Before the Independent Hearing Panel appointed by the Canterbury Regional Council

IN THE MATTER OF The Resource Management Act 1991

AND

IN THE MATTER OF Application CRC190445 to discharge stormwater to land and water

Section 42A Officer's Report

Report of Michael Law

1 Introduction

1.1 Background

1. This report forms part of Canterbury Regional Council's (CRC) audit of the assessment of environmental effects (AEE) provided by Christchurch City Council (the applicant) in support of resource consent application to discharge stormwater from the reticulated stormwater network within the Christchurch City boundaries.

2. This report will provide the decision-maker with information and advice related to ensuring that the discharge of stormwater does not result in an unacceptable risk of flooding.

1.2 Qualifications

3. My full name is Michael Charles Law.

4. I am currently employed as Senior Associate - Water Resources at Beca Ltd in Christchurch, where I have worked since 8 August 2009.

5. I hold a BSc(Hons) degree in Geography from Huddersfield Polytechnic in the United Kingdom (UK). I also have a Post-Graduate Diploma in Agricultural Water Management (Soil & Water Engineering) from Silsoe College, part of Cranfield University in the UK. I have twenty-eight years' experience as a water resource and hydrological specialist, particularly in the areas of water resource management, hydrology, hydrological modelling, flood risk assessment and control, river restoration, and stormwater/flood modelling.

6. Prior to joining Beca as a Water Resource Manager, I was a Director of Weetwood Service Ltd an independent consultancy in water management and sustainability in the UK. Before that I was a Hydrology Team Leader at the Environment Agency in England.

7. I am a Chartered Member of the Chartered Institute of Water and Environmental Management (CIWEM). My membership number is 302580.

8. I confirm that I have read and am familiar with the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. I agree to comply with that Code. Other than where I state I am relying on the evidence of another person, my evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

1.3 Scope of Report

9. The Applicant originally lodged an application for resource consent in June 2015 (CRC160056), which was publicly notified in early 2016 at the Applicant's request. Following the receipt of submissions, further information from the applicant was requested. This information was audited and there were still outstanding concerns with regard to the proposal and potential effects on the environment and inconsistency with the planning framework. An amended application was provided to CRC on 9 July 2018 (CRC190445) including details of the Contaminant Load Modelling approach and revised resource consent conditions. An additional amendment to the proposal was the authorisation of all stormwater discharges to the reticulated network from 1 January 2025 or on the expiry of individual consents held by property owners. The original resource consent application excluded 'high risk' sites.

10. This report is prepared under the provisions of Section 42A of the Resource Management Act 1991 (RMA). This section allows a Council officer or consultant to provide a report to the decision-maker(s) on a resource consent application made to the Council, and allows the decision-maker(s) to consider the report at the hearing. Section 41(4) of the RMA allows the decision-maker(s) to request and receive from any person who makes a report under Section 42A *"any information or advice that is relevant and reasonably necessary to determine the application"*.

11. This report is supplementary to the Section 42A report prepared by CRC for the above consent applications.

12. In my report I have reviewed the relevant sections of the following information provided in the AEE, its appendices and accompanying technical reports:

    a. Resource Consent Application and Assessment of Effects on the Environment (June 2015)

    b. Amended Application Letter (July 2018)

    c. Proposed resource consent conditions (July 2018); CSNDC conditions

    d. Environmental Monitoring Programme;

    e. Responses to Section 92 Further Information Requests (November 2015 and June 2016)

    f. Ōtākaro/Avon Stormwater Management Plan;

    g. Ōtākaro/Avon Stormwater Management Plan: Technical Reports;

    h. Huritīni/Halswell River Stormwater Management Plan;

i. Pūharakekenui/Styx Stormwater Management Plan Part A;

j. Pūharakekenui/Styx Stormwater Management Plan Part B;

k. Ōtākaro/Avon Stormwater Management Plan Cultural Impact Assessment;

l. Ōtākaro/Avon Surface Water Plan;

m. Pūharakekenui/Styx Stormwater Management Plan Cultural Impact Assessment;

n. Huritīni/Halswell River Stormwater Management Plan Cultural Impact Assessment; and

o. GHD Limited – Christchurch City Council Stormwater Modelling Specification for Flood Studies. September 2012;

p. GHD Limited – Christchurch City Council Stormwater Modelling Consolidation Model Status Report Summary. August 2012

q. Golder Associates (NZ) Limited – Assessment of Current and Future Stormwater Contaminant Load for Christchurch: CLM Modelling Report – Best Practice Infrastructure. July 2018

r. CRC internal memo - CRC160056 Stormwater discharges to the Halswell Drainage District, implications of the Christchurch City Council Comprehensive Stormwater Network Discharge Consent proposal. March 2016

13. Finally, I have also considered relevant issues raised by submitters in relation to the effects I have considered in this report.

2 Assessing stormwater performance

14. The CSNDC covers a large area incorporating a diverse range of catchments, including large low-lying catchments such as the Avon and Heathcote, as well as small, steep catchments such as those that characterise Lyttelton Harbour and the Banks Peninsula. This diversity presents a challenge in assessing the effects of stormwater discharge and defining performance measures that will adequately protect against unacceptable increases in flood risk.

15. Unlike monitoring water quality, where monitoring of agreed parameters against set concentrations allows performance to be measured under a range of flow conditions, monitoring of stormwater quantity performance can only be measured with reference to flood events.

16. Generally, it is not appropriate to include absolute performance measures, such as requiring that an area does not flood under any conditions, or that a given water level is never exceeded at a certain location. This is due to the variability of flood inducing rainfall, and the risk of events greater than the design standard for stormwater systems. Rather, the performance of the stormwater network is measured using modelled performance against design storm events of a defined rarity.

17. To model performance changes over time, environmental inputs (such as rainfall) are kept the same, while changes in land use, development, the drainage network, and stormwater mitigation measures are incorporated in flood models. The results of these models are compared against baseline (also referred to as existing or pre-development) model results. The difference in model results being the relative effects of the catchment changes.

18. This approach is explained in Section 9.4.2 of the AEE accompanying the application

3 Modelled catchments

19. CCC have (or are in the process of completing) computer flood models of the four main catchments draining the metropolitan area of Christchurch. These are the Styx, Avon, Heathcote and Halswell catchments. Only the upper reaches of the Halswell catchment is within the CCC boundary; the remainder being in Selwyn District. CCC also have a flood model of the Avon-Heathcote estuary. CCC are currently managing a project to develop a city-wide model that will combine all of the individual catchment models.

20. Figure 1 shows the area covered by the CSNDC included in the existing modelled catchments (2, 3, 5, 6, and part of 4) and those areas within the City boundary where catchment-wide flood models are not available.

