



Engineers & Consultants

Memorandum

Date:	10/09/2021
To:	Jamie Sirl, Team Leader City Planning, Hamilton City Council
From:	Caleb Clarke, Morphum Environmental
CC:	Craig Sharman, Beca, Paul Ryan, Hamilton City Council
Project number:	P01826
Reviewed by:	Alice Monk
Released by:	Caleb Clarke

Subject: Stormwater Technical Assessment: Plan Change 7 – Rotokauri North Private Plan Change – BBO Design, 2021

Plan Change 7 (PC7) to the Hamilton City District Plan was originally limited notified on 21 February 2020. The submissions period closed on 23 March 2020 and with a hearing expected to be held in October of 2020. However, it was found that the Sub-Catchment Integrated Catchment Management Plan (SCICMP) did not clearly set out how stormwater will be managed in the Structure Plan Area to enable its feasible implementation through the subdivision and land use consenting processes.

It was recommended that the design calculations and plan was progressed to show the locations and footprints of the key stormwater infrastructure such as wetlands, dry detention basins, conveyance channels and swales, as well as tables setting out the nominal dimensions and key performance criteria for each of these infrastructure items.

Hamilton City Council (HCC) has engaged Morphum Environmental Ltd (Morphum) to undertake a technical assessment of matters relating to stormwater management for the new SCICMP which was prepared by BBO for PC7.

- ROTOKAURI NORTH, Sub-Catchment Integrated Catchment Management Plan, dated Aug 2021 prepared by Tollemache Consultants Ltd and it's Appendix K Stormwater System Report (SSR)-V3, prepared by BBO.

The following memos are attached, containing an itemised list of comments:

- Morphum memo dated 13 July 2021
- Morphum memo dated 6 September 2021

In summary, the SCICMP sets out clearly how stormwater will be managed in the Ohote and Te Otamanui catchments in the Structure Plan Area and shows that stormwater management in the Mangaheka and Rotokauri South major subcatchments is conceptually feasible but will need to be further worked through in the next design phase. This enables feasible implementation of the

development area through the subdivision and land use consenting processes to achieve its intended outcomes.

A 1D SWMM model and 2D HEC-RAS model have been prepared as well as a plan showing the locations and footprints of the key stormwater wetlands, stream reaches and swales. A table showing the areas and volumes provided by each wetland was provided.

The catchment is very flat, and the site may need to be lifted in order to achieve adequate fall in some areas.

- Flood levels within and upstream of the site for the 10 and 100 year events need to be maintained sufficiently low to provide appropriate levels of service as follows:
 - o 10 year peak flows not to flood private property
 - o 100 year flows less than 150mm deep within road pavement
 - o 100 year water levels 300mm below commercial and 500mm below habitable floor levels
- Primary conveyance grades through the site – open channel and pipe reticulation needs to maintain sufficient grade and cover to translate invert levels back up through the catchment. Insufficient grade or cover will require infilling of the site.
- Groundwater management including subsoil drainage through the site – This is important to protect underground services and road subgrades as well as provide utility of relatively dry pervious areas in the site. This is shown in Drawing 3-21 (Ref D3.4.1) of the Waikato Regional Infrastructure Technical Standard.

Previous studies

The stormwater impacts from development from the proposed PC7 Area have previously been assessed in the following Studies:

- Rotokauri Integrated Catchment Management Plan (ICMP) Final, dated June 2017 and prepared by HCC.
- Rotokauri ICMP – Major Drainage Preferred Option & Stormwater Management Solution Report, dated 21-Sep-2016 and Prepared by AECOM

These reports proposed a solution as described in *Table 5-4: Design parameters for stormwater management – Northern Development Area* of the Rotokauri ICMP, with the following general stormwater measures:

- Outflows to the assessed existing culvert flow of 0.7m³/s including attenuation to 80% of the 1% AEP including Climate Change peak flows for 2, 10 and 100 year
- Extended detention of 1.2 times the water quality volume
- Attenuation of 2 and 10 year design storms
- Stormwater quality treatment to achieve 75% Sediment removal and receiving water body water and sediment quality guideline values
- Flood storage provided in a central green corridor with freeboard requirements met.
- The portion of the PC7 Catchment draining to the Rotokauri South Development area has further requirements.

PC7 and Rotokauri North SCICMP approach

The currently proposed implementation methods to manage stormwater within the Rotokauri North Plan Change 7 area are set out in Section 9 of the SCICMP (Tollemanche Consultants Ltd, 2021).

The introductory paragraph to this section states:

In general, land falling within the Mangaheka and Rotokauri South catchments (identified above) should adhere to the implementation requirements of those relevant ICMPs. However, there are some overarching recommendations of this ICMP that impose additional restrictions over and above the adopted ICMPs. These are clearly identified in the breakdown of recommendations and implementation guide (Table 13). Where the recommendations of this ICMP exceed the requirements of the Mangaheka or Rotokauri South ICMPs, the higher requirements imposed under this ICMP shall apply. Similarly if the areas falling under the Mangaheka ICMP or Rotokauri South portion of the Rotokauri ICMP have a higher requirement, that higher requirement must be adhered to.

Figure 16 sets out the proposed catchment boundaries/areas, which include Ohote, Te Otamanui West, Te Otamanui East, Mangaheka and Rotokauri South.

The proposed methods are outlined in Table 13: Implementation/Mean of Compliance.

The proposed design parameters for the proposed methods are set out in Table 10: Design Parameters, Section 8.2.

The general SCICMP approach is as follows:

1. 1% AEP discharge downstream limited to 80% of pre-development peak flow apart from Mangaheka requiring 70% of pre-development peak flow.
2. Flood storage to meet the above requirements estimated at:
 - a: 68,000 m³ for the Ohote catchment (assumed to include freeboard above wetlands and contained in swales).
 - b: 23,360 m³ for the Te Otamanui catchment (assumed to include freeboard above wetlands and contained in swales).
 - c: 14,150m³ for the Mangaheka catchment
 - d: Storage volume for the Rotokauri South catchment not defined
3. Green drainage corridors to convey catchment flows within naturalized streams (as shown by Green spine on Structure Plan)
4. Centralised treatment comprising water quality wetlands with extended detention and flood storage outlets.
5. Pipelines to convey private property discharges flows to centralized treatment wetlands
6. Road kerb and channel with underdrain collecting overland flows and groundwater into reticulation and conveying to treatment wetlands.
7. On Lot management comprising tool box of varying scales of rain tank, inert roof materials green roofs bioretention and underground storage.

Flood Storage

The Mangaheka and Rotokauri South Subcatchments of the Rotokauri North SCICMP discharge via wetlands that are likely to be able to achieve reduced peak flows to mitigate ultimate downstream flood impacts.

The Te Otamanui post development subcatchment areas are likely to reduce slightly through the development, when part of the Te Otamanui West subcatchment will have high flows directed to the Ohote outlet.

A key hydraulic constraint is the Exelby Road outlet, which discharges from the PC7 area to the Ohote Catchment. This culvert was assessed by AECOM in the Rotokauri South ICMP as having an existing discharge of 0.7m³/s, requiring approximately 85,000m³ detention upstream to match peak flows in the post development scenario.

The SCICMP Attachment K SSR indicates the existing 1% peak flow from the Exelby Road culvert as 2.72m³/s and includes a proposal for the Rotokauri North SCICMP to provide 68,000m³ of storage over the Ohote subcatchment wetlands to mitigate the 100-year post development peak flow to 80% or 2.17m³/s. It is noted that storage volume in the main channel has not been quantified in the reports.

The SSR proposes that the existing Exelby Road culvert would be upgraded as part of the development. It is considered that this will allow for increased resilience for extreme events to be passed without exceeding the 100-year freeboard within the Rotokauri North Development zone, with an upstream weir arrangement required to govern the detention of floodwaters up to the 100 year peak flow.

The modelling demonstrates the 1% water levels can be managed within the freeboard requirements. However, the lack of long sections showing the levels is unclear. Further there are a range of variables and uncertainties that should be addressed under further refinement of the ICMP through consenting and design processes as follows.

- Confirmation of worst case for upstream flows from Ohote upstream 1 and Ohote upstream 2. The modelling allows for current discharges whereas these properties would need to be developed with post development runoff attenuated to 80% of pre-development peak flow. This would result in increased volume and longer duration peak flows which may or may not impact on downstream storage timing and therefore peak water levels.
- Final earthworks and road design will need to allow for storage areas, overland flow paths and depths that may require increased excavation or filling with implications on staging and economic feasibility of development.
- Pipeline designs will need to allow for subsoil connections to generally be above the 10 year peak water levels.
- The final design of discharge culverts from the area will need to allow for appropriate detention utilizing upstream storage as well as allowing for extreme flows to be passed without upstream flooding exceeding freeboard.
- As extended detention designs are confirmed residual erosion issues for downstream environments should be confirmed including defining potential mitigation works as required.
- Interaction with a proposed arterial road to the east of the site with proposed designation to be progressed by HCC will need to manage the interactions of discharge points and water levels and shared treatment infrastructure configuration.

Taking into account these items, it is considered that the proposed Plan Change and Current ICMP has flexibility in the flood volumes currently estimated, the potential conveyance system design and the configuration of the outlets at the several discharge points from the Development area to meet stormwater flood management objectives.

Wetland Designs

The indicative treatment wetland footprints shown have permanent storage zone areas greater than 4 percent of their catchment areas and therefore are considered to indicate appropriate footprint to achieve Waikato Regional ITS requirements. The wetlands are indicated as being off-line to the major

inflows and the freeboard flood storage filling up from the downstream flood storage zones such that the velocities within wetlands are managed.

Rotokauri South Catchment

The SCICMP Section 9 implementation methods indicate that the requirements of the Rotokauri South and Mangaheka ICMP's shall apply except where Table 13 contains items that are more stringent than those ICMP's. Rotokauri South ICMP requirements to be met as baseline which are more stringent than the SCICMP include the following:

- Interim Flood Storage comprising of 1200m³/ha of developed land.
- Phosphorous removal of 70% based on for example pretreatment through on lot and road corridor measures and polishing treatment with centralized wetlands.
- Integration with downstream open channel and wetland G8.

