98 | 0.056 | 74 | 4.99762 | | 63 | 0.058 | 90.8 | 1.49267 |
| 21 | 99 | 0.054 | 93.2 | 1.00074 | | 17 | 0.043 | 95.6 | 0.50269 |
| 3 | 27 | 0.05 | 94.4 | 0.75339 | | 25 | 0.056 | 74 | 4.99762 |
| 4 | 44 | 0.043 | 95.6 | 0.50269 | | 15 | 0.056 | 74 | 4.99762 |
| 5 | 32 | 0.057 | 76.4 | 4.47226 | | 16 | 0.057 | 75.2 | 4.77466 |
| 6 | 33 | 0.06 | 83.6 | 2.98967 | | 12 | 0.043 | 95.6 | 0.50269 |
| 7 | 31 | 0.057 | 76.4 | 4.47226 | | 99 | 0.056 | 74 | 4.99762 |
| 8 | 59 | 0.056 | 74 | 4.99762 | | | | | |
| 9 | 4 | 0.06 | 88.4 | 1.99982 | | | | | |



| Time | (tuflow2d_1392_aug_mpd_100_38d) Level [m] |
|---|---|
| 0 | 2.76 |
| 0.166667 | 2.577182 |
| 0.333333 | 2.636068 |
| 0.5 | 2.807314 |
| 0.666667 | 2.87597 |
| 0.833333 | 2.91023 |
| 1 | 2.841956 |
| 1.166667 | 2.766957 |
| 1.333333 | 2.71912 |
| 1.5 | 2.657488 |
| 1.666667 | 2.688811 |
| 1.833333 | 2.719011 |
| 2 | 2.785682 |
| 2.166667 | 2.816715 |
| 2.333333 | 2.828649 |
| 2.5 | 2.80516 |
| 2.666667 | 2.766113 |
| 2.833333 | 2.729264 |
| 3 | 2.710896 |
| 3.166667 | 2.706303 |
| 3.333333 | 2.737365 |
| 3.5 | 2.772203 |
| 3.666667 | 2.795065 |
| 3.833333 | 2.809331 |
| 4 | 2.792046 |
| 4.166667 | 2.765421 |
| 4.333333 | 2.741124 |
| 4.5 | 2.724181 |
| 4.666667 | 2.724931 |
| 4.833333 | 2.741152 |
| 5 | 2.766767 |
| 5.166667 | 2.787342 |
| 5.333333 | 2.79593 |
| 5.5 | 2.784798 |
| 5.666667 | 2.767904 |
| 5.833333 | 2.746042 |
| 6 | 2.732352 |
| 6.166667 | 2.733498 |
| 6.333333 | 2.747022 |
| 6.5 | 2.767271 |
| 6.666667 | 2.785126 |
| 6.833333 | 2.791134 |
| 7 | 2.782945 |

| | |
|---|---|
| 7.166667 | 2.768214 |
| 7.333333 | 2.75275 |
| 7.5 | 2.74387 |
| 7.666667 | 2.742537 |
| 7.833333 | 2.751061 |
| 8 | 2.766697 |
| 8.166667 | 2.780262 |
| 8.333334 | 2.786925 |
| 8.5 | 2.782892 |
| 8.666667 | 2.77281 |
| 8.833334 | 2.762426 |
| 9 | 2.756364 |
| 9.166667 | 2.758385 |
| 9.333334 | 2.766872 |
| 9.5 | 2.778969 |
| 9.666667 | 2.789091 |
| 9.833334 | 2.796251 |
| 10 | 2.795716 |
| 10.16667 | 2.795138 |
| 10.33333 | 2.796241 |
| 10.5 | 2.802296 |
| 10.66667 | 2.811493 |
| 10.83333 | 2.82834 |
| 11 | 2.846696 |
| 11.16667 | 2.868165 |
| 11.33333 | 2.895497 |
| 11.5 | 2.920159 |
| 11.66667 | 2.958719 |
| 11.83333 | 3.024479 |
| 12 | 3.137669 |
| 12.16667 | 3.37356 |
| 12.33333 | 3.584645 |
| 12.5 | 3.748502 |
| 12.66667 | 3.942048 |
| 12.83333 | 4.221321 |
| 13 | 4.478392 |
| 13.16667 | 4.631721 |
| 13.33333 | 4.690969 |
| 13.5 | 4.70268 |
| 13.66667 | 4.703316 |
| 13.83333 | 4.70985 |
| 14 | 4.727952 |
| 14.16667 | 4.761673 |
| 14.33333 | 4.813999 |