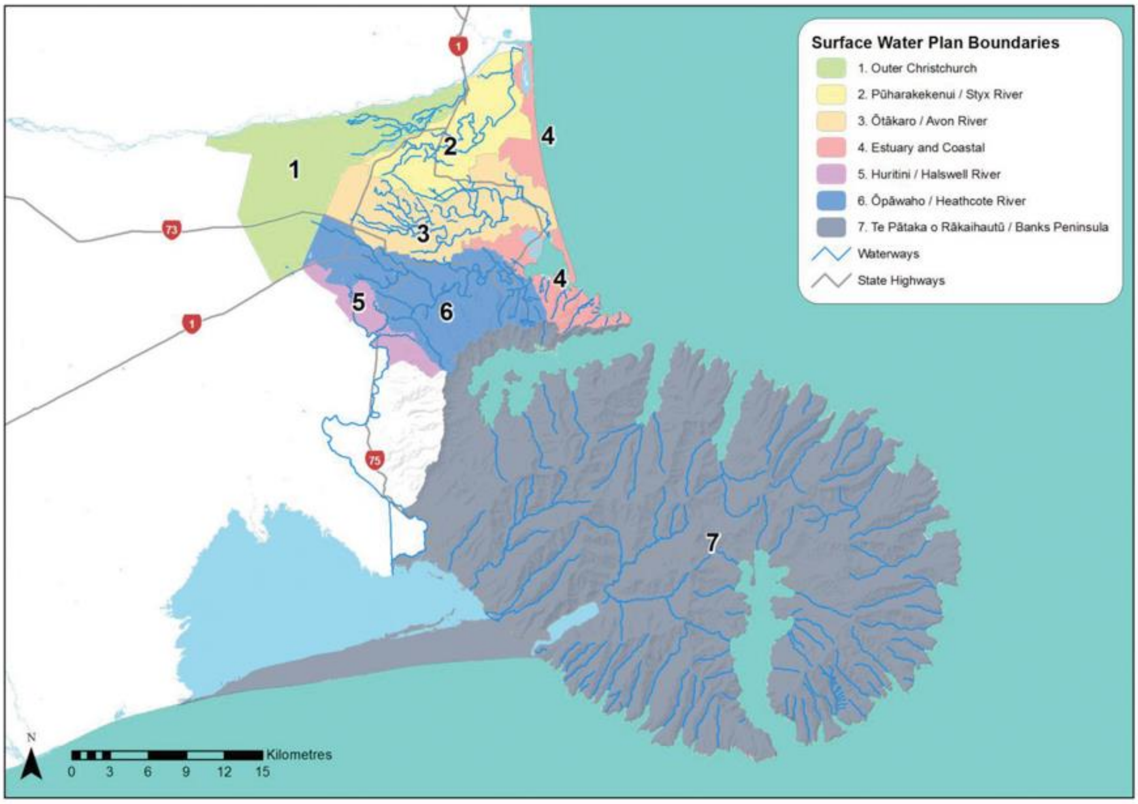

Figure 1. Catchments and area covered by the CSNDC[1]

[1] https://www.ecan.govt.nz/do-it-online/resource-consents/notifications-and-submissions/notified-consents/christchurch-city-council-comprehensive-stormwater-discharge-crc190445/

21. In their CSNDC application, CCC propose that the performance of the stormwater network in the four modelled catchments is to be:

   a. Assessed at one location within each catchment, as an allowable increase in the modelled 50-year ARI[2] flood level. The details are presented in Schedule 7 of the proposed CSNDC conditions and in Appendix A of this document but have been summarised in Table 1 below. Section 8.2.4 of the AEE acknowledges that the flood mitigation will vary from catchment to catchment.

Table 1 - Summary of CSNDC conditions Schedule 7 (July 2018)

Item	Modelled catchment			
	Pūharakekenui/ Styx	Otākaro/ Avon	Ōpāwaho/ Heathcote	Huritīni/ Halswell
Baseline year	2012	2014	1991	2016
Monitoring location	Harbour Road Bridge	Gloucester Street	Ferniehurst Street	Minsons Drain confluence
Allowable increase in 50-year ARI water level (mm)	100	50	30	0

   b. Re-assessed every five years. This means that changes in catchment land use and development during the five-year interval will be incorporated into the model and the model re-run for the design events. The updated model results will be compared against the baseline model results for the catchment to assess performance against the conditions in Schedule 7 of the consent.

22. Alternative approaches are to be taken in the un-modelled catchments, where an emphasis will be placed on ensuring acceptable effects at the catchment scale by requiring adequate mitigation at the development site scale.

23. Having reviewed the proposed CSNDC conditions, I have concerns about the following issues:

   a. Number of performance monitoring locations;

   b. Use of a single design event;

   c. Allowable increase in water level and baseline year;

   d. Absence of design flood levels

   e. Re-assessment interval; and

   f. Performance measurement in non-modelled catchments

[2] ARI: Average Recurrence Interval. ARI is the inverse of AEP (Annual Exceedance Probability)

24. In the following paragraphs, I explain and address my concerns regarding each of these issues.

3.1 Monitoring locations

25. With performance only being measured at one location in each of the four modelled catchments, this will not reflect variations in effect across the catchment. Indeed, where the proposed target location is not at the outfall of the catchment, there is no mechanism by which CRC can control increases in downstream flood level, which could occur with unmitigated development downstream of the target location.

26. For example, the control location for the Avon catchment is Gloucester Street Bridge in the city centre. Approximately 75% of the Avon's stream network is downstream of this location (Figure 2) which means that the CSNDC will not control stormwater in the Avon catchment downstream of this point.

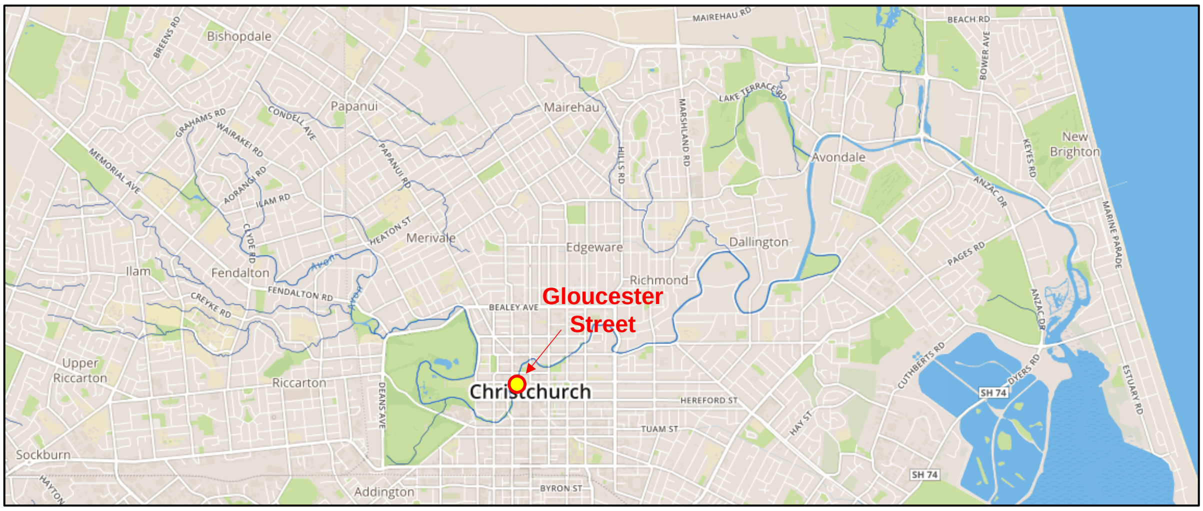

Figure 2 – Avon surface water network

27. To resolve this issue, I recommend that multiple performance monitoring locations are identified in each modelled catchment.