The Submission of Mr Ruske raises the issue of stormwater management in accordance with the Rotokauri South ICMP as not being adequately demonstrated in the evidence supporting the proposed private plan change.

Submissions

The following comments are made on submissions relating to stormwater aspects of the ICMP.

Submission 40 - Waikato Regional Council

Topic 1 The Rotokauri North ICMP does not set out a specific hydraulic performance standard to be achieved such as hydraulic neutrality. It is not clear how hydraulic neutrality could be achieved given an overall increase in stormwater runoff from development.

I consider that the stormwater management approach contained in the ICMP can facilitate the protection of downstream aquatic values but the detail of this will need to be dealt with in discharge design to meet WRC resource consenting for the discharge from shared infrastructure elements, in particular the Exelby culvert from the Ohope subcatchment.

Topic 3 Climate Change and Hazards – although the stormwater modelling report refers to taking account of the base climate change scenario, there is no consideration of more extreme scenarios such as description of the anticipated effects on infrastructure, risk of increased flooding footprints, emergency management, or if overtopping of the downstream road culverts would occur.

It is understood that the design allows for 2.1 degrees of climate change. I consider the new proposal, including proposal to upgrade the Exelby culvert on the Ohote subcatchment as having scope to allow for the discharge of extreme events or multiple events back to back without excessively encroaching on the freeboard levels above the green infrastructure spine and increasing hazard.

Submission 15 and 79 (previously 41)

We consider the submissions by Rotokauri North Tangata Whenua Working Group, and Te Whakakitenga o Waikato Incorporated, to provide significant value to be incorporated into the evolving proposals and consider the ICMP in conducting engagement to date and adopting a green infrastructure approach can facilitate alignment with many of these outcomes if the development

process allows for appropriate ongoing mana whenua input to determining appropriate outcomes for water.

Submission 34

items 3.4 and 3.6. The submission calls for more detailed consideration of the small PP7 area that discharges to the Rotokauri South Catchment. This is proposed to be slightly reduced to 13.5 ha and will fall under the Rotokauri South Development Area provisions in the existing Rotokauri ICMP and such is not covered by the special provisions of the Rotokauri North ICMP. We anticipate this will need clarification including the process by which the more stringent Rotokauri South Development area provisions for Phosphorous removal and interim storage will be applied through applications in this part of the PPC7 area.

Further Submission 4&5 The submission indicates Runoff from the State Highway (Te Kowhai Road) enters the neighbouring property at 338 Te Kowhai Road and that this will worsen as part of the proposal. It is understood that the Propose Plan Change will not worsen this discharge and the runoff could be managed as part of normal State Highway stormwater management.

Further Submission 8 The Submission seeks inclusion of further work on management of shortcomings of disconnected development occurring ahead of the remainder of the structure plan, and requests the addition of Objective and policy:

- Ensuring the maintaining and natural functioning of fresh water bodies, requesting the addition of objective and policy.
- Groundwater in the surrounding area and impacts on the Waikato River and aquatic values are protected.
- Clarification on how hydraulic neutrality is to be achieved.

We consider these requests can be readily addressed by the plan change text and evolving ICMP stormwater proposals.

Recommendations

Whilst the general approach of the ICMP is considered appropriate and adaptable to the likely consenting and detailed design requirements as development proceeds, there are details in the documentation that are inconsistent or anomalous. The following information should be added to the ICMP wording to better reflect the intent of the ICMP to meet the relevant objectives and requirements.

1. SCICMP Table 10 Drainage design criteria for Piped Drainage infrastructure should have the criteria "with road subsoil drainage connections above the 10 year HGL" or similar added to the end.
2. SCICMP Table 10 Drainage design Criteria for Cross Culverts should add the word designation replaced with Rotokauri North Development Area.
3. SCICMP Table 13 should specify the following for the Rotokauri South Area:
 - a. Interim storage of 1200m³/ha required for any development ahead of the Rotokauri South Green Corridor
 - b. Phosphorous removal of 70% TP
4. Figure 2-8A Rotokauri North Structure Plan dated 24-06-2021 should have the indicative

green spine areas for the Mangaheka Catchments added to the Plan as are indicated in SSR Figure 3-1.

5. Cross sections and long sections of the main green spine channels and their furthestmost contributing catchments should be provided in the SSR. Water levels have been provided in a table, long sections have been described in meetings and cross sections provided in peer review response comments and these should be included in the SSR for clarity.
6. Staging and trigger rules should provide for the design and consenting of all stormwater infrastructure and effects upstream and downstream of each area within the five subcatchments. These evolving designs should be incorporated in SCICMP iterations and approved by HCC.



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Memorandum

Date:	13/07/2021
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Project Number:	P01826
Reviewed by:	Caleb Clarke
Released by:	Caleb Clarke

Subject: Rotokauri North SC-ICMP SW Management Review (prepared by BBO, June 2021)

The Rotokauri North Sub-catchment (SC) ICMP (June 2021) and Appendix K: Stormwater System Report (SSR) – dated May 2021 and revised June 2021 were prepared by BBO to support the submission for Private plan Change (PPC) 7. It is a revision of the *Private Plan Change 7, Attachment 9, Sub-Catchment Integrated Catchment Management Plan (April 2019)*. An enlarged version of Figure 1-1 – Rotokauri North ICMP - SWMM Model Layout was requested and provided, to show the node names and enable us to interpret the tabulated results spatially.

Morphum were engaged to review the document with respect to stormwater. The advice provided in this memo will support improved solutions and ultimately enable PPC7 to progress in a way that meets HCC's objectives, particularly with respect to Strategic Objective 4 (SO4).

Key points

- The ICMP and Stormwater System Report provide for resolution of many stormwater issues and provide for many important opportunities and outcomes.
- The Hydraulic Grade is a key issue for the development of this area. The system function is difficult to decipher from the ICMP and SSR; there is no summary table and some information is missing (as indicated in the items of this memo). Specifically, it is unclear what the permanent water levels are in the wetlands and at the site discharge points. It would be useful to include in the reports a table that summarises the design water levels, surface area and volumes (permanent, extended detention, and storage above that) for each wetland or storage zone.
- It is recommended the applicant provide overview long sections through the site, along the stormwater system alignments for the water quality, 2 year, 10 year and 100 year ARI, 24 hour events to confirm that the proposed layout provides adequate capacity for hydraulic grade.

- Details are required to show how Rotokauri South sub-catchment will be managed and if mitigation will be provided prior to discharging to Wetland G8.
- The method for securing the key drainage areas through the private plan change are not clear. For example, what will be the zoning or designation for the areas indicated on Figure 13 of the ICMP as Green Spine/ Area Indicative only.

1.1.1 Objectives and Overview

This SC-ICMP identifies three of the strategic objectives chosen from the Mangaheka and Rotokauri operative ICMP's to focus on: RN Structure Plan, Quantity Control, and Quality Control. Why were the other relevant objective of those ICMPs excluded, eg. Stakeholder Engagement and Ecological protection and enhancement?

Table 133 (Section 8 of the SC-ICMP) is unclear for Roads. We understand the "Recommended Device Options" to be, treatments for the Lot/Area Type listed, regardless of the location where the treatment is put. If that's correct, then Treatment and Detention should be listed against Roads with recommended option being the main swales and wetlands.

Has peak flow mitigation for the Rotokauri South sub-catchments been accounted for in the Rotokauri Arterial Designation (RAD) design for Wetland G8? We note from Paul Ryan's email June 11 2021, following a June 10 meeting between RAD team and PC7 team that "*Plan changes 7 needs to:*

- *limit the catchment draining to greenway to match the NOR area*
- *allow for the overflow from the Greenway into mangaheka. (not a RAD NOR issue)."*

The Rotokauri Greenway model and the Mangaheka ICMP model were reported in Motoriki datum, but the RAD was done in NZVD. What datum is this project reported in? Noted that the RAD design has Wetland G8 with normal water level at 27.95mRL (NZVD) and the 100 year water level (based on ICMP levels) at 30.503mRL (NZVD). Please provide all levels against one datum and show that this sub-catchment can discharge to Wetland G8 and that minimum grade and cover can be achieved in up to the 10 year ARI event to support the statement that "*A pipeline of minimum length of 330m is required to convey the flow from the sub-catchment to the wetland.*"

Why is WRC TR2018/01 referred to, when TR2020/07 is the latest version of the Waikato stormwater management guideline?

1.1.2 Overall System Hydraulics

SC-ICMP Section 8, Table 10: For piped drainage infrastructure, the criteria proposed would enable the HGL to be at any level below the ground. As per email dated 11 June 2021 from Craig Sharman to Renee Fraser-Smith, the applicant should revise so that HGL for 10 year ARI not exceed pipe soffit and also not exceed invert level of subsoil drains at their outlet.

Terrain: It was noted in Section 6.0 of the SSR, that the terrain model was created from LIDAR then modified by lowering at the wetlands and raising land to provide cover over pipes. We assume that no levels on the boundary of the terrain model were changed in this process. The resultant terrain (shown in Figure 6-1 in the SSR) shows that the topography in Ohote and Te Otamanui appears to match the sub-catchments shown in the concept layout plan in Appendix B. However, has the division of minor sub-catchments been considered in relation to possible future earthworks, roads and minor overland flow paths and how will this be carried through into the Structure Plan?

Levels: A manning's of 0.035 has been used for the 2D modelled area, is that appropriate for the smaller events when water levels will be lower in the base of vegetation and manning's would likely be higher?

Existing Outflows: Figure 4 in the SC-ICMP shows an existing catchment outflow crossing Te Kowhai Road, near proposed sub-catchment Ohote 1 C. It appears to have been abandoned in the proposed system. Why and what is the impact of this?

