BEFORE THE WAIMAKARIRI DISTRICT PLAN REVIEW HEARINGS PANEL

IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	the hearing of submissions and further submissions on the Proposed Waimakariri District Plan
AND	hearing of submissions and further submissions on Variations 1 and 2 to the Proposed Waimakariri District Plan
	Hearing Stream 12E: Rezoning Requests

FIRST STATEMENT OF EVIDENCE OF DR AMIR MONTAKHAB (FLOOD RISK ASSESSMENT – BLOCK A AND B) FOR RICHARD AND GEOFF SPARK (PDP SUBMITTER 183 / VARIATION 1 SUBMITTER 61)

Dated 4 March 2024

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Summary Statement

1. The subject site comprises multiple titles and is best broken down into two separate areas, these areas being:

   (a) Block A: North of Boys Road (approximately 25.7 ha),

   (b) Block B: South of Boys Road and west of a future Eastern Bypass Arterial Road (approximately 36.4 ha).

2. The Waimakariri District Council (WDC) has conducted computational flood hazard modelling for both the Rangiora urban area and the wider Waimakariri District, including the subject site in both models.

3. For the 200-year ARI storm event, the findings reveal minimal flood impact on Block A. Additionally, the Waimakariri District Council has employed computational flood modelling to assess an Ashley River breakout scenario, confirming no flooding impact on Block A.

4. However, for Block B, particularly the southernmost portion between Middlebrook Stream and Southbrook Stream, the 200-year ARI storm event shows significant flooding over the centre of the site due to the breakout of Middlebrook Stream. Furthermore, an evaluation involving an Ashley River breakout scenario confirmed flooding impacts on this southernmost portion of Block B.

5. The key flood mitigation requirements from the Waimakariri District Council include:

   (a) Mitigating all effects in a 50-year event.

   (b) For the 200-year ARI storm event and Ashley Breakout event, an increase in flooding on neighbouring properties is considered acceptable under the following conditions:

      (i) The flood level around any habitable dwelling should not be increased by more than 20mm.

      (ii) If there is an increase in the flood level around any habitable dwelling, it must be demonstrated that the freeboard (measured from the maximum flood level to the finished floor level) is more than 500mm.

6. The proposed development aims to implement a flood attenuation device, such as constructed wetlands or detention basins within Stormwater Management Areas (SMAs) on the downstream areas of the site. The aim of these devices would be to provide flood

attenuation up to a 50-year ARI storm event for the site itself, effectively returning flows to pre-development levels before discharge into Northbrook Stream, aligning with WDC requirements. A cut-off channel is proposed to collect floodwater from the contributing catchment on the western boundary and manage the overflow from Middlebrook (in Block B). Notably, this floodwater was a primary cause of flooding in Block B during the pre-development condition. The purpose of the proposed cut-off channel is to address this issue by effectively managing the flow in accordance with development conditions while minimizing any adverse impacts on both upstream and downstream catchments.

7. Fraser Thomas Limited (FTL) has conducted two-dimensional computational flood hazard modelling to assess the suitability of the proposed development in accordance with Waimakariri District Council requirements. The investigation aimed to assess the impact of post-development within the site and the neighbouring area by comparing the results with pre-development conditions. The following scenarios were considered:

   (a) Pre-development 200-year ARI.

   (b) Post-development 200-year ARI, including flood mitigation up to 50-year flood attenuation.

   (c) Ashley River Breakout storm event scenario.

   (d) Culvert Blockage Scenario (Gefkins Road Driveway)

   (e) Climate change factor with RCP 8.5 has been allowed for in our modelling work.

8. It was found that during a 200 year storm event:

   (a) The development area within Block A and B will not be subject to flooding in the post development scenario.

   (b) In the post-development scenario, the maximum flood depth behind the Marsh Road culvert is not impacted by the post development scenario.

   (c) The development at Block A and B has no adverse impact on the upstream catchment areas.

   (d) Flood modelling for the 200-year storm event indicates compliance with Waimakariri District Council requirements. Peak flood levels around habitable dwellings are not increased by more than 20mm.

   (e) It is anticipated that the proposed development will have no effect on the Council wastewater ponds south of Block B. The flood mitigation channel will ensure no additional flows are discharged to the contributing catchment of the wastewater ponds.

(f) The development will have no impact on the flood levels or flows within Middlebrook and Southbrook.

9. It was found that the primary cause of flooding in Block B originates from floodwater in the contributing upstream catchment from the western boundary, including overflow from the Railway and overtopping from the Middlebrook stream bank just upstream of the Gefkins Road Driveway culvert, where there is a spill point. The majority of floodwater comes from the overtopping of Middlebrook. In the post-development scenario, the proposed cut-off channel is proposed to manage these floodwaters safely with minimal adverse impact to upstream and downstream areas. However, it is crucial to note that this cut-off channel is a critical point in the model, and any changes to its design can impact the overall model. Despite the high-level design of the cut-off channel, it needs to be carefully designed to achieve minimal impact in detailed design stage.