| | |
|---|---|
| 14.5 | 4.882728 |
| 14.66667 | 4.963463 |
| 14.83333 | 5.050848 |
| 15 | 5.142869 |
| 15.16667 | 5.250101 |
| 15.33333 | 5.346433 |
| 15.5 | 5.440368 |
| 15.66667 | 5.531859 |
| 15.83333 | 5.607444 |
| 16 | 5.671848 |
| 16.16667 | 5.736785 |
| 16.33333 | 5.795597 |
| 16.5 | 5.843076 |
| 16.66667 | 5.880293 |
| 16.83333 | 5.906179 |
| 17 | 5.917976 |
| 17.16667 | 5.917687 |
| 17.33333 | 5.906859 |
| 17.5 | 5.884793 |
| 17.66667 | 5.853353 |
| 17.83333 | 5.810894 |
| 18 | 5.761385 |
| 18.16667 | 5.701399 |
| 18.33333 | 5.63595 |
| 18.5 | 5.569046 |
| 18.66667 | 5.501935 |
| 18.83333 | 5.419336 |
| 19 | 5.329371 |
| 19.16667 | 5.235523 |
| 19.33333 | 5.138614 |
| 19.5 | 5.023588 |
| 19.66667 | 4.923669 |
| 19.83333 | 4.822715 |
| 20 | 4.717747 |
| 20.16667 | 4.614311 |
| 20.33333 | 4.51224 |
| 20.5 | 4.415397 |
| 20.66667 | 4.313693 |
| 20.83333 | 4.216771 |
| 21 | 4.132327 |
| 21.16667 | 4.047659 |
| 21.33333 | 3.971339 |
| 21.5 | 3.897073 |
| 21.66667 | 3.823619 |

| | |
|---|---|
| 21.83333 | 3.747824 |
| 22 | 3.684138 |
| 22.16667 | 3.624553 |
| 22.33333 | 3.579498 |
| 22.5 | 3.53382 |
| 22.66667 | 3.49125 |
| 22.83333 | 3.452202 |
| 23 | 3.42098 |
| 23.16667 | 3.392863 |
| 23.33333 | 3.366015 |
| 23.5 | 3.34269 |
| 23.66667 | 3.32115 |
| 23.83333 | 3.299946 |
| 24 | 3.282707 |
| 24.16667 | 3.268563 |
| 24.33333 | 3.24963 |
| 24.5 | 3.231318 |
| 24.66667 | 3.209002 |
| 24.83333 | 3.188999 |
| 25 | 3.170405 |
| 25.16667 | 3.150327 |
| 25.33333 | 3.134391 |
| 25.5 | 3.108566 |
| 25.66667 | 3.088754 |
| 25.83333 | 3.069761 |
| 26 | 3.052969 |
| 26.16667 | 3.032605 |
| 26.33333 | 3.014653 |
| 26.5 | 2.99549 |
| 26.66667 | 2.979256 |
| 26.83333 | 2.958658 |
| 27 | 2.943942 |
| 27.16667 | 2.932129 |
| 27.33333 | 2.920719 |
| 27.5 | 2.910524 |
| 27.66667 | 2.900152 |
| 27.83333 | 2.891231 |
| 28 | 2.880179 |
| 28.16667 | 2.872303 |
| 28.33333 | 2.863032 |
| 28.5 | 2.854908 |
| 28.66667 | 2.846177 |
| 28.83333 | 2.841058 |
| 29 | 2.835117 |