Figure 4: Topography map



Storage: The analysis shown in Table 1 assumed that the “Maximum Volume” values reported in the SWMM “Storage Volume Summary” data is above permanent water level, and the 100 year ARI, 24 hour event data was used. It is unclear why the “Max Pcnt Full” is so low in the 100 year ARI, 24 hour event – please clarify. The reserves were excluded from the total areas in Table 1.

Table 1: System Storage Check

Catchment	Total Developed Area (ha)	Storage Volume (m ³)	Storage m ³ / ha
Ohote	63.52	68,100	1072
Te Otamanui	32.84	23,355	711
Mangaheka	18.54	14,153	763
Rotokauri South	13.45	**	*

*Rotokauri South catchments should meet the 1200m³/ha of development requirement of the Rotokauri ICMP.

** Wetland G8 is outside of this SC-ICMP area so wasn't included.

1.2 Stormwater Quantity Control

1.2.1 HEC-RAS 2D Hydraulic Model

SSR Section 7.3 discussed culvert embedment depth. The NZ Fish Passage Guidelines recommend that “culvert invert will be embedded by 25- 50% of culvert height”. However, this section explains that 200 mm embedment will be used regardless of culvert height and explains the theory behind this decision, which seems counterintuitive. Please provide stronger evidence or revise design to provide full embedment depths.

Tailwater: The SSR doesn't discuss tailwater conditions used on modelling. We can see that in the 2D model, the initial stored volume in the system was set to 2mm and assume this is just to kick start modelling. How was initial water level in the stream and wetlands accounted for in the model, or was the terrain model developed to sit above the permanent water level?

Cross sections: Please provide stream cross sections and the total width of land required to contain a stream channel that conveys the required flow.

1.2.2 EPA SWMM-5 1D Hydrologic Model

EPA-SWMM-5 is a suitable modelling package to use for estimating runoff and sizing devices. It would be useful for the applicant to include some screen shots or details of the device designs and outlet configurations used in modelling.

The consistency between HEC-RAS and EPA-SWMM results appear to be good so we assume that the volumes and dimensions modelled in the terrain modelled used in HEC-RAS were fed into the SWMM model as inputs. What capacity was assumed for the stream reaches? If this land needs to be designated or translated onto the Rotokauri Structure Plan, please provide stream cross sections and the total width of land required to contain a stream channel that conveys the required flow.

Comments regarding catchment definitions:

- Rotokauri South 1 drains in the Rotokauri Arterial Designation area – has this catchment been accounted for in the Wetland G8 design?
- It was assumed that 50% of the wetland minor sub-catchments is impervious/water. However, many of these sub-catchments appear to be more than 50% impervious in Figure 3-2 eg. Te Otamanui 4A (1.2 ha) appears to be nearer to 90% covered by the wetland itself.
- The impervious percentage for streams seems low, at 10%. The proposed channel dimensions and baseflow during winter should be used as an indicator of water areas providing effective impervious.
- What percentage impervious was assumed for Ohote Upstream North, West and East sub-catchments? They are not included in Table 4.1 of the SSR and the runoff coefficients in the SWMM sub-catchment results are consistently lower than the other fully developed sub-catchments.
- Referring to Table 4-2 in the SSR, is the impervious percentage of 5% suitable for the Mangaheka Upstream catchment?
- Table 4-1 of the SSR - Were catchment slopes based on the existing surface or estimated for future?
- The initial infiltration rates for the rainfall to runoff sub-catchment analysis were sourced from Rawls et al. (1983). This comes from USA literature and is typically accepted in the USA. Please provide local references support the infiltration rates and the depression storage values.

Inflows: Was the generated flow or accepted flow from external sub-catchments Ohote Upstream West and East (as stated on the catchment layout plan) fed into HEC-RAS as inflow? It should be the larger of, 100% the predevelopment total runoff generated, or the throttled (80% of ED 100yr peak flow) total runoff hydrograph generated from the 24hr 100yr storm on fully developed catchment.

Events: A Scenario of 50% of 2yr ARI event has been used. Typically, 1/3rd of the 2 year ARI event is used to define frequent storm conditions representing the 95th percentile storm event size.

Wetlands: It seems that there is one wetland missing from the design. Has the wetland named Mangaheka 2A (1.6ha) in the concept layout been modelled? The storage node at that location in the SWMM model layout image is named W Rotokauri South 1, but a wetland named that isn't on the concept layout plan. Additionally, although difficult to see on the SWMM model layout image, it doesn't look like this network (J148 down to MH S1 4) is connected to the swale between Mangaheka W1 and the culvert. It is mentioned that and that Mangaheka 2A is connected via a pipe – is that intended to go along Burbush Road? Can this be conveyed in an open channel instead?

SSR Section 6.2.1: It is stated that "the highest depth-averaged velocities are found immediately downstream of the inflow points into the wetlands." Why is that? Would expect higher flows to be in the streams rather than the wetlands, particularly in the 100-year ARI event.

Peak flow: The peak flow comparison was done at four locations on the perimeter of the study area, which is a suitable approach assuming that the proposed storage devices are built in approximately the

same locations as designed here and are fed by the equivalent catchments as used for this study. How will this be ensured during design phase? Eg. will these areas be designated? How will the structure plan and staging/order of development be managed to meet this?

Peak flow: In Section 8.2 of the ICMP, Table 12 (and SSR Table 5-1) the average flows from SWMM tabular report were listed for Mangaheka instead of the max flow, eg. at Mangaheka_Out node the peak flow was 3.04 m³/s and average of 0.82 m³/s was adopted into the Tables. Please clarify why the average flow was included in the report summary, rather than the peak.

Peak flow: The peak flow at Rotokauri South discharge location has been noted as NA in the ICMP and SSR. However, the SWMM results show that the combined peak at the two out nodes in all reported storms are higher than the predevelopment peaks shown in ICMP Section 8.4 Table 11. Can this increase be mitigated in RAD Wetland G8?

Please provide a table summarising the design water levels, surface area and volumes (permanent, ED, and storage above that) for each storage zone.

Rotokauri South ICMP areas will need to comply with Rotokauri ICMP requirements including interim storage and catchment boundaries will need to be maintained. Also, the overflow path from the Rotokauri South catchment into the paleo-channel toward Mangaheka needs to be allowed for.

1.3 Stormwater Quality

It is not clear the basis for the sizing of the wetlands. Please provide a table summarising the design water levels, surface area and volumes (permanent, ED, and storage above that) for each wetland or storage zone. What percentage of the impervious catchment were the wetlands sized at?

ICMP table 6 indicates treatment devices to be used for roads. Are there roads that will not drain to treatment wetlands? What type of device is proposed, this is not indicated in ICMP Table 13.

ICMP Table 13 indicates that communal devices will have detention 0.5m above water quality volume. It is assumed this refers to extended detention which should be no deeper than 0.35m above water quality volume as per the RITS, please change.

The ICMP Table 13 provides for no water efficiency measures on affordable housing which is contrary to the HCC District Plan requirements and may not be acceptable to HCC.

Figures 6-6 of the SSR show that Ohote Wetland 6 is still elevated about 200 mm above starting water level after 72 hours. This long draw down is also noted by 002d in Table 7. What tailwater assumptions were used in the modelling and what is the impact of extended drain down time?

It seems that the invert of wetlands is below the groundwater table. As stated in the SC-ICMP the groundwater depth is "*approximately 0.1 to 1.5m (below ground surface) in the low-lying areas*". For example, with the existing ground level at Wetland Ohote 7A at approximately RL29m, the groundwater table may be between RL27.5m and RL28.9m. The initial water levels shown on Figures 6-6 to 6-8 of the SSR wetland are around RL27.3m, indicating that they may be within the groundwater. The image below is from the SRS Appendix A, indicating that the water levels in the 50% of 2-year ARI event may also be below the groundwater level. How has the groundwater level been determined? Will relief points be provided for groundwater flows to be collected without liner floatation? Evidence is required to confirm the risk of wetlands having high normal baseflow disturbing hydraulics, displacing small storm runoff and reducing water quality treatment, and submerging vegetation causing mortalities? Ideally wetlands should be designed at or above normal groundwater level.

W_G8	STORAGE	0.13	0.36	28.76
W_Mangaheka_1	STORAGE	0.08	0.28	29.68
W_Ohote_1	STORAGE	0.16	0.36	27.54
W_Ohote_2	STORAGE	0.18	0.39	27.62
W_Ohote_3	STORAGE	0.17	0.38	27.65
W_Ohote_4	STORAGE	0.17	0.38	27.66
W_Ohote_5	STORAGE	0.15	0.36	27.67
W_Ohote_6	STORAGE	0.19	0.41	27.64
W_Ohote_7	STORAGE	0.17	0.38	27.61
W_Mangaheka_2	STORAGE	0.05	0.24	29.64
W_Te_Otamanui_1	STORAGE	0.15	0.40	28.57
W_Te_Otamanui_2	STORAGE	0.14	0.39	28.58
W_Te_Otamanui_3	STORAGE	0.05	0.14	28.62
W_Te_Otamanui_4	STORAGE	0.09	0.32	28.77

Figure 1: 50% of 2yARI depth (column 4) and HGL (column 5) in wetlands

1.4 Streams and Culverts

Please provide typical Stream (Green Spine) dimensions including proposed batter slopes to confirm footprint.

High flow: Have the proposed culverts in Ohote Stream catchment been sized? / What constraints were used in the SWMM to model them? Where is T Culvert 01?

Low flow: Does the example culvert design explained in SSR Section 7.2.3 (shown to be a 1500 mm square concrete box in the HY-8 image) represent any of the culverts proposed in this project (in size, slope and shape)? It is demonstrated that the designer understands the requirements of the culvert for aquatic organism passage, but this doesn't show that the requirements can be met by the actual three 1.5m diameter culverts at the project boundaries and proposed culverts in the project area.