10. It was found that the during the Ashley River breakout scenario:

(a) The development area within Block B will not be subject to flooding. The proposed flood mitigation channel will be able to divert flood waters around the development area.

(b) There will be less than minor increases to peak flood levels due to the proposed development at Block B.

11. Possible future development in the southern portion of block B is under consideration, based on a change in land use and potentially designating it as a separate block, Block C. The current flood modelling hasn't accounted for any development in the Block C area, If such development occurs, a comprehensive flood modelling effort will be essential to assess post-development conditions and devise effective mitigation strategies. This might include designing a significant conveyance channel to redirect floodwater from the upstream contributing catchment, thereby minimizing the impact of the development on flooding. However, this approach would also reduce the land area available for redevelopment. The dimensions and location of the channel must be carefully designed, taking into account on-site constructability, topography, and evaluating performance through flood modelling to confirm the optimal and efficient size and location. Special attention will be necessary to prevent any risk of flooding for the public wastewater pond, which could be affected by Southbrook Stream.

Introduction

12. My full name is Amir Montakhab, and I live in Auckland.

13. I am a senior Environmental Engineer with over 15 years of experience, having worked across various sectors including government, consultancy, and academia. My expertise spans three-waters engineering, covering aspects such as stormwater management, river engineering, flood hazard assessment, land development, and water supply.

14. My environmental engineering journey commenced outside of New Zealand, working with construction companies and universities. I have worked in New Zealand since 2012, holding positions of Water Engineer. Positions I've held include Water Engineer at OPUS Consultant Engineering (now WSP), Senior Environmental Engineer at Morphum Environmental Consultants, Principal Engineer at Auckland Council, and Environmental Engineering Technical Lead at CKL Consultants. Currently, I hold the position of Environmental Engineering Lead at Fraser Thomas Consultants.

15. Fraser Thomas Limited (FTL) is a company of professionally qualified structural, geotechnical, civil and environmental engineers, environmental scientists and land surveyors. FTL is a multi-disciplinary consulting firm that has been in operation for over 50 years, with wide ranging experience and expertise in the resource management, engineering, surveying and contaminated land industry.

16. My academic background comprises a Bachelor's degree in Civil Engineering, a Master's in Water Engineering, and a Ph.D. in Water Resource Engineering. I am also a Chartered Professional Engineer and Chartered Member of Engineering New Zealand, I also serve as an assessor for Engineering New Zealand.

17. Over the years, I have developed specialised skills and gained considerable experience in land development, stormwater management and three-waters infrastructure. This includes both greenfield and brownfield developments, covering projects of varying scales. My areas of expertise include hydrology/stormwater projects, encompassing catchment management planning, stormwater design and modelling, assessment of environmental effects, peer reviews, and associated reporting.

18. I am recognised as a Stormwater Subject Matter Expert and actively contribute to the field. Serving as a panel member on the Water New Zealand Stormwater Committee, I have been the main and co-author of several Auckland Council technical guideline documents, primarily in the stormwater field, including:

(a) The Auckland Code of Practice for Land Development and Subdivision - Chapter 4: Stormwater, Version 3.

(b) Auckland Council Guideline Document 2021/007 (GD07) Version 1 Stormwater Soakage and Groundwater Recharge in the Auckland Region.

19. As Environmental Engineering Lead at FTL I have been closely involved in the preparation of the Fraser Thomas Flood Assessment Report dated 22 February 2024 which is attached as **Annexure A** to this evidence.

Code of Conduct

20. I have read the Code of Conduct for Expert Witnesses (contained in the Environment Court Practice Note 2023) and I agree to comply with it. Except where I state that I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

Scope of Evidence

21. My evidence will address the following matters:

(a) Flood hazard assessment for Block A and B.

22. In preparing my evidence I referred to and considered the following:

(a) Aerial imagery, DHI flood modelling maps, input data, output hydrographs, and the 2020 DHI flood modelling report "Flood Hazard Models Update - District and Urban and MIKE FLOOD models" for Waimakariri District Council. The site has also been surveyed by FTL, including several cross sections of Northbrook, Middlebrook, and Southbrook.

23. I have looked over site photographs, and looked at relevant roads on Google Streetview.

Site Location and Surrounds

24. The subject site comprises multiple titles and is best broken down into two separate areas as shown on Figure 1. These areas being:

(a) Block A: North of Boys Road (approximately 25.7 ha),

(b) Block B: South of Boys Road and west of a future Eastern Bypass Arterial Road (approximately 36.4 ha).

25. This evidence document has been prepared for Block A and B.

26. Block A is located north of Boys Road, adjacent to Northbrook Stream and two stormwater ponds from other recent subdivisions to the north and west of the site.

27. Block B is situated to the south of Block A, positioned between Boys Road and Marsh Road. See Figure 1 for the existing site layout.

28. The southernmost part of Block B, situated between Middlebrook Stream and Southbrook Stream, referred to as Block C, has not been included in the flood modelling done to date. However, it may be considered for future development and hence some qualitative comments on the likely effects of flooding on development of this block and vice-versa are covered later in my evidence.