| | |
|---|---|
| 29.16667 | 2.829418 |
| 29.33333 | 2.823845 |
| 29.5 | 2.819174 |
| 29.66667 | 2.814257 |
| 29.83333 | 2.807929 |
| 30 | 2.80383 |
| 30.16667 | 2.801229 |
| 30.33333 | 2.796607 |
| 30.5 | 2.791747 |
| 30.66667 | 2.787362 |
| 30.83333 | 2.785198 |
| 31 | 2.783024 |
| 31.16667 | 2.780663 |
| 31.33333 | 2.779669 |
| 31.5 | 2.777079 |
| 31.66667 | 2.774664 |
| 31.83333 | 2.77076 |
| 32 | 2.772107 |
| 32.16667 | 2.770415 |
| 32.33334 | 2.768073 |
| 32.5 | 2.767014 |
| 32.66667 | 2.76712 |
| 32.83334 | 2.767138 |
| 33 | 2.766491 |
| 33.16667 | 2.765146 |
| 33.33334 | 2.763482 |
| 33.5 | 2.763458 |
| 33.66667 | 2.762593 |
| 33.83334 | 2.761094 |
| 34 | 2.761357 |
| 34.16667 | 2.761576 |
| 34.33334 | 2.761769 |
| 34.5 | 2.762032 |
| 34.66667 | 2.761481 |
| 34.83334 | 2.76216 |
| 35 | 2.760837 |
| 35.16667 | 2.760709 |
| 35.33334 | 2.759771 |
| 35.5 | 2.760586 |
| 35.66667 | 2.760373 |
| 35.83334 | 2.760607 |
| 36 | 2.760662 |

Two sensitivity checks completed below for 100yrCC scenario

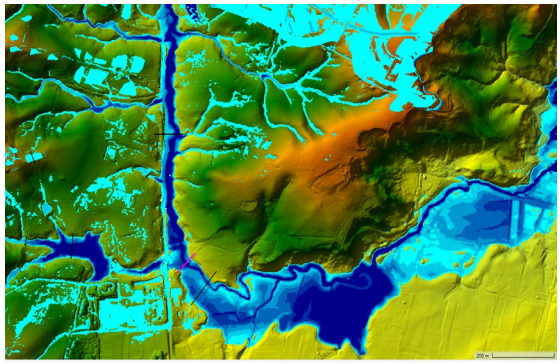
1 Update manning of CSL building platforms to 0.03

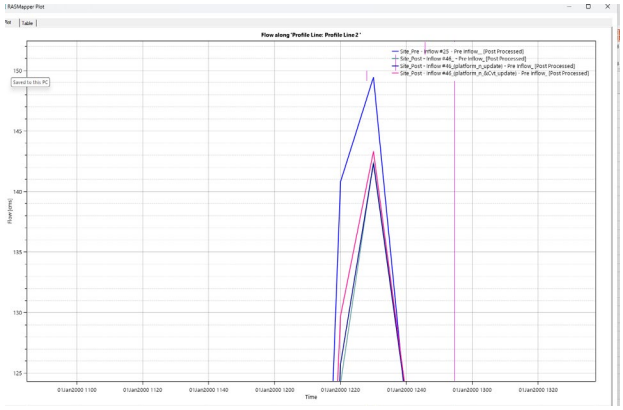
-**Results** - Neglible impact on peak flows