1.5 Other items

ICMP Section number 3.9.2 occurs twice

ICMP Table 13 is labelled as Table 133

SSR Table 6-2 appears to be missing (mentioned in Section 6.2.2) – should this have said Table 4-2?



Engineers & Consultants

Memorandum

Date:	6/09/2021
To:	Jamie Sirl Jamie.Sirl@hcc.govt.nz , Craig Sharman Craig.Sharman@beca.com
From:	Caleb Clarke Caleb.Clarke@morphum.com , Alice Monk Alice.Monk@morphum.com ,
CC:	Paul Ryan Paul.Ryan@hcc.govt.nz
Project Number:	P01826
Reviewed by:	Caleb Clarke
Released by:	Caleb Clarke

Subject: Rotokauri North SC-ICMP SW Management Review (prepared by BBO, June 2021) - Memo 2

This follows on from Morphum memo dated 13 July 2021 and BBO response (SC ICMP Stormwater Peer Review Response) dated 23 July 2021 containing the following files.

Revised document provided:

- Rotokauri North Subcatchment ICMP Stormwater System Report-V3 – with updated content highlighted.

Morphum were engaged to review the documents with respect to stormwater. The advice provided in this memo will support improved solutions and ultimately enable PPC7 to progress in a way that meets HCC's objectives, particularly with respect to Strategic Objective 4 (SO4).

Italics = wording from Morphum memo dated 13 July 2021 which we have now numbered for clarity going forward.

Key points

1. *The ICMP and Stormwater System Report provide for resolution of many stormwater issues and provide for many important opportunities and outcomes.*
2. *The Hydraulic Grade is a key issue for the development of this area. The system function is difficult to decipher from the ICMP and SSR; there is no summary table and some information is missing (as indicated in the items of this memo). Specifically, it is unclear what the permanent water levels are in the wetlands and at the site discharge points. It would be useful to include in the reports a table that summarises the design water levels, surface area and volumes (permanent, extended detention, and storage above that) for each wetland or storage zone.*

BBO reply – A summary table of the wetlands including the elevation and area of the permanent water level, the bund level and the HGL and stored volumes for the 2yr, 10yr and 100yr ARI events, has been added to the text as Table 4-3. These assumed levels were applied in the 1D and 2D stormwater

modelling. The permanent water levels in the wetlands are related to the stormwater network outfall levels and the re-established stream levels, which will be developed as part of detailed design. Hence these assumed levels, will have to be revised through detailed design.

MEL reply – It is assumed that Table 4-3 column 3 unit is ha (not m² as stated in heading), which would indicate that the area of wetlands at permanent water is suitable, at between 4% and 5% of the contributing catchments for each discharge point. Understood that refinement will occur in detailed design.

Regarding HGL levels,

- 3. It is recommended the applicant provide overview long sections through the site, along the stormwater system alignments for the water quality, 2 year, 10 year and 100 year ARI, 24 hour events to confirm that the proposed layout provides adequate capacity for hydraulic grade.*

BBO reply – The proposed stormwater management system was designed in a 1D model (EPA SWMM) and tested in a 2d model (HEC-RAS 2D). The 2D model was based on concept level earthworks that accounted for accommodation for stormwater pipe networks. The 2D model clearly shows that the treatment and attenuation/conveyance system has capacity for 100-year ARI drainage, while accounting for climate change. It logically follows that the system will have capacity for the 2-year and 10-year ARI events. Detailed long sections will be provided as part of detailed design.

MEL reply – The comment stands - Long sections need to be prepared so that the the assumed terrain and model results can be reviewed easily. Sections should extend across the site boundaries so that the downstream and upstream land and water is shown to tie in.

- 4. Details are required to show how Rotokauri South sub-catchment will be managed and if mitigation will be provided prior to discharging to Wetland G8.*

BBO reply - Major sub-catchment Rotokauri South falls within the catchment of basin 3 as part of the Rotokauri Greenway (Beca Limited, 2018). Treatment and attenuation of the flow of basin 3 takes place in the minor arterial wetland G8, hence this wetland also has to treat and attenuate all flow from major sub-catchment Rotokauri South 1. No mitigation will take place prior to the discharging into the pipeline that conveys the flow to wetland G8. Design of wetland G8 is outside the scope of the Rotokauri North sub-catchment ICMP.

MEL reply – It is agreed that wetland G8 is outside of this scope. However, upstream source controls will need to be incorporated into the Rotokauri South part of the subdivision design, prior to discharging to Wetland G8, as required by the Rotokauri ICMP (Table 5-5: Means of compliance with ICMP).

- 5. The method for securing the key drainage areas through the private plan change are not clear. For example, what will be the zoning or designation for the areas indicated on Figure 13 of the ICMP as Green Spine/ Area Indicative only.*

BBO reply – This is not a sub-catchment - ICMP issue. The SC-ICMP is an information document to support the Plan Change which includes a Structure Plan and new/amended provisions to the HCC District Plan. It is not the job of the SC-ICMP to propose how the detail is incorporated into those documents. This is a planning matter, and is being addressed by the planning workshops held between Tollemache Consultants, HCC and Beca (on behalf of HCC). However for clarity, unlike the Rotokauri South "greenway", HCC are not funding or responsible for providing the stormwater management. This is a private plan change and the infrastructure for stormwater is to be delivered by the future developers. Designations are not an option for private development.

The Green Spine Areas are shown indicatively on the proposed structure plan to signal where these are anticipated. These are shown on land with titles held by the Plan Change applicant (GSL) and/or a company falling under its umbrella. The Green Spine areas will contain the proposed stormwater infrastructure according to the HCC and WRC stormwater management guidelines. The Plan change is

not the mechanism required to secure these areas, nor is it necessary to locate devices on a Structure Plan. Future resource consent for subdivision and development will create the final areas for stormwater management purposes. Proposed rules of the PPC and existing rules in the HCC District Plan require that further sub-catchments IMCP's be prepared to support development within Rotokauri North. Thus, there is an existing mechanism to ensure that device location, catchments etc adhere to the recommendation of this PPC level sub-catchment ICMP at design stage.

MEL reply – Explanation accepted. This will need to be managed by HCC through the subdivision consenting processes.

1.1.1 Objectives and Overview

6. *This SC-ICMP identifies three of the strategic objectives chosen from the Mangaheka and Rotokauri operative ICMP's to focus on: RN Structure Plan, Quantity Control, and Quality Control. Why were the other relevant objective of those ICMPs excluded, eg. Stakeholder Engagement and Ecological protection and enhancement?*

BBO reply: The objectives are not intended as "replacements" to those contained in the Mangaheka and Rotokauri operative ICMP's. They are "in addition to".

MEL reply – Explanation accepted.

7. *Table 133 (Section 8 of the SC-ICMP) is unclear for Roads. We understand the "Recommended Device Options" to be, treatments for the Lot/Area Type listed, regardless of the location where the treatment is put. If that's correct, then Treatment and Detention should be listed against Roads with recommended option being the main swales and wetlands.*

BBO reply: Treatment of road run-off as well as the residential and commercial properties is carried out in the wetlands. This has now been explicitly stated in Table 13.

MEL reply – Explanation is suitable however, the revised ICMP has not been provided so the revised table has not been checked.

8. *Has peak flow mitigation for the Rotokauri South sub-catchments been accounted for in the Rotokauri Arterial Designation (RAD) design for Wetland G8? We note from Paul Ryan's email June 11 2021, following a June 10 meeting between RAD team and PC7 team that "Plan changes 7 needs to:*

- *limit the catchment draining to greenway to match the NOR area*
- *allow for the overflow from the Greenway into mangaheka. (not a RAD NOR issue)."*

BBO reply: From the Rotokauri ICMP documentation, it was not directly clear where the proposed catchment boundaries of the Rotokauri South 1 major-subcatchment are. The Rotokauri Greenway – Design Report by Beca shows the boundaries of catchment SC3D (on page 63) that includes the Rotokauri South 1 major subcatchment. It is assumed that boundaries of SC3D are along the centre of the Greenway, then the major subcatchment Rotokauri South 1 is estimated to be 73% of catchment SC3D which yields an area of 14.4 Ha.

As part of the pre-development SWMM model a catchment delineation was carried out on the Rotokauri North area which included the current road boundaries and existing culverts. This yielded an area for the Rotokauri South 1 major sub-catchment of 15.3Ha. When identifying the boundaries of the proposed minor sub-catchments, the boundaries of the major sub-catchment Rotokauri South 1 were adjusted to better align with proposed lay-out of the development. This reduced the area of major sub-catchment Rotokauri South 1 to 13.35 Ha. The area from the Rotokauri North area that drains to the greenway therefore matches the NOR area.

The requiring authority's conditions for the Rotokauri Greenway Notice of Requirements includes article 42b ("Maintaining existing sub-catchment drainage patterns up until the development of adjacent subcatchment") and 42f ("Maintaining the overland flow route to the north of Basins 3 and 4 along the proposed Arterial Road. Documentation relating to the Rotokauri Arterial Transport Network design shall be provided to confirm this has been allowed for."). Hence the overflow from the Greenway into the Mangaheka stream falls outside of the Rotokauri North sub-catchment ICMP.

MEL reply –

Agree that the portion of SC3D within PPC7 is not explicit in the Rotokauri Greenway Design Report by Beca, so this method seems suitable assuming that the 73% was derived spatially. We accept that the area flowing south is approximately the same as what was assumed by Beca.

Regarding NoR conditions: The question is who leads the design of extreme event spill from Rotokauri Greenway into Mangaheka Stream? This would affect the Mangaheka sub-catchments of PPC7 because the wetlands they discharge to appear to be on the spill flow route. Currently these two wetlands are in both PPC7 and RAD with different designs (discussed further under Item 27). As stated in condition 42f, the overland flow route is along the arterial road, which goes through PPC7. It was decided that the wetlands treating flow from arterials would be designated in the RAD process, so we agree the RAD design should theoretically allow for (in road and drainage reserve areas) conveyance of the high level spill from Rotokauri Greenway northward to Mangaheka Stream.