28. As performance will be measured by comparing modelled flood levels (which may be extracted for any node in the river or pipe network, or anywhere on the modelled 2D surface), there is no absolute requirement for the monitoring locations to be the same as river level or flow recording locations. However, it makes sense to use recorder locations, as they are points around which the models are likely to be calibrated and hence are likely to be at their most accurate.

29. In Table 2 and Figures 2 to 5, I suggest multiple performance monitoring locations within each catchment. These are only suggestions, and CCC may propose alternative sites. However, the aim is to provide a network of performance monitoring locations that safeguard the catchments, while providing robust results where the effects of land use change and development can be clearly disaggregated from changes due to other effects, such as climate change induced changes in sea level.

30. In the following paragraphs, I consider the performance monitoring locations in each of the four modelled catchments.

Table 2. Suggested assessment locations for modelled catchments

Modelled catchment			
Pūharakekenui/ Styx	**Otākaro/ Avon**	**Ōpāwaho/ Heathcote**	**Huritīni/ Halswell**
Harbour Road Bridge Radcliffe Road Main North Road	Gloucester Street New Brighton Road Fitzgerald Avenue Strowan Straven road Cranford Flockton Horseshoe Lake	Ferniehurst Street Woolston Buxton Terrace Curletts Road Penruddock Rise	Minsons Drain Sabys Road Ryans Road

3.1.1 Pūharakekenui/ Styx

31. CCC's proposed monitoring location for the Styx catchment is at Harbour Road Bridge, close to the downstream limit of the catchment. As such it would meet the requirement of being far enough downstream as to ensure that any potential development within the catchment is upstream of the performance monitoring location. However, being so close to the downstream limit means that water levels are affected by the operation of the tide gates and the ability to discharge water to the tideway. As such, peak water levels may be affected by changes in downstream boundary conditions.

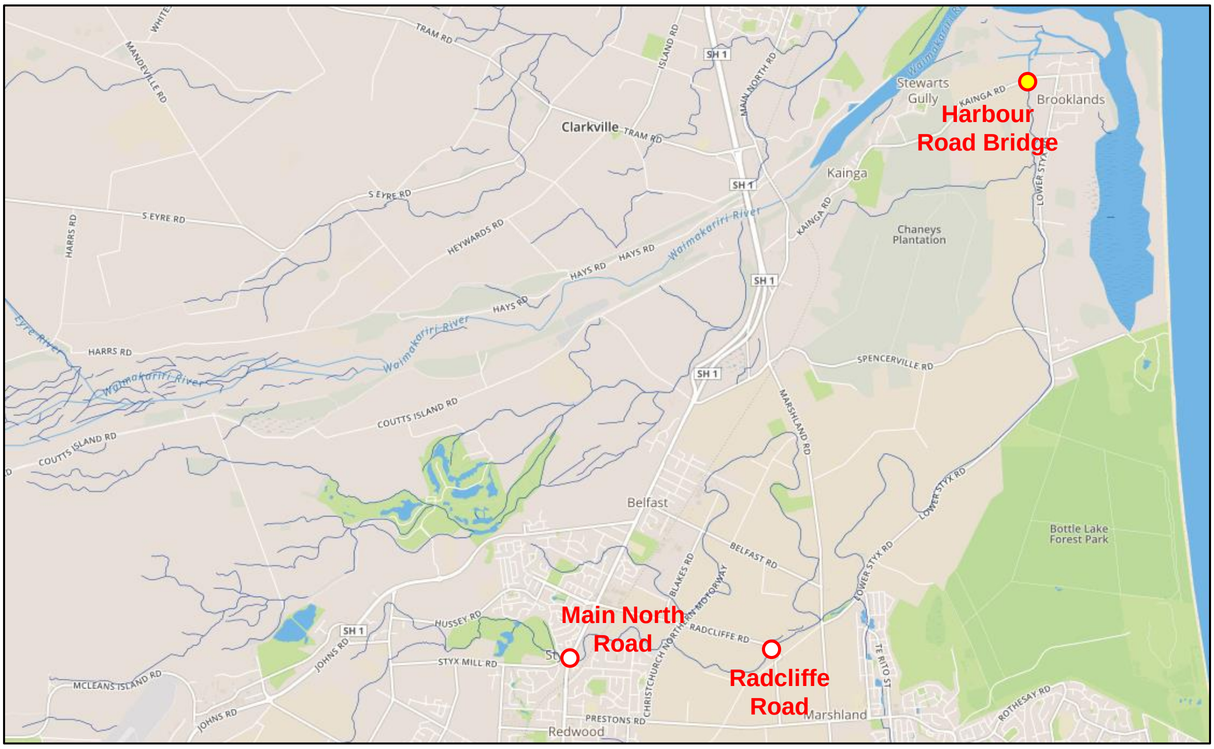

Figure 2. Pūharakekenui/ Styx - Suggested monitoring locations

32. I suggest that Harbour Road Bridge is retained as a performance monitoring location due to its downstream location and the sensitivity of the area to flooding, as evidenced by the comments of submitters.

33. However, I also propose additional locations further upstream in the catchment; at Radcliffe Road and Main North Road, as shown on Figure 3. These additional sites will allow the contributions from the upper catchment to be assessed, with a focus on peak flows that is not possible in the tide-locked or ponded lower part of the catchment.

3.1.2 Otākaro/ Avon

34. The additional performance monitoring locations that I suggest for the Avon catchment are based on the locations listed in Table 6-1 of the Avon SMP Blueprint for which peak flood levels are reported. The Avon SMP Blueprint only names the sites, and does not provide a locations map. Therefore, the locations that I have marked on Figure 1 may not be in exactly the correct place. However, the selected locations provide good coverage of the catchment and allow mitigation measures to be targeted to sub-catchments where development pressures are having a more pronounced effect.