2 Update model to include Culverts 13-4, 14-1, 6-6 and updated culvert 2 to 1.5m x 1.5m box shape culvert

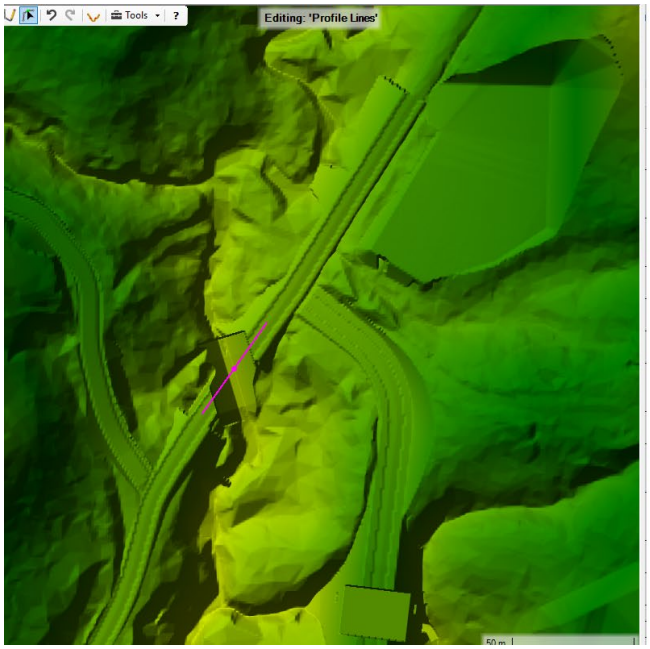
-**Results** -addition of culvert 6-6, 14-1,13-4 results in peak flow at cross section (in figure below) increase of 0.1% from 142.48 to 142.62 m3/s, the peak flow is notably still 6.84 m3/s below predevelopment (149.46 m3/s).

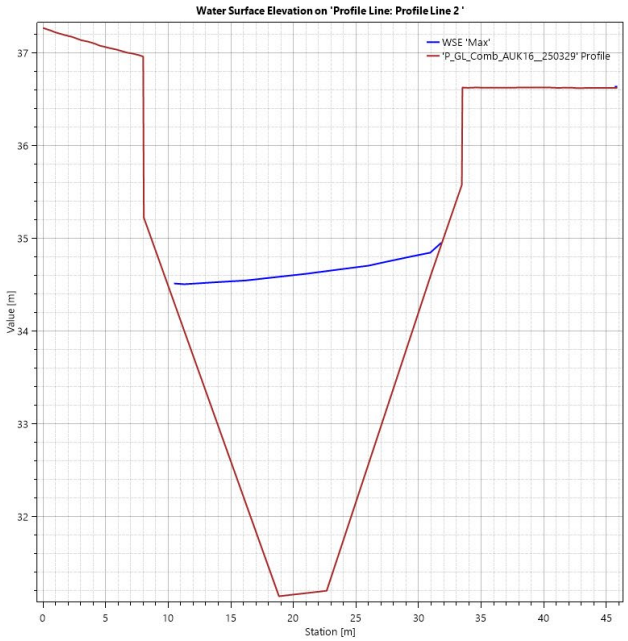
| CULVERT No. | TYPE | Plan SIZE | Model | Embedment |
|---|---|---|---|---|
| **1** | BOX CULVERT | 5m x 2m | 5m x 1.5m | 0.5m |
| **2** | BOX CULVERT | 1.5m x 2m | 1.5m x 1.5m | 0.5m |
| **3** | BOX CULVERT | 4m x 2m | 4m x 1.5m | 0.5m |
| **4** | BOX CULVERT | 6m x 2m | 6m x 1.5m | 0.5m |
| **5** | BOX CULVERT | 2m x 1.5m | 2m x 1m | 0.5m |
| **6** | BOX CULVERT | 1.5m x 2m | 1.5m x 1.5m | 0.5m |
| **7** | PRIMARY-CIR-CULVERT | 0.6mø | 0.6 | 0.15m |
| | | | | |
| **COUNTRYSIDE** | | | | |
| **13-4** | CIR-CULVERT | 1.20mø | 1.20mø | 0 |
| **14-1** | BOX CULVERT | 1.5m x 1.5m | 1.5m x 1.5m | 0 |
| **6-6** | CIR-CULVERT | 1.05mø | 1.05mø | 0 |
| **1-1** | PRIMARY-CIR-CULVERT | 1.20mø | | |
| **1-1** | SECONDARY-BOX CULVERT | 4m x 1.5m | | |





Screenshot of proposed bridge terrain modification replacting 2.6m existing culvert



Sensitivity checks for 100yrCC scenario CSL (post-development) with no upgrade to Forestry Road with no climate change

1. CSL (post-development) with no upgrade to Forestry Road.

**-Results -** Negligible impact on peak flows  Post development peak flow = 67.405 Predevelopment peak flow at profile line 2 = 67.042 m3/s ( increase of 0.5%)