How this effects PPC7 - There are currently two designs tabled for the wetlands and catchments in the north east corner of PPC7 area in different locations (wetland Mangaheka 1A is positioned closer to Te Kowhai Road culvert in the RAD design). Consider collaborating/propose a way forward.

- 9. The Rotokauri Greenway model and the Mangaheka ICMP model were reported in Motoriki datum, but the RAD was done in NZVD. What datum is this project reported in? Noted that the RAD design has Wetland G8 with normal water level at 27.95mRL (NZVD) and the 100 year water level (based on ICMP levels) at 30.503mRL (NZVD). Please provide all levels against one datum and show that this sub-catchment can discharge to Wetland G8 and that minimum grade and cover can be achieved in up to the 10 year ARI event to support the statement that "A pipeline of minimum length of 330m is required to convey the flow from the sub-catchment to the wetland."*

MEL reply – Response to this was provided in a subsequent email from BBO on 23/08/21 stating "The vertical datum is Moturiki 1953 and the horizontal datum is NZTM." This should be stated for clarity in the proposed ICMP. The question of achieving fall between this catchment and wetland G8 was not answered. However, we have compared 100 yr ARI levels from the information that we have available. It is understood that the SWMM nodes named "MH_S1_.." are the Rotokauri South major sub-catchment, showing that, in the 100 yr event, the HGL at the downstream node may be around RL30.72. We can now compare that to the flood level in the Greenway adjacent to Wetland G8 which is RL30.8 (Moturiki). Therefore, levels in the PC7 subcatchment need refining to demonstrate discharge by gravity to wetland G8 in primary and secondary flow events.

- 10. Why is WRC TR2018/01 referred to, when TR2020/07 is the latest version of the Waikato stormwater management guideline?*

BBO reply: Reference in the document should have been the latest version of the Waikato stormwater management guideline. This has been updated in the latest version of the document.

MEL reply - Explanation accepted.

1.1.2 Overall System Hydraulics

11. SC-ICMP Section 8, Table 10: For piped drainage infrastructure, the criteria proposed would enable the HGL to be at any level below the ground. As per email dated 11 June 2021 from Craig Sharman to Renee Fraser-Smith, the applicant should revise so that HGL for 10 year ARI not exceed pipe soffit and also not exceed invert level of subsoil drains at their outlet.

BBO reply: Stormwater pipe outfalls will discharge into treatment wetlands at the PWL. Depth of 10year flood in the treatment wetlands is likely to be greater than the discharge pipe diameter. Due to the flat nature of the site and tailwater levels that will exceed the level of the discharge pipe soffit, it is virtually impossible to ensure the HGL during 10-year flood does not exceed pipe soffit at all locations within development. This will have no negative impact on the performance of the system.

MEL reply – We raised this as a key concern in the pre-app meeting. The options are to lower the 10yr ARI HGL by increasing downstream capacity, raise the ground levels so that subsoil drains can lift, or use swales to convey flow. This is a major outstanding issue unresolved since the Pre-App meeting. HCC requires free drainage from road subsoils in a 10 year ARI event peak.

12. Terrain: It was noted in Section 6.0 of the SSR, that the terrain model was created from LIDAR then modified by lowering at the wetlands and raising land to provide cover over pipes. We assume that no levels on the boundary of the terrain model were changed in this process. The resultant terrain (shown in Figure 6-1 in the SSR) shows that the topography in Ohote and Te Otamanui appears to match the sub-catchments shown in the concept layout plan in Appendix B. However, has the division of minor sub-catchments been considered in relation to possible future earthworks, roads and minor overland flow paths and how will this be carried through into the Structure Plan?

BBO reply: The division of minor sub-catchment was based on the latest proposed version of the lay-out of the development, including possible earthworks, roads, and overland flow paths. However, it is likely that there will be changes to the lay-out, as the design progresses. The effect of the changes on the stormwater management, including the boundaries of the minor sub-catchment, will be assessed as part of detailed design. The high-level earthworks were laid out to confirm that the use of reticulated stormwater network is feasible, which is what is required for a plan change. We are not proposing changes to the Structure Plan (refer to previous response on planning mechanisms). With regard to the Plan Change, we are demonstrating that drainage of Rotokauri North is hydraulically and operationally feasible.

MEL reply – Approach seems to be suitable. However, refer to other items regarding our hydraulic feasibility concerns.

13. Levels: A manning's of 0.035 has been used for the 2D modelled area, is that appropriate for the smaller events when water levels will be lower in the base of vegetation and manning's would likely be higher?

BBO reply: The 2D model was specifically set up to confirm the stream routing and required attenuation volume as obtained from the 1D model. The 2D model was therefore only run for the 100yr ARI storm event. If, during detailed design, the model is run for smaller storm events, then a suitable manning's n will be adjusted for these smaller storm events.

MEL reply - Explanation accepted.

14. Existing Outflows: Figure 4 in the SC-ICMP shows an existing catchment outflow crossing Te Kowhai Road, near proposed sub-catchment Ohote 1 C. It appears to have been abandoned in the proposed system. Why and what is the impact of this?

BBO reply: To obtain the existing peak flow rates at the outflow points, the SWMM model does incorporate the existing crossing of Te Kowhai Road at Ohote 1. The run-off that is currently directed to this crossing is therefore not added to the existing flow rates at the Exelby Rd crossing. However, to

simplify the proposed model of the stormwater management set up for the sub-catchment ICMP, this crossing was not utilized. In the proposed model, all the run-off is directed toward the Exelby Road culvert outlet instead. To meet the existing flow rates at the Exelby Road crossing therefore required a small amount of additional attenuation. As part of detailed design, use of the Te Kowhai crossing at Ohote 1 will be investigated for draining the backs of lots along Te Kowhai Road. This would be accomplished through the use of swales along the back of properties next to Te Kowhai Road and may reduce the volume of run-off that goes into Wetland Ohote 1.

MEL reply – This is conservative with respect to the Exelby discharge point and Ohote watershed. We note (from the Rotokauri N SC-ICMP June 2021, Figure 5) that the existing catchment to Te Kowhai Rd culvert is 7.4ha and is part of Te Otamanui watershed. Please confirm what the reduction of flow going to Te Otamanui is and the effects of this. It is understood that downstream wetlands in Te Otamanui need water.

15. Storage: *The analysis shown in Table 1 assumed that the "Maximum Volume" values reported in the SWMM "Storage Volume Summary" data is above permanent water level, and the 100 year ARI, 24 hour event data was used. It is unclear why the "Max Pcnt Full" is so low in the 100 year ARI, 24 hour event – please clarify. The reserves were excluded from the total areas in Table 1.*

Table 1: System Storage Check

Catchment	Total Developed Area (ha)	Storage Volume (m ³)	Storage m ³ / ha
Ohote	63.52	68,100	1072
Te Otamanui	32.84	23,355	711
Mangaheka	18.54	14,153	763
Rotokauri South	13.45	**	*

*Rotokauri South catchments should meet the 1200m³/ha of development requirement of the Rotokauri ICMP.

** Wetland G8 is outside of this SC-ICMP area so wasn't included.

BBO reply: The values reported in the Storage Volume Summary are above the permanent water level. The "Max Pcnt Full" is calculated based on the given storage curve as well as the given max depth for the node. To make sure that the nodes do not pressurize but flood instead, for example for manholes, the max depth for the node is often set to a higher value than "ground level". In the case of the wetlands, this max depth was set to 4m, even though the storage curve (and therefore "ground level") only went to 2m. All the volume above the 2m of the storage curve is still taken into account when calculating the "Max Pcnt Full". As an example, the max depth for wetland Ohote 2 was changed to 2m, this yielded a "Max Pcnt Full" of 88%.

MEL reply – Confirmation accepted regarding Table 1. Explanation accepted regarding modelling technicalities - the method seems suitable. It was explained that, to create the proposed terrain, the existing ground level was lifted at the nodes where HGL surpassed the existing ground level, and this should be refined in detailed design phases.

1.2 Stormwater Quantity Control

1.2.1 HEC-RAS 2D Hydraulic Model

16. SSR Section 7.3 discussed culvert embedment depth. *The NZ Fish Passage Guidelines recommend that "culvert invert will be embedded by 25- 50% of culvert height". However, this section explains that 200 mm embedment will be used regardless of culvert height and explains the theory behind this decision, which seems counterintuitive. Please provide stronger evidence or revise design to provide full embedment depths.*

BBO reply: The embedment requirement was discussed with Paul Franklin and Eleanor Gee, co-writers of the NZ Fish Passage Guidelines. They clarified that the suggested typical embedment of 25% to 50%

of the culvert height was mainly meant for circular culverts. Increasing the embedment depth up to 50% in a circular culvert increases the width of the flow in the culvert. For a particular flow rate, the increased width of the flow yields lower velocities in the culvert which aids fish passage. Increasing the embedment layer does not increase the width of the flow if a box culvert is used. In a box culvert the embedment layer has to be suitable to maintain natural stream habitat and substrates, but not allow a channel to be formed that reduces the flow width in the culvert and increases the velocity. Based on the above, the 200mm embedment layer is proposed for box culverts only. If circular culverts are used, a proper analysis of the impact on the embedment layer on the expected velocities within the culvert will be carried out as part of the culvert design for fish passage.

MEL reply - Explanation accepted.