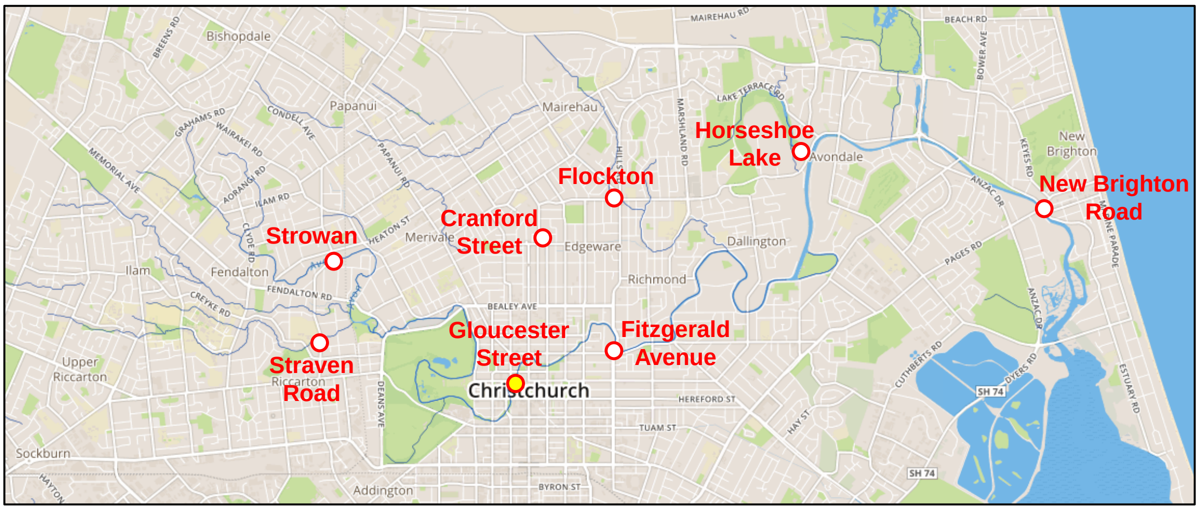

Figure 3. Otākaro/ Avon - Suggested monitoring locations

3.1.3 Ōpāwaho/ Heathcote

35. Only monitoring the Heathcote at Ferniehurst Street presents the same issues as with only monitoring the Avon at Gloucester Street, namely that a large part of the catchment is downstream of the monitoring location. Therefore, I suggest two additional monitoring locations downstream of Ferniehurst Street. While the location at Woolston may be tidally affected, the effects of tide and sea level rise can be neutralised in the models, such that differences in modelled water levels will only reflect   changes in the catchment.

36. The majority of development pressures in the Heathcote catchment are upstream of Ferniehurst Street; with particular note being made of:

   a. Sub-divisions along the Port Hills at Worsley and Westmoreland;

   b. Ongoing development at Wigram;

c. Development and stormwater management at Spreydon Lodge; and

d. Cross-catchment flows between the upper Halswell and Heathcote catchments.

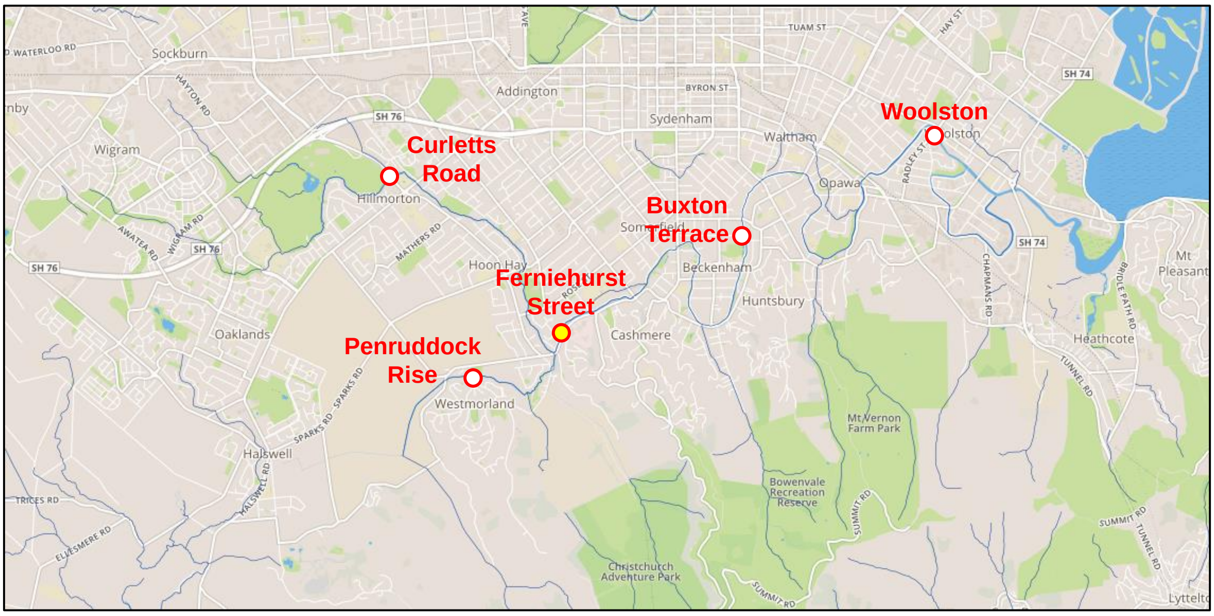

Figure 4. 3.1.3 Ōpāwaho/ Heathcote- Suggested monitoring locations

37. Therefore two monitoring locations are proposed upstream of Ferniehurst Street; Penruddock Rise on the Cashmere Stream and the Heathcote River at Curletts Road.

3.1.4 Huritīni/ Halswell

38. CCC's proposed monitoring location on the Halswell River at the Minsons Drain confluence is appropriate, as it is City boundary. Downstream, the river flows through Selwyn district to Lake Ellesmere / Te Waihora. However, I recommend that additional locations are added on Nottingham Stream and Knights Stream to provide better protection to individual sub-catchments.

39. The Halswell River is sensitive to flood volume, as well as peak water level or flow. This is not addressed by CCC's proposed performance monitoring at the Minsons Drain confluence. An additional approach would be to set a performance target based on the amount of time that water levels remain above a threshold that is based on the level at which the river spills further downstream.

40. CCC's proposed condition refers to the *"critical duration event"*, but does not indicate whether this is the critical duration for the upper part of the catchment within CCC's boundary, or the whole of the Halswell River catchment. The critical duration event for the whole catchment is estimated to be 60 hours, far longer than the critical duration for the other Christchurch catchments.

Figure 4. 3.1.4 Huritīni/ Halswell - Suggested monitoring locations

41. This is an issue that was raised in 2016 by CRC's Jolene Irvine and Matthew Surman in their internal memo[3] to Adele Dawson commenting on CCC's 2016 proposed conditions for the Halswell River, with a recommendation that the critical duration event is defined. Irvine and Surman go on to recommend further conditions, with reference to:

   a. Differentiating between land drainage and development stormwater flows;

   b. Reviewing the Halswell Stormwater Management Plan within two years;

   c. CRC's Regional Engineer and Drainage/River Liaison Committees being consulted;

   d. Providing full definition of *"full flood attenuation".*

42. I am in agreement with the sentiments and recommendations presented by Irvine and Surman, which confirm that the information provided by CCC does not provide CRC with confidence that the proposed consent conditions will safeguard the Halswell catchment from exacerbated flooding from within the CCC boundary.