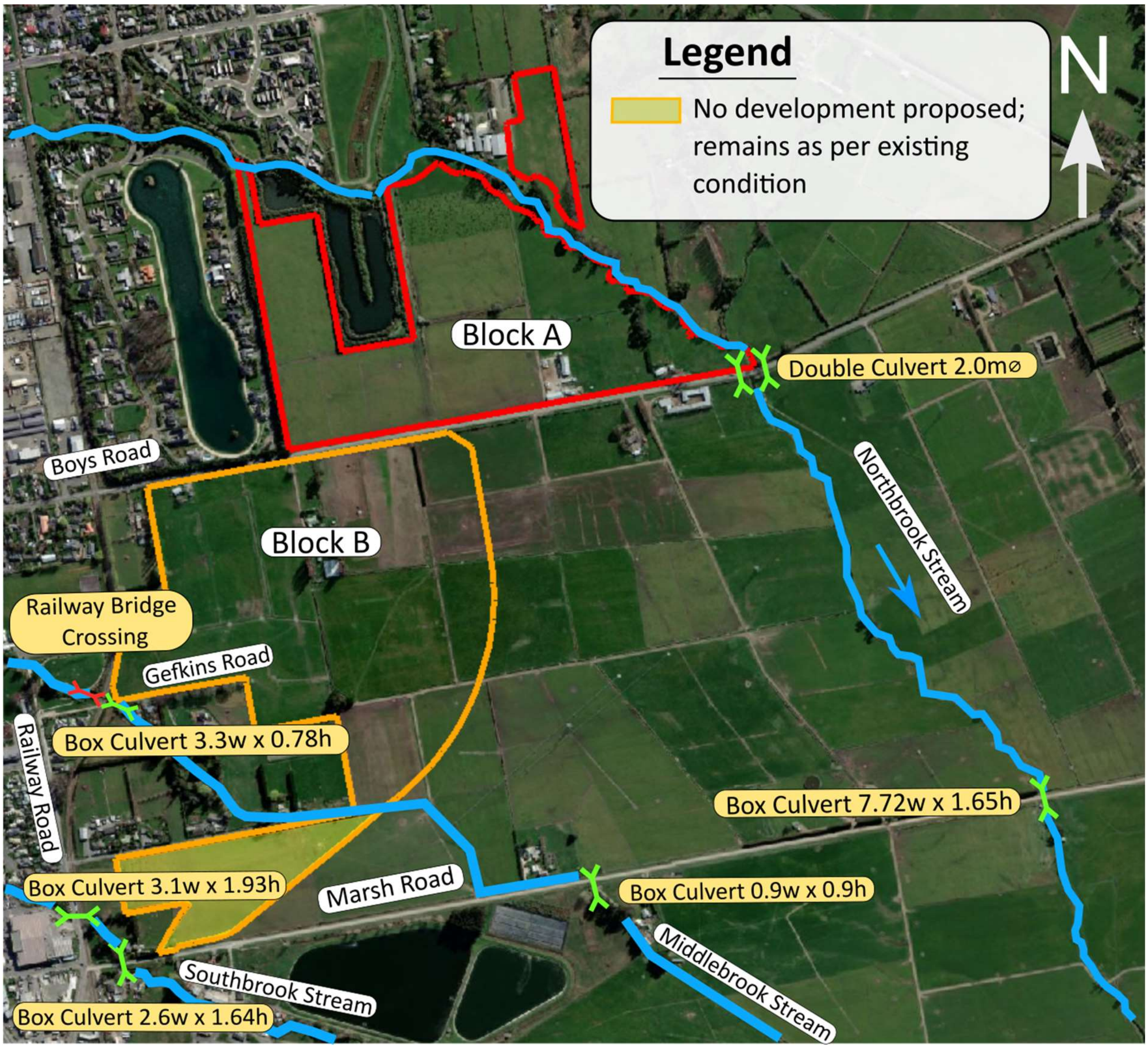

Figure 1: Block Delineation, with blue showing streams and green showing culverts

29. The site is a greenfield area primarily designated for farming purposes. Its existing drainage system comprises several farm drains positioned within the site, diverting surface water flow towards Northbrook Stream.

30. Northbrook stream follows the northern and eastern boundaries of the site, culminating in a discharge through a twin 2-meter diameter culvert under Boys Road. Its course continues until it reaches Marsh Road, where it flows through a 7.72m wide by 1.65m high box culvert.

31. The Middlebrook stream crosses from the western corner of Block B, as depicted in Figure 1, passing under the Railway Bridge and a box culvert beneath the Gefkins Road driveway (3.3m width x 0.78m height). Gefkins Road provides access from Railway Road to properties at 64, 62, 60, 17, and 21 Gefkins Road. The culvert on Middlebrook stream at Gefkins Road specifically serves properties at 17 and 21 Gefkins Road, continuing through 24, 10, and 2 Dunlops Road — it is noted that there might be private culverts within these properties that are currently unknown. After briefly re-entering the site, the stream crosses under 150 Marsh Road and exits through a 900mm square box culvert under Marsh Road.