17. *Tailwater: The SSR doesn't discuss tailwater conditions used on modelling. We can see that in the 2D model, the initial stored volume in the system was set to 2mm and assume this is just to kick start modelling. How was initial water level in the stream and wetlands accounted for in the model, or was the terrain model developed to sit above the permanent water level?*

BBO reply: The outfall structures at Exelby Rd, SH39 and the Mangaheka wetlands control the flow out of the catchments. Due to the attenuation provided within the catchment, the water surface within the catchment will be higher than that downstream of the outfall structures, however it cannot be assumed to have a free outfall. Flow rates or elevation data were not available at any of the outfall locations for determining the tailwater condition. At Exelby Rd and SH39 crossings, a section of channel was added downstream of the culverts/weirs in the SWMM model. The channel ended at the outfall node. The tailwater conditions were obtained by giving the outfall node an appropriate invert level and setting the outfall type to Normal, causing a normal flow calculation for the channel to establish the tailwater. The flow conditions at the outfall point are then calculated based on the upstream channel. For the Mangaheka catchments, a part of the Mangaheka stream was included in the SWMM model to yield appropriate tailwater conditions. The size of the culvert crossing Te Kowhai Rd East was unknown; hence the model was calibrated using elevation data from the report "Mangaheka Integrated Catchment Management Plan – Stormwater 1D Modelling Report" which is an attachment to the Mangaheka ICMP. For the Rotokauri South catchment, the water is conveyed to wetland G8 which is not part of the subcatchment ICMP and hence no tailwater modelling was carried out.

As part of the stormwater management plan, the existing stream will be re-established and will have functional floodplains. The details of the re-established streams will be worked out as part of detailed design. In addition, the initial water levels in the streams are currently not known and hence these were not included in the 1D and 2D models. The cross-sectional profiles used in the 1D and 2D models were instead simplified approximations of the final cross-sections and therefore did not explicitly include the part of the stream that has a permanent flow. For the large storm-events modelled, the details of the stream have little impact on the flow behaviour.

For the wetlands, the invert levels used in the models were at the permanent water level.

The report has been updated to clarify the above.

MEL reply -

The methods used to estimate initial water level in the streams are appropriate. However, it does seem important to know the outfall inverts because the invert of downstream culverts could impact positive drainage of primary flow from the subdivision.

It is understood that, in 10 yr and 100 yr events, the bunds between wetlands and stream will be submerged. Overflow from wetland to stream is discussed above - note that overflow from wetland to stream should occur at the inlets and overflow from the streams to the wetlands should occur from the outlets. This arrangement protects the wetlands from high velocities.

18. Cross sections: Please provide stream cross sections and the total width of land required to contain a stream channel that conveys the required flow.

As mentioned above in a reply to a previous comment, the cross-sectional profiles used in the 1D and 2D models were simplified approximations of the final cross-sections to be designed as part of detailed design. The proposed batter slopes are 1:4 (V:H) and an example cross-section is shown below for the Ohote and Te Otamanui streams. Away from the wetlands and based on the latest lay-out of the development, the width of land available for the stream cross-section along the Ohote stream varies between 30m and 50m. For the Te Otamanui stream this varies between 27m and 53m.

MEL reply – The assumptions outlined in this response should be included into the SSR, and the section capacity provided/assumed by the SC-ICMP work should be stated so that it can be carried forward into detail designs.

1.2.2 EPA SWMM-5 1D Hydrologic Model

19. EPA-SWMM-5 is a suitable modelling package to use for estimating runoff and sizing devices. It would be useful for the applicant to include some screen shots or details of the device designs and outlet configurations used in modelling.

BBO reply: Additional details of the device and outlet design for the SWMM model of the stormwater management set up for the sub-catchment ICMP have been added to the report in section 4.4.

MEL reply – Refer to Item 17.

20. The consistency between HEC-RAS and EPA-SWMM results appear to be good so we assume that the volumes and dimensions modelled in the terrain modelled used in HEC-RAS were fed into the SWMM model as inputs. What capacity was assumed for the stream reaches? If this land needs to be designated or translated onto the Rotokauri Structure Plan, please provide stream cross sections and the total width of land required to contain a stream channel that conveys the required flow.

BBO reply: The relevant Structure Plan is the proposed "Rotokauri North Structure Plan" (not the Rotokauri Structure Plan". The HEC-RAS 2D model was generated to model the routed flow in the streams and floodplains and carry out a secondary check of the attenuation volume and flood depths. Therefore, the elevations and dimensions of the wetlands, the elevations and simplified cross-sectional information of the streams and the input run-off flow rates from the 1D SWMM model were used to set up the terrain and boundary conditions of the 2D model. As outlined previously, the Green Spine Areas are shown on the proposed structure plan and are shown on land with titles held by the Plan Change applicant (GSL) and/or a company falling under its umbrella. The Plan change is not the mechanism required to secure these areas – future resource consent for subdivision and development will create the final areas for stormwater management purposes (as per below there is also existing rules that ensure future development adhered to the sub catchment ICMP). Examples of the simplified stream cross-sections have been provided as part of a reply to a previous comment.

MEL reply – The green spine areas are shown on the proposed Rotokauri North Structure Plan for Ohote and Te Otamanui watersheds, but don't appear to be shown for Mangaheka wetland M1, M2 and swale. It is agreed that final stormwater management areas will be determined in subdivisions. However, the plan change process needs to ensure that enough land is indicated as green spine in Mangaheka major sub-catchment so that it can subsequently become stormwater management areas / green corridors in the subdivision process. We appreciate that this is interlinked with decision made under Item 8.

21. Comments regarding catchment definitions:

- i. Rotokauri South 1 drains in the Rotokauri Arterial Designation area – has this catchment been accounted for in the Wetland G8 design?
- ii. It was assumed that 50% of the wetland minor sub-catchments is impervious/water. However, many of these sub-catchments appear to be more than 50% impervious in Figure 3-2 eg. Te Otamanui 4A (1.2 ha) appears to be nearer to 90% covered by the wetland itself.

-
- iii. *The impervious percentage for streams seems low, at 10%. The proposed channel dimensions and baseflow during winter should be used as an indicator of water areas providing effective impervious.*
 - iv. *What percentage impervious was assumed for Ohote Upstream North, West and East sub-catchments? They are not included in Table 4.1 of the SSR and the runoff coefficients in the SWMM sub-catchment results are consistently lower than the other fully developed sub-catchments.*
 - v. *Referring to Table 4-2 in the SSR, is the impervious percentage of 5% suitable for the Mangaheka Upstream catchment?*
 - vi. *Table 4-1 of the SSR - Were catchment slopes based on the existing surface or estimated for future?*
 - vii. *The initial infiltration rates for the rainfall to runoff sub-catchment analysis were sourced from Rawls et al. (1983). This comes from USA literature and is typically accepted in the USA. Please provide local references support the infiltration rates and the depression storage values.*
-
- i. BBO had a meeting with Beca on June 2nd to coordinate the work. This included a discussion about the area that falls within Rotokauri North that is to be treated by wetland G8. Hence, Beca is aware that this catchment has to be accounted for in wetland G8.
 - ii. The areas shown in blue on Figure 3.2 are indicative only. The permanent water level area covers approximately 42% of the wetland areas as indicated in Figure 3.2, while during the 100yr ARI storm event and at maximum water depth, the area covered by water is 62% of the wetland area as indicated in Figure 3.2.
 - iii. As part of the stormwater management plan, the existing stream will be re-established and will have functional floodplains. Therefore, the future baseflow during winter is currently not known. Instead, for this high-level analysis, the future stream has been assumed to have a bottom width of 1m to 1.5m, side slopes of 2.5:1 (H:V) and have a baseflow depth of approximately 0.2m. These assumptions are similar to those used for a previously completed stream re-establishment that had a much larger upstream catchment. This yields an estimated the top-width for the stream of 2.2m which would cover approximately 7% of the areas as indicated in Figure 3.2. The 10% used in the SWMM model allows for some additional area during detailed design to include the appropriate sinuosity added to the stream.
 - iv. During the modelling of the existing conditions, the impervious percentage was set to 5% for the Ohote Upstream East, West and North sub-catchments. During future developments, these major sub-catchments will require their own treatment and attenuation devices and the proposed peak flow rates from these devices will have to match 80% of the existing peak flow rates. Hence during the modelling of the proposed conditions, the impervious percentage for these catchments was kept at 5% and the rainfall for these catchments was not changed to the rainfall adjusted for climate change, so that the peak flow rates from the catchment remained the same as for the existing condition. Table 4.1 has been updated to include the Ohote Upstream catchments.
 - v. No, the 5% is indeed not appropriate. Based on the land-use of the upstream catchment, the percentage impervious was estimated to be 35.7% which was the value used in the model as per the results in Appendix A. Table 4.1 has been updated accordingly. However, to obtain a reasonable estimate for the tailwater in the Mangaheka stream upstream of the Te Kowhai Rd East without having access to the Te Kowhai Rd East culvert information, the peak water surface elevation was calibrated using data from the report "Mangaheka Integrated Catchment Management Plan – Stormwater 1D Modelling Report" which is an attachment to the Mangaheka ICMP (Hamilton City Council, 2019). This has reduced the impact of the estimated impervious percentage on the tail water condition for the Mangaheka wetlands, which was the only reason why Mangaheka upstream was included in the report.
 - vi. For the existing model, the slopes of the major sub-catchment were based on the existing

slopes. The existing model was not run with the minor sub-catchments. The proposed model was initially run with the major sub-catchments with slopes based on the existing slopes and was later refined to run with the minor sub-catchments, based on the high-level earthworks model developed to create the initial sub-catchment delineation. Note that for most subcatchments the difference in the slopes was very small.

- vii. The New Zealand Soil Classification by the New Zealand Geotechnical Society Inc is based on grain sizes that are identical to the grain sizes used as part of the Universal Soil Classification System. The work presented by Rawls et al. (1983) on soil water properties uses the universal Soil Classification System which, therefore, also works with the New Zealand Soil Classification. In addition, soil water properties are measured using the standard constant head permeability test, which are the same here and in the United States. As water, soil rain size, and gravity are the same in New Zealand and the United States, results obtained from a very comprehensive study in the United States are acceptable for use in New Zealand as well. Likewise, Bridge Scour, by Melville (Professor Bruce Melville, Auckland University) and Coleman, is widely referred to in the US and Professor Melville's work forms a significant part of the Hydraulic Engineering Circulars 18 and 23, which are also widely applied in NZ and Australia.