3.1.5 Map-based performance monitoring

43. In addition to measuring performance at the target locations, it would be possible to review a catchment-wide map of flood level increases to assess performance. This would identify areas not represented by the target locations. Whether the difference map should (or could) be used for enforcement needs further thought, given modelling uncertainties that could result in anomalies.

[3] CRC160056 Stormwater discharges to the Halswell Drainage District, implications of the Christchurch City Council Comprehensive Stormwater Network Discharge Consent proposal. March 2016

3.2 Design events

44. CCC propose that performance is measured against one design event; the 50-year ARI or 2% AEP event.

45. Measuring performance against only one design event risks increases to flood depths, extents and hazard in other magnitude events occurring, but with CRC not having a means to trigger remedial action. Particularly, this would be an issue if there is an increase in flooding in frequent events, such as those up to the 10-year ARI event.

46. Requiring CCC to report performance against multiple flood events covering a wide range of ARI (from the mean annual flood to the 100-year ARI) would be onerous. However, I recommend that the targets are based on performance measured against two design events. These would be the:

    a. 5-year ARI (20% AEP) event to reflect performance in smaller, more frequent, events that are likely to represent recent experience.

    b. 50-year ARI (2% AEP) event reflecting design standards and performance in larger, less frequent events.

47. As an aside, I do note that in CCC's applications that design events are in some cases referred to as Annual Recurrence Interval (ARI), and at other times as Annual Exceedance Probability (AEP). Generally, AEP is used in the Assessment of Effects on the Environment. One form should be used throughout the application.

3.3 Allowable increases and baseline conditions

48. As noted in Table 1, performance is monitored as an allowable increase in 50-year ARI (2%AEP) flood level when compared to a baseline condition, with different values for each catchment. While I note that the allowable increases and reference years have been derived from the relevant catchment Stormwater Management Plans (SMP), the information provided in the SMPS do not clearly explain:

    a. Why different baseline years have been used for the four modelled catchments; and

    b. What the source is of the suggested allowable increases in flood level

3.3.1 Baseline year

49. CCC propose that performance in the Heathcote catchment will be measured against a baseline condition for 1991, while the baseline condition for the neighbouring Halswell catchment is 2016. The South West Area SMP explains that 1991 was chosen as the reference year for the Heathcote due to the significant amount of development that has taken place since then. A similar approach would seem appropriate for the Halswell catchment given the extensive post-quake developments at Longhurst and Knights Stream Park. Applying a 2016 reference for the Halswell baseline condition precludes the effect of the new developments being assessed and managed.

50. Such variance presents an issue of credibility to the community.

51. I am also unclear as to how the difference in baseline condition will be represented when considering flows between catchments and with the future adoption of the city-wide stormwater model.

52. Noting that there are cross-catchment flows between upper Halswell and upper Heathcote catchments, between the Heathcote and Avon, and between the Avon and Styx, will a common baseline be required?

3.3.2 Allowable increase in flood level

53. CCC propose an allowable increase of 50 mm in the River Avon's 50-year ARI flood level at Gloucester Street, with allowable increases ranging from 0 mm to 100 mm in the other catchments.

54. Though some allowable increases are reported in SMPs, I am unclear as to how the allowable increases have been determined. For example, Table 6.1 of the Avon SMP Blueprint states that flood levels would rise 140 mm at Gloucester Street if unmitigated, but reduce by 40 mm if 'Scenario F' (Rain Gardens scenario) were implemented. Does CCC's proposed allowable increase of 50 mm indicate that they are planning for partial mitigation of effects rather than full mitigation?

55. I would have expected the application or AEE to include a summary of the proposed allowable increases and reference years for the baseline condition, and a brief technical explanation (not just a reference back to the relevant SMP) as to why they are appropriate. Therefore, further explanation is required from CCC for the Avon and other modelled catchments.

56. If additional performance monitoring locations are required (Section 3.1) and performance is measured against the 5-year ARI and 50-year ARI flood events (Section 3.1.5), then allowable increase in design flood level will be required for the new locations and both design events.

3.4 Design flood levels

57. Schedule 7 lists the proposed allowable increases in design flood level, but does not provide the reference design flood level that will be used to test future performance. This should be provided by CCC.

58. I accept that the modelled design flood level may change as a result of refinements and enhancements in flood modelling, and so it would be appropriate to provide a mechanisms within the consent conditions to allow the figures in Schedule 7 to be updated. The ability to amend Schedule 7 would also allow design flood levels and targets to be applied to catchments that are currently not modelled.

3.5 Re-assessment interval

59. CCC propose (Section 4.3, Environmental Monitoring Programme. July 2018) to assess stormwater performance every five years in the Pūharakekenui/ Styx, Ōtākaro/ Avon, Ōpāwaho/ Heathcote River and Huritīni/ Halswell Rivers by updating the catchment land use and development, re-running the models and comparing the resulting maximum water levels at the performance monitoring locations against those for the baseline conditions (Schedule 7). Reporting the results every five years means that performance will be reported five times during the 25 year lifetime of the consent.

60. It is likely that CCC will update, re-calibrate and re-run the stormwater model in the aftermath of a significant flood event in the city.

61. Therefore, I recommend that CCC should also report stormwater performance after such a model re-calibration. This raises two questions:

    a. What size of event should trigger reporting of stormwater performance?

    b. Does the five-year interval 'clock' get reset if reporting is triggered by a significant event?

62. There is a 93% chance of a 10-year ARI event occurring in the 25-year lifespan of the consent, and a 72 % chance of a 20-year ARI event occurring over the same period. It is suggested that one of these events is used to trigger additional performance reporting.

63. If the 5-year interval clock is reset after reporting for a significant flood event, then it is likely that stormwater performance reporting will occur on one additional occasion. Not resetting the clock, is likely to result in two additional reporting occasions.

64. Tables 3a and 3b indicate the number of reporting occasions required based in performance reporting intervals of 5 or 10 years, and trigger ARIs for significant floods of 5 to 50 years.

Table 3a. Number of reports in 25 years – 'Clock' reset after significant flood reporting

Performance reporting interval	Trigger event recurrence interval			
	5 years	10 years	20 years	50 years
5 years	7-8	6-7	**5-6**	5
10 years	5-6	4-5	3-4	2-3

Table 3b. Number of reports in 25 years – 'Clock' <u>not</u> reset after significant flood reporting

Performance reporting interval	Trigger event recurrence interval			
	5 years	10 years	20 years	50 years
5 years	9-10	7-8	6-7	5-6
10 years	7-8	4-5	3-4	2-3

65. I suggest that:

    a. 5-year performance recording interval is retained;

    b. 20-year ARI flood event triggers additional reporting, though it must be clarified whether the event must cover the whole council area and/or over what duration; and

    c. The interval clock is reset after a significant event, so as to avoid re-reporting only a year or two after an event-triggered report.