32. Southbrook Stream flows through a 3.1m wide, 1.93m high box culvert under Railway Road. Continuing, it traverses under Marshes Road via a 2.6m wide, 1.64m high box culvert. Subsequently, the stream follows a path between the wastewater ponds, ultimately joining with Middlebrook.

33. Middlebrook Stream and Southbrook Stream converge before joining Northbrook. Northbrook, in turn, contributes to the formation of the Cam River, also recognised as Ruataniwha. The Cam River flows through western Kaiapoi, merging with the Kaiapoi River, and ultimately plays a part in the flow of the Waimakariri River, leading to its discharge into the coast.

Waimakariri District Council Flood Modelling Data

34. Between 2019 and 2020, the Waimakariri District Council (WDC) engaged DHI to conduct computational flood hazard modelling. The scope of the modelling encompassed district-wide flood hazard modelling, a local urban flood model for the Rangiora township, and a river breakout model for the South Ashley River.

35. DHI have stated that: "*The results of these models will be used in preparing the upcoming district plan changes by identifying flood hazard risk and flood extents for low probability flood events, 1%, 0.5% and 0.2% AEP design rainfall events of a 24hr duration. The*

models also account for climate change using the HIRDS v4 RCP 8.5 rainfall. The current modelling has been peer reviewed and accepted by WSP."

36. WDC has provided three flood model results for the 200-year ARI storm event, adjusted for climate change (RCP 8.5):

    (a) The local urban model, known as the local model, uses a 1D/2D approach with MIKE DHI. It focuses on the Rangiora urban area, and flood maps are shown below the site (See Figure 2).

    (b) The district-wide flood model, known as the district model, utilises the wider catchment size for modelling. The flood results can be found in Figure 3.

    (c) The Ashley River Breakout model is referred to as the Ashley Breakout model. The flood results are shown in Figure 4.

37. **For Block A**: the results from all three WDC models consistently indicate minimal to no flooding impact on Block A. However, a discrepancy arises between the district model and local urban model, with the former suggesting a more severe situation compared to the local urban model. This discrepancy is partly attributed to floodwaters backing up behind Boys Road from the stream flowing under Boys Road to the east (adjacent to Camside Road). Nevertheless, flooding within the site remains minor in both scenarios. In the district model's worst-case scenario, there is a bit more overland flow generated by rainfall on the site itself. The site is not at risk of flooding from areas upstream. Additionally, the Ashley Breakout model indicates no impact of flooding for Block A.

38. **For Block B:** the results from the District model indicate worsening conditions compared to the Local model, despite similar flood behaviour. Stream-specific outcomes are as follows:

    (a) Northbrook:

        (i) Northbrook overtopping minimally impacts Block B, although all flow through the site eventually discharges into Northbrook.

    (b) Middlebrook:

        (i) The modelling results show floodwaters from the breakout of Middlebrook stream entering the site, flowing from west to east across the railway crossing. Modelling indicates that Middlebrook begins overtopping before reaching the culvert under Gefkins Road, following the natural overland flow path within Block B and ultimately discharging into Northbrook at a spill level of approximately 17.9mRL.

(ii) The District model depicts exacerbated flooding from Middlebrook across the site.

(iii) It is unclear if the council model includes the culvert under Gefkins Road, contributing to overtopping flow toward Block B, especially in the culvert blockage scenario.

(c) Southbrook:

(i) Ponding occurs at the corner of Railway Road and Marsh Road. Overtopping flow from the Southbrook bank continues along the natural overland flow path adjacent to Marsh Road, crossing the very southern portion of Block B (currently not proposed for development and remaining in its existing condition). The flow ultimately discharges into the 900mm square box culvert under Marsh Road.

39. The results of the District and Local models show that surface water enters the site as sheet flows from the western boundary, from the Railway side. However, a notable portion of floodwater accumulates in ponding areas behind the railway on the urban side due to the elevated railway bank.

40. The Ashley breakout model results show significant flooding only in the lowest section of Block B, which is currently not proposed for any development and will remain as per existing conditions. This model scenario does not impact the rest of Block B.