MEL reply –Accepted, with note to refer to Item 22 response.

v. Table 4-1 hasn't been updated in SSR version 3. Ensure that all decisions noted in responses are carried through to the reports.

22. Inflows: *Was the generated flow or accepted flow from external sub-catchments Ohote Upstream West and East (as stated on the catchment layout plan) fed into HEC-RAS as inflow? It should be the larger of, 100% the predevelopment total runoff generated, or the throttled (80% of ED 100yr peak flow) total runoff hydrograph generated from the 24hr 100yr storm on fully developed catchment.*

BBO reply: Yes, the generated flows from the external sub-catchments were used as input for the 2D HECRAS model for the Ohote Stream. As mentioned above, these flow rates were based on the predevelopment total runoff generated, as future development will be required to match 80% of the predevelopment peak flow rates from these catchments. In addition, as no details of the development for these catchments are known, it is not possible to generate suitable fully developed catchment flow rates.

MEL reply – Not Accepted. Please comment on the implications of the additional volume and therefore duration of outflow likely from the post development 1% AEP flow from upstream catchments throttled to 80% of pre development peak flow. This may require a scenario with assumed impervious similar to PP7 impervious to check the PP7 area storage requirements and therefore peak water level will hold true. Note that the response to Item 14 (the question around the 7.4ha existing catchment going to the Te Kowhai culvert) may balance this non-conservative approach if that catchment is discharged north toward Te Otamanui in post development scenario.

23. Events: *A Scenario of 50% of 2yr ARI event has been used. Typically, 1/3rd of the 2 year ARI event is used to define frequent storm conditions representing the 95th percentile storm event size.*

BBO reply: The 50% of the 2yr ARI event approximates the mean annual flood and is used typically used for a channel forming discharge and the migration trigger for upstream migration of native fish species. The mean annual flood or ½ the 2-year is also applied as the upper limit for which fish passage in culverts, which is consistent with NIWA New Zealand Fish Passage Guidelines, 2018. 1/3 of the 2-year flow is generally applied for determining a stormwater quality volume for treatment.

MEL reply - Explanation accepted.

24. Wetlands: *It seems that there is one wetland missing from the design. Has the wetland named Mangaheka 2A (1.6ha) in the concept layout been modelled? The storage node at that location in the SWMM model layout image is named W Rotokauri South 1, but a wetland named that isn't on the concept layout plan. Additionally, although difficult to see on the SWMM model layout image, it doesn't look like this network (J148 down to MH S1 4) is connected to the swale between Mangaheka W1 and the culvert. It is mentioned that and that Mangaheka 2A is connected via a pipe – is that intended to go along Burbush Road? Can this be conveyed in an open channel instead?*

BBO reply: Initially major sub-catchment Mangaheka 2 was directed southward to discharge in the Rotokauri South drain (at this time this major sub-catchment was referred to as Rotokauri South 1 and the current Rotokauri South 1 was referred to as Rotokauri South 2). During our discussion with Beca about the boundaries of the major sub-catchments, it became clear that it was not possible to discharge Mangaheka 2 southward and instead had to be discharged northward into the Mangaheka. The map of the nodes included in the SWMM model forwarded to Morphum on 7/07/2021 was of an earlier copy of the SWMM model before this change was made while the results in the Appendix A were from the latest copy. This has caused the confusion as indicated by the reviewer.

An updated copy of the map, focused on the Mangaheka 2 sub-catchment is shown below. This includes Wetland Mangaheka 2 and the pipeline that connects the outfall structure of the wetland with swale upstream of the discharge point into the Mangaheka. It may be possible to construct this pipeline as an open channel instead for at least part of its length (it also has to cross two major roads, note that the pipeline follows the minor north-south arterial, not Burbush Rd). Options will be investigated as part of detailed design.

MEL reply - Explanation accepted. Refer to other items related to the positions of this wetlands.

25. SSR Section 6.2.1: *It is stated that "the highest depth-averaged velocities are found immediately downstream of the inflow points into the wetlands." Why is that? Would expect higher flows to be in the streams rather than the wetlands, particularly in the 100-year ARI event.*

BBO reply: 2D hydraulic models provide depth averaged velocities. The velocity of pipe discharge into a treatment wetland must be higher than the velocity within the wetland. The treatment wetlands and attenuation areas are designed to not only reduce velocity but attenuate the peak flow. The inflow points into the wetlands consist of pipes with a diameter of approximately 1m and therefore a cross-sectional area of 0.79 m². And the discharge pipes into the wetlands are likely to be pressurized during the 100yr ARI storm event. The streams including the flood plains have cross-sectional areas of up to 30m² and are open to the atmosphere. Even though there are 16 different sources of water flowing into the stream and therefore the throttled flow rate in the stream may be larger than the flow rate from a single discharge pipes, continuity indicates that the velocity of the water in the discharge pipes has to be significantly greater than that in the stream.

MEL reply - Explanation accepted.

26. Peak flow: *The peak flow comparison was done at four locations on the perimeter of the study area, which is a suitable approach assuming that the proposed storage devices are built in approximately the same locations as designed here and are fed by the equivalent catchments as used for this study. How will this be ensured during design phase? Eg. will these areas be designated? How will the structure plan and staging/order of development be managed to meet this?*

BBO reply: The "Rotokauri North Sub-catchment ICMP – Stormwater System Report" is being submitted as technical evidence in support of a Plan Change application. As outlined previously, despite having prepared this Sub catchment ICMP the resource consent process still requires ICMP's to be submitted (existing HCC rules and those inserted by the PPC) for review as part of any future stage of development. This is the relevant mechanism for ensuring that the future designs adhere to the proposed approach.

MEL reply - Explanation accepted.

27. Peak flow: In Section 8.2 of the ICMP, Table 12 (and SSR Table 5-1) the average flows from SWMM tabular report were listed for Mangaheka instead of the max flow, eg. at Mangaheka_Out node the peak flow was 3.04 m³/s and average of 0.82 m³/s was adopted into the Tables. Please clarify why the average flow was included in the report summary, rather than the peak.

Mangaheka_Out is the node downstream of Te Kowhai Rd East and the end of the routed model that begins at the Mangaheka minor subcatchments. Please note that this is not the outflow from the combined Mangaheka 1 and Mangaheka 2 wetlands. This happens at node J_M_Stream_03 (as seen in the updated map of the SWMM model presented above). The discharge flow rate is the difference between the total flow rate at this node minus the lateral inflow from the Mangaheka_Upstream sub-catchment. Using the max flow rate information in Appendix A (p110) would give a discharge estimate for the Mangaheka wetlands of 0.793m³/s, however the peaks of the flow rates from the sub-catchment and wetlands do not align. Instead, the time-series from the total flow rates and lateral flow rates were obtained as shown below. Subtracting the two time-series and finding the maximum difference yielded a value of 0.8146m³/s which is the value as presented in Table 5-1.

MEL reply – The approach of combining hydrographs then subtracting the Mangaheka upstream catchment hydrograph is suitable for the pre vs. post comparison assuming that Mangaheka Upstream catchment will mitigate peak flow (as per the Mangaheka ICMP) prior to discharge into the watercourse of interest.

There are several complications with the major sub-catchment discharging to Mangaheka

- *The design point for the post development peak flow is shown at the upstream end of the proposed swale. The pre-development condition includes flow from the west-east culvert under Burbush Road, so is the design point at the Te Kowhai Rd East culvert? If so, it is noted that the swale area is omitted from the post development but that the effect of this would be minimal.*
- *There is a blank space on the SWMM model image, which we assume is beyond the high point on the arterial road.*
- *The location and catchment for Mangaheka 1A (named device 6 in Managaheka ICMP, and D6A in the RAD) needs to be discussed with HCC and RAD design team. Catchment Te Otamanui 2F has been treated differently in the various designs. However, we understand that sending it towards Te Otamanui (as proposed by BBO) may be preferred by HCC to restore historic flow directions and connection with paleo channel.*
- *Is it feasible to convey water around the Mangaheka 1E & F catchments up to Mangaheka 1A against the grade of the adjacent Mangaheka Stream – ensure that proposed stream is wide enough to accommodate this. The dynamics of the stream between J_M_Stream_03 and the Te Kowhai Rd East culvert haven't been explained - please show that there is enough space for the wetland and stream between the arterial and the property boundary while meeting capacity required for the stream.*

28. Peak flow: The peak flow at Rotokauri South discharge location has been noted as NA in the ICMP and SSR. However, the SWMM results show that the combined peak at the two out nodes in all reported storms are higher than the predevelopment peaks shown in ICMP Section 8.4 Table 11. Can this increase be mitigated in RAD Wetland G8?

BBO reply: The Rotokauri South 1 major sub-catchment falls within the catchment of basin 3 as part of the Rotokauri Greenway (Beca Limited, 2018). Treatment and attenuation of the flow of basin 3 takes place in wetland G8, hence this wetland also must treat and attenuation the flow from major sub-catchment Rotokauri South 1.

MEL reply - Refer to Item 4.

29. Please provide a table summarising the design water levels, surface area and volumes (permanent, ED, and storage above that) for each storage zone.

BBO reply: A summary table of the wetlands including the elevation and area of the permanent water level, the bund level and the HGL and stored volumes for the 2yr, 10yr and 100yr ARI events, has been added to the text as Table 4-3.

MEL reply – Refer to Item 2.

30. Rotokauri South ICMP areas will need to comply with Rotokauri ICMP requirements including interim storage and catchment boundaries will need to be maintained. Also, the overflow path from the Rotokauri South catchment into the paleo-channel toward Mangaheka needs to be allowed for.

BBO reply: From the Rotokauri ICMP documentation, it was not directly clear where the proposed catchment boundaries of the Rotokauri South 1 major-subcatchment are. The Rotokauri Greenway – Design Report by Beca shows the boundaries of catchment SC3D (on page 63) that includes the Rotokauri South 1 major subcatchment. It is assumed that boundaries of SC3D are along the centre of the Greenway, then the major subcatchment Rotokauri South 1 is estimated to be 73% of catchment SC3D which yields an area of 14.4 Ha.