66. The recommended scenario is highlighted in Table 3a.

67. It should be confirmed whether the individual catchment stormwater models or CCC's citywide stormwater model are complete and fit-for-use, or will be when the first round of reporting is required.

4 Non-modelled catchments

68. The approach taken to ensuring no unacceptable stormwater-induced increase in flood risk in the unmodelled Otukaikino, and Banks Peninsula catchments is different from than in the modelled catchments.

4.1 Otukaikino catchment

69. The Otukaikino catchment lies to the northwest of the city, between Belfast and the Waimakariri River (Figure 6). Flooding occurs due to backwater effects in the Waimakariri River. CCC doesn't record water level in the Otukaikino River, and the catchment is not modelled.

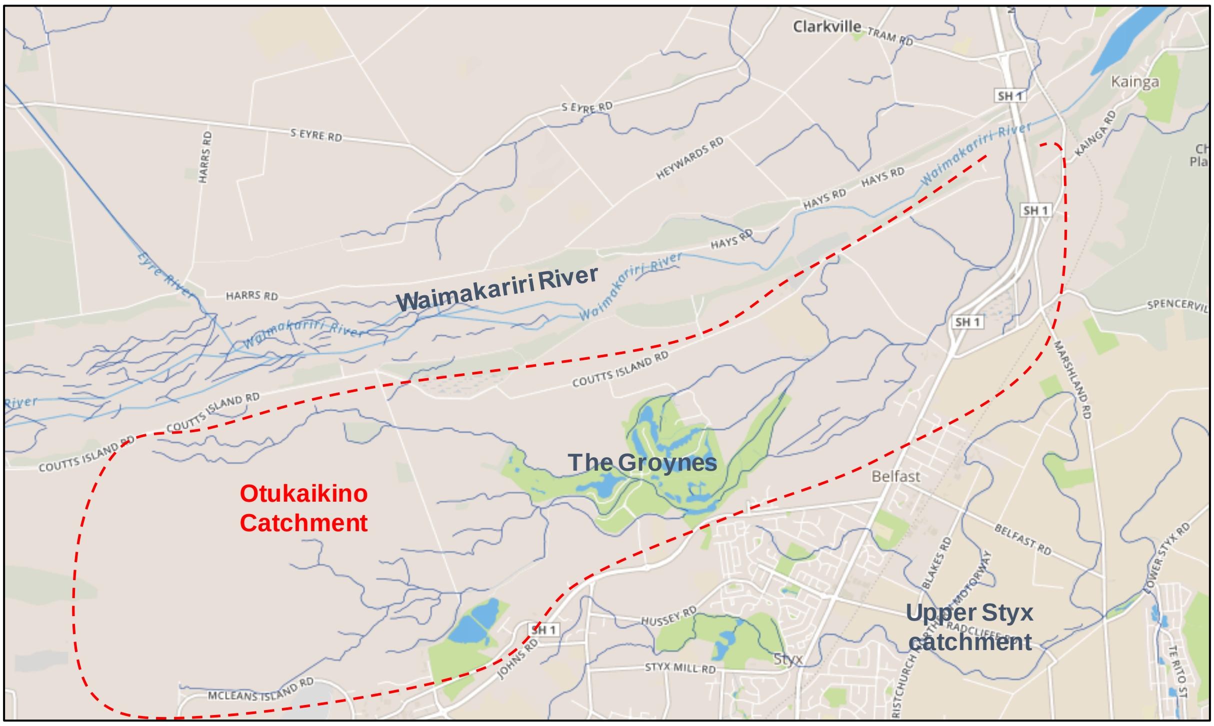

Figure 6. Otukaikino Catchment map

70. CCC propose that "a best practice approach to mitigation of development will be implemented (, with) discharges from all new greenfield development into the Christchurch City Council network …mitigated using the 'Partial Detention' strategy"[4].

[4] From CSNDC proposed conditions Schedule 7, July 2018.

71. Partial detention is defined in CCC's proposed conditions of July 2018 as *"… storage within first flush basins plus additional storage though flooding of wetland areas to an average depth of 500 mm discharging over a minimum of 96 hours for the critical 2 percent annual exceedance probability design storm event."*

72. Whereas it is possible to take a catchment-wide approach to measuring stormwater performance in the modelled catchments, the approach proposed in the Otukaikino catchment relies on managing flood risk at the development scale, with the expectation that this will provide the required performance at the catchment scale.

73. I have not reviewed any evidence of whether the partial detention approach delivers the desired catchment-wide performance with regard to managing flood risk within acceptable limits. In the absence of catchment-wide modelling, managing runoff peaks and volume at the development scale is a pragmatic approach in the current situation.

74. The proposed lifespan of the CSNDC consent is 25 years. Is it anticipated that a stormwater model of the Otukaikino catchment will not be developed over that time, or that the catchment will not be incorporated within the city-wide stormwater model? Given advances in modelling capability and efficiency, I would expect that the catchment could be modelled effectively within that time period. In which case, should the proposed conditions reflect future opportunity to measure stormwater performance in a comparable manner to that proposed for the four modelled catchments?

4.2 Te Pātaka o Pākaihautū/ Banks Peninsula

75. Catchments draining Banks Peninsula and those draining the Port Hills to Lyttelton Harbour tend to be relatively small and steep, and are not included in any existing stormwater models. Most of the catchments are predominantly rural.

76. CCC propose that *"Discharges from all new greenfield development within settlement areas of Te Pātaka o Pākaihautū/ Banks Peninsula into the Christchurch City Council Network are mitigated using the 'Extra-Over Detention' strategy"*[5].

77. Extra-Over Detention is defined in CCC's proposed conditions of July 2018 as *"… attenuation sufficient stormwater to control peak flow rates from a developed site back to pre-development flow rates for storms up to and including the critical 2 percent annual exceedance probability design storm event."*

78. As with the approach adopted in the Otukaikino catchment, the Extra-Over Detention approach adopted for the Banks Peninsula catchments relies on managing runoff at the development scale to deliver the desired catchment-wide performance. The approach concentrates on peak flow, rather than flood volume, and that is likely to be appropriate for these catchments given the steeper terrain and limited storage.

[5] CSNDC proposed conditions Schedule 7, July 2018.

79. Managing peak flows will help control stream erosion, but the length of time that flows are above 'normal' can also affect the amount of erosion. Attenuating peak flows to pre-development rates, but keeping them at that rate for extended periods may exacerbate erosion risk, particularly with loess soils. This risk would need to be managed at the development consent scale.