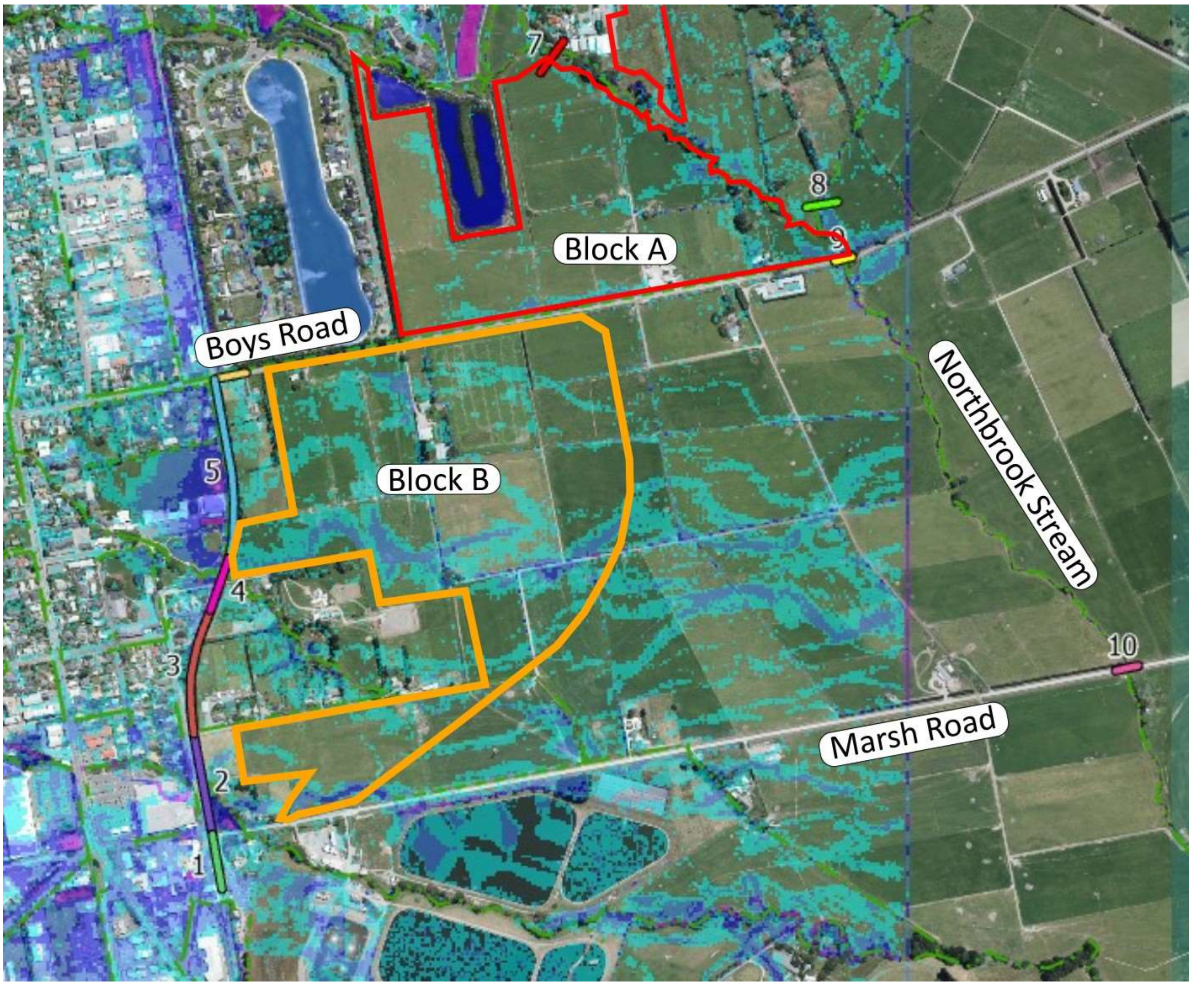

Figure 2: Local Urban Model Results (Local Model), 200 year ARI storm event + CC (Flood Maps provided by Waimakariri District Council 22/06/2023)