As part of the pre-development SWMM model a catchment delineation was carried out on the Rotokauri North area which included the current road boundaries and existing culverts. This yielded an area for the Rotokauri South 1 major sub-catchment of 15.3Ha. When identifying the boundaries of the proposed minor sub-catchments, the boundaries of the major sub-catchment Rotokauri South 1 were adjusted to better align with proposed lay-out of the development. This reduced the area of major sub-catchment Rotokauri South 1 to 13.35 Ha. Both values are a reasonable match with estimated value based on the Beca design report.

The requiring authority's conditions for the Rotokauri Greenway Notice of Requirements includes article 42b ("Maintaining existing sub-catchment drainage patterns up until the development of adjacent subcatchment"). Hence once development of Rotokauri North begins, the paleo-channel toward the Mangaheka no longer has to be allowed for, therefore this issue has not been included in the Rotokauri North subcatchment ICMP.

MEL reply – Also refer to Item 8. We agree with the RAD discussion. However, the requirements of the Rotokauri ICMP include 1200m³/ha interim storage until which time that the Greenway is built, and water quality treatment to reach 70% phosphorous removal which requires 40% removal through pretreatment upstream from wetlands. This needs to be met prior to discharge from Rotokauri South major sub-catchment. The phosphorous removal requirement should be included in means of compliance tables and the interim storage requirement may impact how much land can be developed here prior to the Greenway completion.

1.3 Stormwater Quality

31. It is not clear the basis for the sizing of the wetlands. Please provide a table summarising the design water levels, surface area and volumes (permanent, ED, and storage above that) for each wetland or storage zone. What percentage of the impervious catchment were the wetlands sized at?

BBO reply: Additional details of the device and outlet design for the SWMM model of the stormwater management set up for the sub-catchment ICMP, including a summary table for the wetlands, have been added to the report in section 4.4.

MEL reply – Refer to Item 2.

32. ICMP table 6 indicates treatment devices to be used for roads. Are there roads that will not drain to treatment wetlands? What type of device is proposed, this is not indicated in ICMP Table 13.

BBO reply: No, all roads within the sub-catchment will drain to treatment wetlands. Table 13 has been updated to explicitly state that the recommended devices for treatment of road run-off are the communal wetlands.

MEL reply - Explanation accepted.

33. *ICMP Table 13 indicates that communal devices will have detention 0.5m above water quality volume. It is assumed this refers to extended detention which should be no deeper than 0.35m above water quality volume as per the RITS, please change.*

BBO reply: It should not be assumed. The decision between attenuating the 2-year or applying EDV will be made as part of detailed design. This statement has been removed from updated text.

MEL reply – Extended detention is required to meet the RITS and should not be deeper than 0.35m to support plant survival, mitigate habitat flushing and erosion. A proposal that does not provide an EDV orifice would need significant justification. The 2y ARI 24 h event is less frequent event for which attenuation would be for flood mitigation rather than extended detention which is for water quality treatment. So, the depth should be tested separately.

34. *The ICMP Table 13 provides for no water efficiency measures on affordable housing which is contrary to the HCC District Plan requirements and may not be acceptable to HCC.*

BBO reply: Noted. This issue will be discussed with HCC.

MEL reply - Explanation accepted.

35. *Figures 6-6 of the SSR show that Ohote Wetland 6 is still elevated about 200 mm above starting water level after 72 hours. This long draw down is also noted by 002d in Table 7. What tailwater assumptions were used in the modelling and what is the impact of extended drain down time?*

BBO reply: Tailwater assumptions have been stated above in reply to a previous comment and the report has been updated accordingly. The drain down times are a result of the very minimal gradients of the stream and surrounding land and hence the relatively slow natural drainage is replicated as the stormwater infrastructure is built into the existing landscape. During the tail-end of the storms, the water levels in the wetland are controlled by the water levels in the stream. To evaluate the impact of the 200mm of water left in the wetland after 72 hrs, the model was run with a second 100yr ARI storm starting 60 hours after the first so that its peak intensity occurred after 72 hrs. The results at wetland Ohote 6 are shown below. The max HGL in the wetland increased from 29.05m to 29.08m, well within the freeboard of the wetland.

MEL reply – Explanation accepted.

36. *It seems that the invert of wetlands is below the groundwater table. As stated in the SC-ICMP the groundwater depth is "approximately 0.1 to 1.5m (below ground surface) in the low-lying areas". For example, with the existing ground level at Wetland Ohote 7A at approximately RL29m, the groundwater table may be between RL27.5m and RL28.9m. The initial water levels shown on Figures 6-6 to 6-8 of the SSR wetland are around RL27.3m, indicating that they may be within the groundwater. The image below is from the SRS Appendix A, indicating that the water levels in the 50% of 2-year ARI event may also be below the groundwater level. How has the groundwater level been determined? Will relief points be provided for groundwater flows to be collected without liner floatation? Evidence is required to confirm the risk of wetlands having high normal baseflow disturbing hydraulics, displacing small storm runoff and reducing water quality treatment, and submerging*

vegetation causing mortalities? Ideally wetlands should be designed at or above normal groundwater level.

BBO reply: Latest data from HDGeo indicates that the groundwater depth varies between 0.1m to 2.5m in the low-lying areas. Text has been updated accordingly. The current ground water level will be impacted by the re-establishment of the Ohote and Te Otamanui streams. Sub-soil drainage will be installed below the roads surrounding the wetlands and stream and therefore a significant initial draw-down of surrounding ground-water is expected to occur during and immediately after construction of the wetlands and streams, until the ground-water levels have found a new equilibrium. The possible use of suitable liners for the wetlands is detailed design issue, but geosynthetic clay liners may be an option.

MEL reply –

We understand that groundwater lowering is expected to occur after the Ohote channel invert is lowered and subsoil drains are installed. Hydraulic functionality and overall feasibility of the subdivision relies on successful dewatering. Ultimately, WRC consent for dewatering will need to be obtained. Detailed design of the groundwater drawdown system (subsoils, lowering of Ohote Stream invert, etc.) should be worked through with a hydrogeologist, to establish the proposed final level, expected area of influence and possible impact on other waterways in the area of influence.

Regarding the proposed wetlands, the response is accepted and should be carried into detailed design - ensure that the ground water table is below the invert of the wetlands to minimise the risk of groundwater encroachment into the operating depth which would reduce the wetland treatment capacity and cause liner floatation. A liner is required as per Section 4.2.17.13 of the RITS, which outlines the important functions that wetland linings provide, including protection of groundwater from contamination and keeping water in the wetland in dry periods.

1.4 Streams and Culverts

37. *Please provide typical Stream (Green Spine) dimensions including proposed batter slopes to confirm footprint.*

BBO reply: See above for details of cross-sections as part of a reply to a previous comment. As stated earlier, these dimensions are preliminary.

MEL reply – Refer to Item 18.

38. *High flow: Have the proposed culverts in Ohote Stream catchment been sized? / What constraints were used in the SWMM to model them? Where is T Culvert 01?*

BBO reply: The culverts in SWMM were only sized at a very high level. The Ohote stream culverts were given single barrel circular culverts with diameter of 1.5m. As there is very little head difference between the upstream and downstream ends of the culverts at any time during the storm events, the gradient of the culverts is also very small and the flow rates remain small to meet the pre-development flow rates, the velocities in the culverts are expected to remain small and therefore no problems are anticipated when designing the culverts for fish passage during detailed design. A quick check of the SWMM results for the 50% of the 2yr ARI storm event shows that the estimated maximum cross-sectional velocity of these culverts is about 0.4 m/s. These results therefore also indicate that achieving suitable fish passage design should be relatively straightforward for these culverts.

Culvert T_Culvert_01 is along the Te Otamanui stream between wetlands Te Otamanui 2 and Te Otamanui 4. In a previous lay-out of the development, a street was included connecting the two sides of the Te Otamanui stream and hence the culvert was included in the SWMM model. Its high level design included a single circular barrel with a diameter of 1.05m. In a later version of the lay-out, this connecting

road was removed, but discussions that included HCC were ongoing about the inclusion of this connecting road or alternatively a pedestrian/bicycle connection. Because of this uncertainty, the initial culvert was left in the model.

MEL reply – We understand that the Exelby Road culvert (and which others?) need replacing, as stated in the ICMP, partly because they are undersized. It is accepted that the culvert sizes will be finalised at a later stage, noting that the culvert diameter or width should be wider than the stream width at normal flow, as per Section 4.2.12.2 of the RITS, which may be approximately 2.2m according to the Item 21.iii response. Peak flow attenuation should be revisited at that stage of design.

39. **Low flow:** Does the example culvert design explained in SSR Section 7.2.3 (shown to be a 1500 mm square concrete box in the HY-8 image) represent any of the culverts proposed in this project (in size, slope and shape)? It is demonstrated that the designer understands the requirements of the culvert for aquatic organism passage, but this doesn't show that the requirements can be met by the actual three 1.5m diameter culverts at the project boundaries and proposed culverts in the project area.

BBO reply: No, the example given does not represent any of the culverts that are part of the proposed development. The example has been inserted to clearly describe the process that will be used during detailed design to meet the fish passage requirements. Some details on the ability to meet the fish passage requirements for the culverts have been included in the reply to the previous comment.

MEL reply – Explanation accepted.

1.5 Other items

40. ICMP Section number 3.9.2 occurs twice

BBO reply: Text in ICMP report has been updated accordingly.

MEL reply - Explanation accepted.

41. ICMP Table 13 is labelled as Table 133

BBO reply: Text in ICMP report has been updated accordingly.

MEL reply - Explanation accepted.

42. SSR Table 6-2 appears to be missing (mentioned in Section 6.2.2) – should this have said Table 4-2?

BBO reply: Yes it should have been. Text has been updated.

MEL reply - Explanation accepted.