80. Should any of the Bank Peninsula catchments be modelled during the proposed 25-year lifespan of the CSNDC consent, then the consent conditions should require that similar conditions to those for the existing modelled catchments should be agreed and adopted

5 Revised Schedule 7

81. In Appendix B, I propose a revised template for Schedule 7 that includes:

    a. Suggested additional assessment locations for each catchment;

    b. Reference design flood levels; and

    c. Both the 20% AEP and 2% AEP design events

6 Erosion and Sediment Control

82. Paragraph 20 of CCC's proposed conditions states that *"The consent holder shall use reasonable endeavours to mitigate the effects of the discharge of stormwater on surface water quality, instream sediment quality, aquatic ecology health and mana whenua values..."*.

83. The means to document this is covered in paragraph 39 of the conditions that states "*An Erosion and Sediment Control Plan (ESCP) shall be prepared and implemented for the construction phase stormwater discharge from any development area in general accordance with Canterbury Regional Council's Erosion and Sediment Control Guidelines for the Canterbury Region, 2007 (Report R06/23 or successor document)."*

84. This firmly places erosion and sediment control as the responsibility of the site developer. However, Schedule 3 of the proposed conditions provides catchment-wide conditions for managing streambed sediment. I am not qualified to comment on whether the proposed targets are environmentally or ecologically appropriate.

85. Management of erosion risk is not covered by any catchment-wide targets. However, this is less critical, as the biggest erosion risk is likely to be in the vicinity of individual stormwater outfalls that will be consented. If the water quantity conditions (revised in accordance with the recommendations of this report) are met, then there should be no significant in increase in erosion resulting from the cumulative effects of changes in the catchment.

7 Issues raised by submitters

86. I am aware of 39 submissions to the 2018 CSNDC application. I have reviewed these and provide the following comments by subject, rather by responding to each submission individually. The issues are highlighted in the text using bold italics. Where a specific submitter or submission is referred to, the submission is noted in the text or as a footnote.

7.1 Design flood event

87. Submitters with interests in the Huritīni/Halswell[6] and Pūharakekenui/ Styx[7] expressed concerns that the rivers and associated drainage networks were at ***capacity during flood events significantly smaller than the reference 50-year ARI (2% AEP) flood*** that the CRNDC proposes to use to monitor water quantity performance. This is an issue that I raised in paragraph 3.2, with the recommendation that performance in the 5-year ARI (20% AEP) flood should also be reported.

7.2 Duration of the consent

88. Multiple submitters considered the duration of the duration of the proposed consent. Submission SUB031463[6] suggested that the initially proposed ***35-year lifespan of the CSNDC was too long***.

89. The proposal (with a revised 25-year lifespan) to set long-term targets for acceptable flood level changes and reporting the effects at least every five years balances the desire for long-term certainty for developers that will last at least the duration of the consent, and the need to monitor and adapt to changes over the shorter timeframes. Three submissions[8] welcomed the reduction to 25 years or thought that the ***25-year term was appropriate***.

90. I have raised in paragraphs 74 and 80 the need to include a mechanism in the consent conditions to include performance monitoring locations in catchments that are currently not modelled, if models are developed within the 25-year consent lifespan.

7.3 Pūharakekenui/ Styx

91. The lower part of the Styx catchment is flood prone, with submitters expressing concern over the effects of:

    a. Cumulative effects of ***additional runoff from development*** in the upper catchment[9]

    b. ***Sea level rise*** and increased closure of the tidal gates preventing egress of floodwater

    c. ***Diversion of water from Cranford and Flockton*** into the Styx catchment[10]

    d. ***Land levels and channel capacity*** around Brooklands and Spencerville following the Christchurch and Kaikoura earthquakes[11].

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[6] SUB031463 Halswell Drainage District Liaison Committee

[7] SUB031467 Barry Robertson

[8] SUB031470 Opawaho Heathcote River Network, SUB031479 Adrianna Hess, and SUB031484 Ravensdown Ltd

[9] SUB031487 Mr and Mrs McGuigan, and SUB031492 Gary Sharlick and Jan Burney, and SUB031497 S McLaughlin

[10] SUB031467 Barry Robertson, and SUB031475 Kathryn Snook

[11] SUB031488 Jan Burney, SUB031492 Gary Sharlick and Jan Burney, and SUB031494 Antonio and Kerrie Rodrigues

e. Water from ***Brooklands Lagoon*** increasing flooding in the lower Styx following the earthquakes[12]

92. Submitters assert that these have resulted in an increased flooding in the lower reaches of the catchment[13] and a ***transfer of risk from upstream to downstream***[14] within the catchment. One submission[14] also identified a lack of flood mitigation targets and inadequate monitoring.

93. Earlier in this report, I proposed that additional performance monitoring locations should be included in the Styx (and other), and that performance should be measured against the more-frequent 5-year ARI event as well as the design 50-year ARI event. Monitoring in the mid- and upper-catchment will have catchment wide benefits. Given that the lower reaches of the Styx catchment are prone to flooding from ponded water, it would also be worth:

    a. Including limits on increases in flood volume as well as peak flow, and;

    b. Addressing whether the proposed 2012 baseline year is appropriate, given the perception that flood risk increased as a result of the 2010-2011 earthquake sequence.

94. These conditions should prevent flood risk being exacerbated in vulnerable parts of the Styx catchment.

7.4 Otākaro/ Avon

95. Two submitters[15] requested ***more reassurance regarding compliance enforcement mechanisms***, which is something that my proposed increase in the number of monitoring locations and flood events attempts to address. SUB031469[15] also referenced the **exceptional values within the Horseshoe Lake**, which is one of the new monitoring locations that I propose.

96. Christchurch Airport (SUB031459) raised the ***risk of bird strike*** if the CSNDC results in additional wetland areas within 3 km of the airport. The proposed consent conditions for the modelled catchments restrict the allowable increases in flood risk in large events. It is unlikely that these will result in measurable increases in flooded extent close to the airport, and any increase would be of limited duration; the time that it takes to drain down after a flood event. There may a greater risk of additional wetland areas in the ***Otukaikino*** catchment, where Partial Detention is the proposed approach for managing catchment-wide flood risk. Drawdown in these wetlands would be over 96 hours (see paragraph 71). Would the risk of bird strike be controlled during consent of individual developments?

[12] SUB031496 Penelope Hargreaves

[13] SUB031492 Gary Sharlick and Jan Burney, SUB031497 S McLaughlin, and SUB031496 Penelope Hargreaves

[14] SUB031474 Snook Family Trust

[15] SUB031469 Dick Ongley and SUB031471 Avon Okatao Network

97. SUB031471[16] proposed that ***flows should be referenced against the indigenous flows***, which I take to be the flow regime that would have occurred pre-European settlement. It would be difficult to model that scenario in a robust and defendable manner, given the lack of accurate information on river channel alignments and dimensions; inputs that are required for accurate flood modelling. I doubt whether suitable information would be available to calibrate such a model.