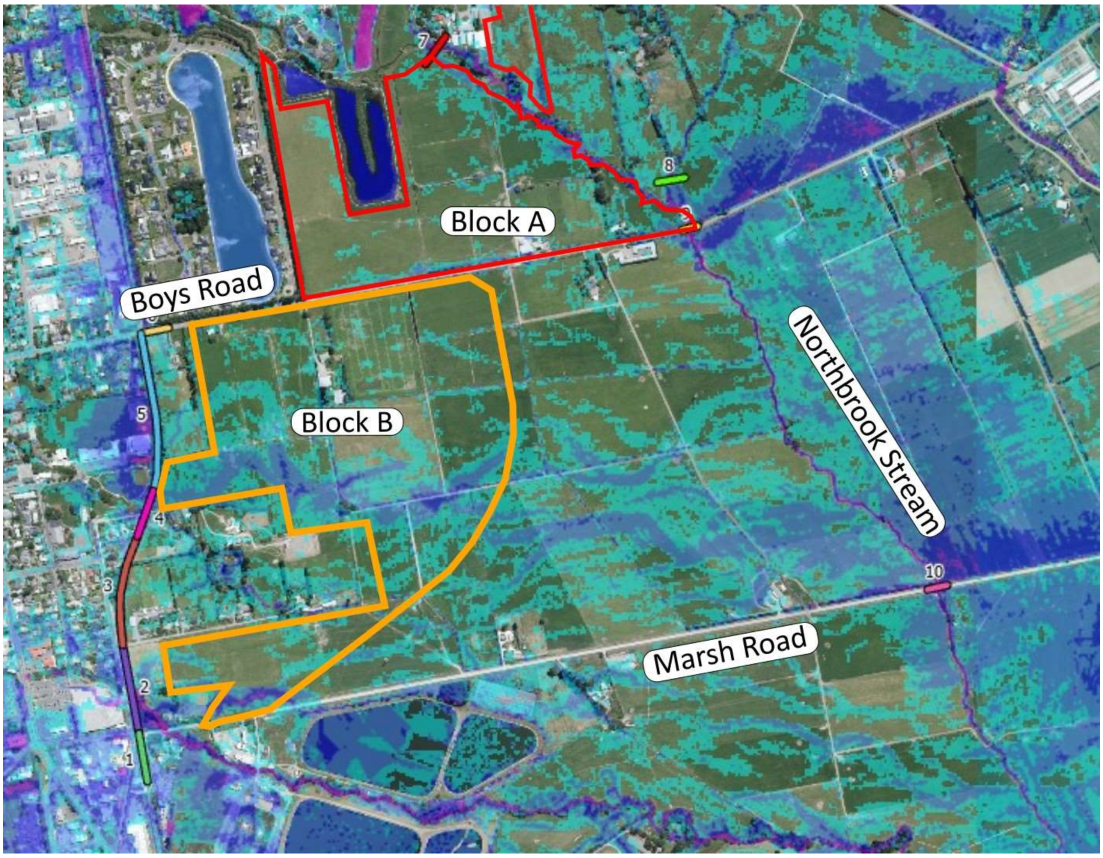

Figure 3: District Wide Flood Model Results (District Model), 200 year ARI storm event + CC (Flood Maps provided by Waimakariri District Council 22/06/2023) – Block B shown in orange

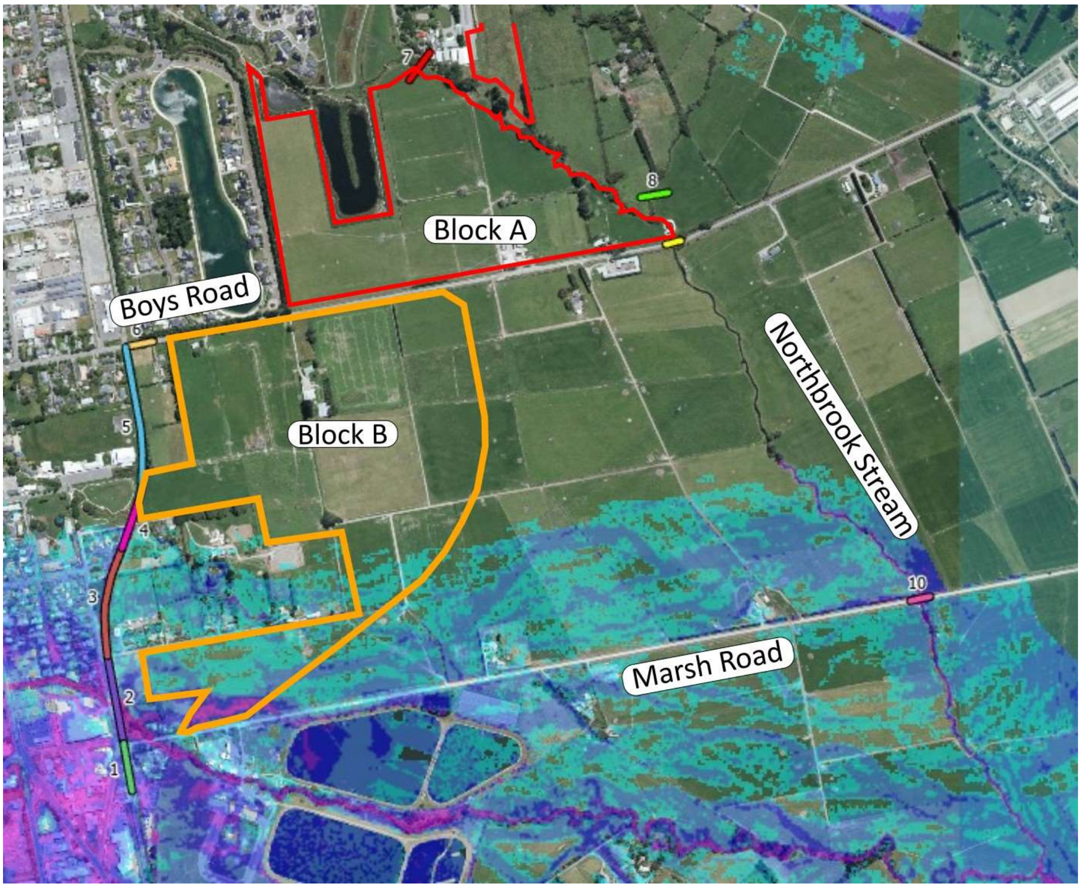

Figure 4: Ashley Breakout Model Results, 200 year ARI storm event + CC (Flood Maps provided by Waimakariri District Council 22/06/2023) – Block B shown in orange

Waimakariri District Council Requirements

41. During the pre-application meeting held on 3 February 2023, it was stated that flood modelling of the 50 year ARI storm event was not required at this stage, as this involves more detail within the site itself and can wait until the resource consent stage. Instead, Council required the 200 year ARI storm event to be modelled and for the results to show that there are less than minor effects on properties both upstream and downstream of the site.

42. In my email communication with Chris Bacon, Network Planning Team Leader at WDC, on 21 November 2023, advice was provided regarding the following item:

> *"Hi Amir*
>
> *The Council's requirement is to mitigate all effects in a 50 year event. That is normally achieved by simply attenuating flows back to pre-development levels. However, if you are demonstrating an increase in flooding in a 50 year event despite attenuating flows then you will need to do some additional work to mitigate those effects.*
>
> *For the 200 year event it is acceptable to have an increase in flooding on neighbouring properties provided that*
>
> *a. The flood level around any habitable dwelling is not increased by more than 20mm or*
>
> *b. If you are increasing the flood level to any habitable dwelling then you need to demonstrate that the freeboard (measured from the maximum flood level to the finished floor level) is more than 500mm.*
>
> *To reflect the inherent uncertainties with this sort of work we normally apply an allowance of up to 20mm for an acceptable increase in flood depth. So provided you are showing an increase of less than 20mm then we would consider this to be a less than minor effect under the RMA."*

43. In subsequent correspondence with Chris Bacon (email of 13/2/24), he has advised:

> *"there are no special requirements surrounding the Ashley Breakout. For all intents and purposes we treat the two events the same and depending on the site one or the other will govern."*

Proposed Development

44. It is proposed to implement a flood mitigation device, such as constructed wetlands or detention basins within Stormwater Management Areas (SMAs) on the downstream areas of the site. The aim of these devices would be to provide flood attenuation up to a 50-year ARI storm event for the site itself, effectively returning flows to pre-development levels before discharge into Northbrook Stream, aligning with WDC requirements.. In the

event of excess flow, a bypass mechanism will be activated, directing the excess flow into Northbrook Stream.

45. The proposed discharge point for Block A to the Northbrook stream will be almost directly to the culvert under Boys Road, rather than sheet flow from the site itself. This is considered to be a less than minor change.

46. As discussed in items 36 and 37, the modelling outcomes for Block B indicate that surface water predominantly enters the site from the western boundary as sheet flow, along with a breakout point from Middlebrook stream toward Block B. In response to these flows, the stormwater management plan introduces an open cut-off channel as shown below. This channel originates at the western boundary, extends along the southern boundary of Block B, and ultimately exits from the eastern boundary, discharging into the existing farm drain and, subsequently, into Northbrook. In alignment with existing conditions, the plan offers a safe and manageable solution within the site to guide flow during extreme flood events. Importantly, the cut-off channel size increases significantly from the point of receiving overtopping flow from Middlebrook, identified as the primary contributor to flooding within Block B (Figure 5).

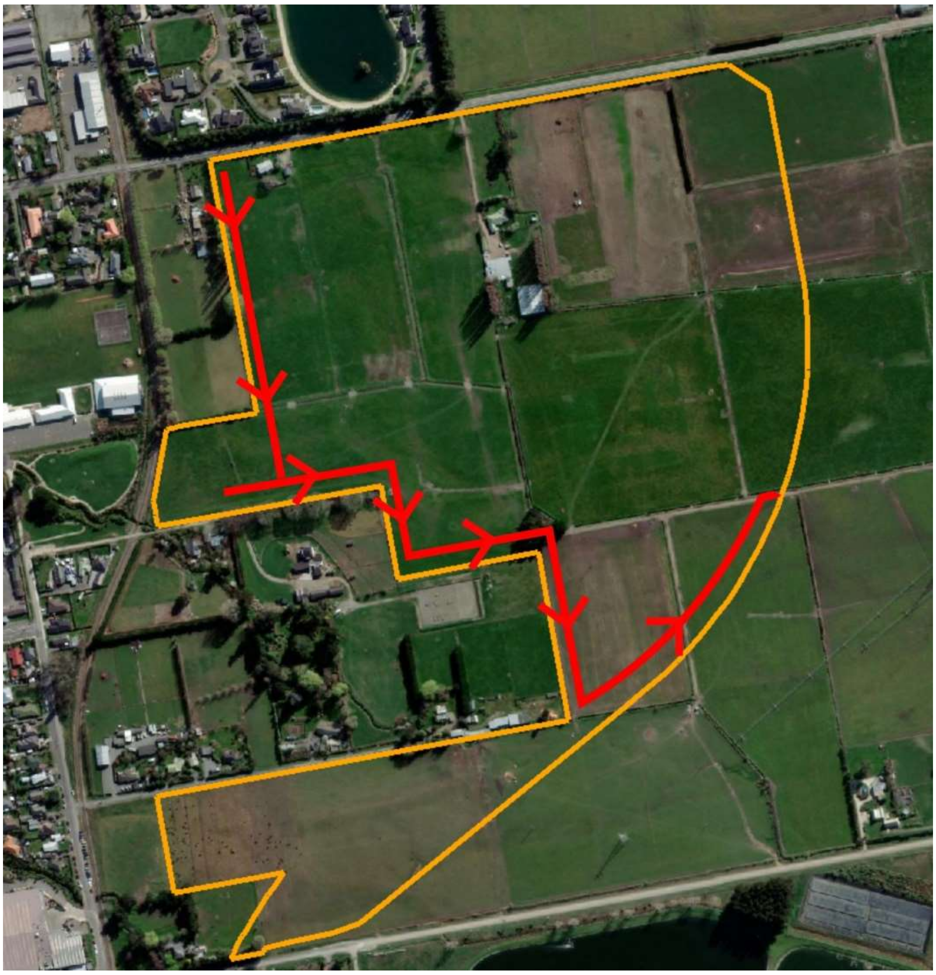

Figure 5: Approximate location of proposed cut off Channel- Block B

47. The primary stormwater system for the proposed development utilises a piped network to collect surface water, diverting it to a constructed wetland.