7.5 Ōpāwaho/ Heathcote

98. SUB031470[8] flags the ***risks and effects due to more than 200 new discharges*** on water quality and flooding in the catchment, and questions how such an increase can have a 'No More than Minor' environmental effects. The aim of my recommendation that additional performance reporting/monitoring sites are included in the catchment is to capture and address any cumulative effects.

99. SUB031483[17] raises concerns about ***sedimentation of Cashmere Stream***, a major tributary of the Heathcote River. As noted in Section 6, prevention of stream erosion and sediment control is the responsibility of the site developer, though Schedule 3 of the proposed conditions provides catchment-wide conditions for managing streambed sediment.

7.6 Huritīni/ Halswell

100. Concern was raised regarding the ***increase in baseflows in the Halswell River*** and ***the effect of stormwater on upper reaches of spring-fed streams***[6]. The increase in baseflows in Christchurch's rivers and streams can be positive in maintaining flows during periods of low flow, but can reduce the capacity of watercourses and storage areas to accommodate stormwater. By setting robust performance targets for key locations in the modelled catchments (including the Halswell), an encompassing approach is taken to managing flood risk within acceptable limits irrespective of whether the pressure on flooding is due to increase base flows or changes in runoff as a result of development.

101. Increasing peak flows or the duration of high flows on streams, and particularly the smaller channels in the upper reaches, can increase the risk of erosion and sediment. Generally, these would need to be controlled through site development conditions.

8 Conclusions

102. The key conclusions from the review of the draft CSNDC and other relevant information are:

    a. Setting allowable increases in flood water level in the modelled catchments is an appropriate approach, but:

        i. Additional performance monitoring locations are required.

        ii. Performance should be measured against the 5-year ARI (20% AEP) and 50-year ARI (2%AEP) design events

[16] SUB1031471 Avon Okataro Network

[17] SUB031483 Cashmere Stream Care Group

iii. More information is required as to how the allowable increases in water level are set for each catchment, and whether the baseline conditions are appropriate.

103. Controlling stormwater runoff from development sites is a pragmatic approach to managing catchment-wide flood risk in unmodelled catchments.

104. In the Otukaikino catchment, where flood volume is as important as managing peak flows, it has not been demonstrated that the Partial Detention approach to stormwater management will deliver the desired catchment-wide performance though the approach sounds feasible.

105. Adopting the Extra-Over Detention approach to managing peak flows from development on the Banks Peninsula is appropriate, though measures are required to ensure that additional time at high flows doesn’t increase the risk of erosion.

106. If stormwater models are developed for any of the catchments that are not currently modelled, then the consent conditions should be amended to incorporate performance monitoring locations and targets for those catchments.

Michael Charles Law

28 September 2018

Appendix A: CRC190445 Proposed Conditions - Schedule 7: Receiving Environment Attribute Target Levels for Water Quantity (received July 2018)

Receiving Environment	Attribute Target Level	Basis for Target	Notes
Otākaro/ Avon	Flood levels for the 2 percent annual exceedance probability critical duration event shall not increase more than 50 millimetres when compared to the March 2014 modelled 2 percent annual exceedance probability design flood level	As measured in the Otākaro/Avon at Gloucester Street Bridge using the CCC flood model	
Pūharakekenui/ Styx	Flood levels for the 2 percent annual exceedance probability critical duration event shall not increase more than 100 millimetres +20% tolerance when compared with the 2012 impervious surface 2 percent annual exceedance probability design flood level	As measured in the Pūharakekenui/ Styx River at Harbour Road Bridge using the CCC flood model	
Ōpāwaho/ Heathcote	Flood levels for the 2 percent annual exceedance probability critical duration event shall not increase more than 30 millimetres when compared to the 1991 impervious surface 2 percent annual exceedance probability design flood level	As measured in the Ōpāwaho/ Heathcote River at Ferniehurst Street using the CCC flood model	
Huritīni/ Halswell	Flood levels for the 2 percent annual exceedance probability critical duration event shall not increase when compared to the March 2016 modelled 2 percent annual exceedance probability design flood level.	As measured in the Huritīni/ Halswell River at the Minsons Drain confluence using the CCC flood model	The Minsons Drain confluence with the Huritīni/Halswell River represents the southerly extent of inputs from Christchurch City catchments, but also contains discharges from Selwyn District. Inputs from catchments outside of the city can be isolated in the CCC stormwater model for compliance assessment purposes.
Otukaikino	Discharges from all new greenfield development into the Christchurch City Council network are mitigated using the "Partial Detention" strategy outlined in the Pūharakekenui/ Styx SMP	As measured through the CCC discharge authorisation compliance process for Resource and Building Consents	CCC does not monitor or model flooding in the Otukaikino River. Flooding occurs primarily due to backwater effects in the Waimakariri River. Therefore, a best practice approach to mitigation of development will be implemented.

Appendix B: Revised template for Schedule 7: Receiving Environment Attribute Target Levels for Water Quantity

Attribute Target Level

Flood levels for the 20% AEP and 2% AEP critical duration event shall not increase more than the **Maximum Increase** listed below when compared to the modelled 20% AEP and 2% AEP **Design Flood Level** for **Baseline Year,** as determined using the CCC flood model

Receiving Environment	Design Flood Level		Maximum Increase		Baseline year
	20% AEP	2% AEP	20% AEP	2% AEP	
Otākaro/ Avon					
Gloucester Street New Brighton Road Fitzgerald Avenue Strowan Straven road Cranford Flockton Horseshoe Lake	*To be added*	*To be added*	*To be added*	50 mm ? ? ? ? ? ? ? ?	2014
Pūharakekenui/ Styx					
Harbour Road Bridge Radcliffe Road Main North Road	*To be added*	*To be added*	*To be added*	100 mm ? ?	2012
Ōpāwaho/ Heathcote					
Ferniehurst Street Woolston Buxton Terrace Curletts Road Penruddock Rise	*To be added*	*To be added*	*To be added*	30 mm ? ? ? ?	1991
Huritīni/ Halswell					
Minsons Drain* Sabys Road Ryans Road	*To be added*	*To be added*	*To be added*	0 mm ? ?	March 2016
* The Minsons Drain confluence with the Huritīni/Halswell River represents the southerly extent of inputs from Christchurch City catchments, but also contains discharges from Selwyn District. Inputs from catchments outside of the city can be isolated in the CCC stormwater model for compliance assessment purposes.					
Otukaikino					
CCC does not monitor or model flooding in the Otukaikino River. Flooding occurs primarily due to backwater effects in the Waimakariri River. Therefore, a best practice approach to mitigation of development will be implemented. Discharges from all new greenfield development into the Christchurch City Council network are mitigated using the "Partial Detention" strategy outlined in the Pūharakekenui/ Styx SMP, as measured through the CCC discharge authorisation compliance process for Resource and Building Consents					