48. The secondary stormwater system for the proposed development manages surface water through overland flow paths (OLFPs), primarily utilising proposed roads. The OLFP safely diverts surface water to a constructed wetland and cut-off open channel, ultimately discharging it into Northbrook Stream.

49. It is proposed to raise ground levels within the site, particularly adjacent to Northbrook Stream, to provide a minimum 500mm freeboard above the flood levels in the stream. This will essentially prevent any overland flow breaching the stream from entering the site.

50. The stormwater management plan outlines the construction of an open channel within Block B, serving to redirect the upstream catchment flow and acting as a component of the post-development secondary stormwater system. This channel, originating from Block B, discharges into the natural farm drain, eventually connecting to Northbrook stream. It's important to note that, for constructability reasons, the exit point of the channel from Block B to the farm drain might require adjustment, potentially extending to neighbouring properties for reconnection with the natural farm drain. The design is believed not to adversely impact the current modelling results, yet any potential effects will be thoroughly investigated during the detailed design phase, with mitigating measures implemented if necessary.

Fraser Thomas Limited (FTL) Flood Modelling

51. Fraser Thomas Limited (FTL) has conducted two-dimensional computational flood hazard modelling to assess the suitability of the proposed development in accordance with Waimakariri District Council requirements. The investigation aimed to assess the impact of post-development within the site and the neighbouring area by comparing the results with pre-development conditions. The following scenarios were considered:

    (a) Pre-development 200-year ARI.

    (b) Post-development 200-year ARI, including flood mitigation up to 50-year flood attenuation.

    (c) Ashley River Breakout storm event scenario.

(d) Culvert Blockage Scenario (Gefkins Road Driveway). In this scenario, we examine the potential impact of a culvert blockage under the Gefkins Road driveway, identified in item 35 as a critical point due to overtopping flow from Middlebrook, which is the primary contributor to flooding within Block B. A blockage in this culvert, located just downstream of the spill point, could lead to a worst-case flooding scenario, diverting additional flow toward Block B. This assessment aims to understand the implications of a fully blocked culvert, resulting in increased water flow directed towards Block B.

52. Climate change factor with RCP 8.5 was included in our modelling.

Hydraulic Modelling Methodology

53. A two-dimensional (2D) HEC-RAS[1] hydraulic model has been used for flood modelling purposes.

54. 2020 LiDAR was used to create the ground topography within and surrounding the site. Surveyed cross sections of relevant streams were embedded into the topography to ensure that stream beds were adequately accounted for. This was necessary as trees, water and other vegetation obstruct the LiDAR, so reliable stream bed information is not usually able to be obtained from LiDAR.

55. The upstream model extent includes the area upstream of Northbrook, Middlebrook and Southbrook Stream, including a small area west of Southbrook Road. The downstream extent has been taken south of Marsh Road and the wastewater treatment ponds, such that the effects on the development are able to be considered by the model. The model extent is shown in Figure 6.

56. Culvert and Bridge Structures in the Model:

(a) Northbrook: There are two major culverts impacting the site, both included in the model:

(i) Double pipe culvert: 2m diameter

(ii) Box culvert on Marsh Road: 7.72m x 1.65m height

[1] U.S. Army Corps Hydrologic Engineering Centre – River Analysis System (HEC-RAS)

(b) Middlebrook:

(i) Railway Bridge: The measured size of the Railway Bridge upstream of the model has been located. For modelling purposes, the surveyed cross-sectional data of the Middlebrook stream has been added, but conservatively, the structure has not been included to account for the worst-case scenario of diverting all flow downstream unrestrictedly. The council model results indicate that this bridge is not restricted or impacted by floodwaters within the 200-year ARI storm event.

(ii) For the culvert under Gefkins Road driveway (as explained in item 44 (d)), two scenarios have been considered due to its criticality: one with the culvert fully open (fully operational) and the other with the culvert fully blocked.

(iii) Box square culvert: 900mm on Marsh Road, included in the model.

(iv) Additionally, there might be some private culverts on this stream through private properties, which are unknown and have not been included in the model.

(c) Southbrook:

(i) Railway Road Culvert: The culvert has been surveyed, and assumed to be fully open for modelling purposes. The box culvert is 3.1m wide, and 1.93m high.

(ii) Marsh Road Culvert: The culvert has been surveyed and assumed to be fully open. During detailed design blockage factors may be applied to this culvert, but at this stage it is unlikely to have any effect on the development, and provides a worst case scenario for the wastewater ponds. The box culvert is 2.6m wide, and 1.64m high.

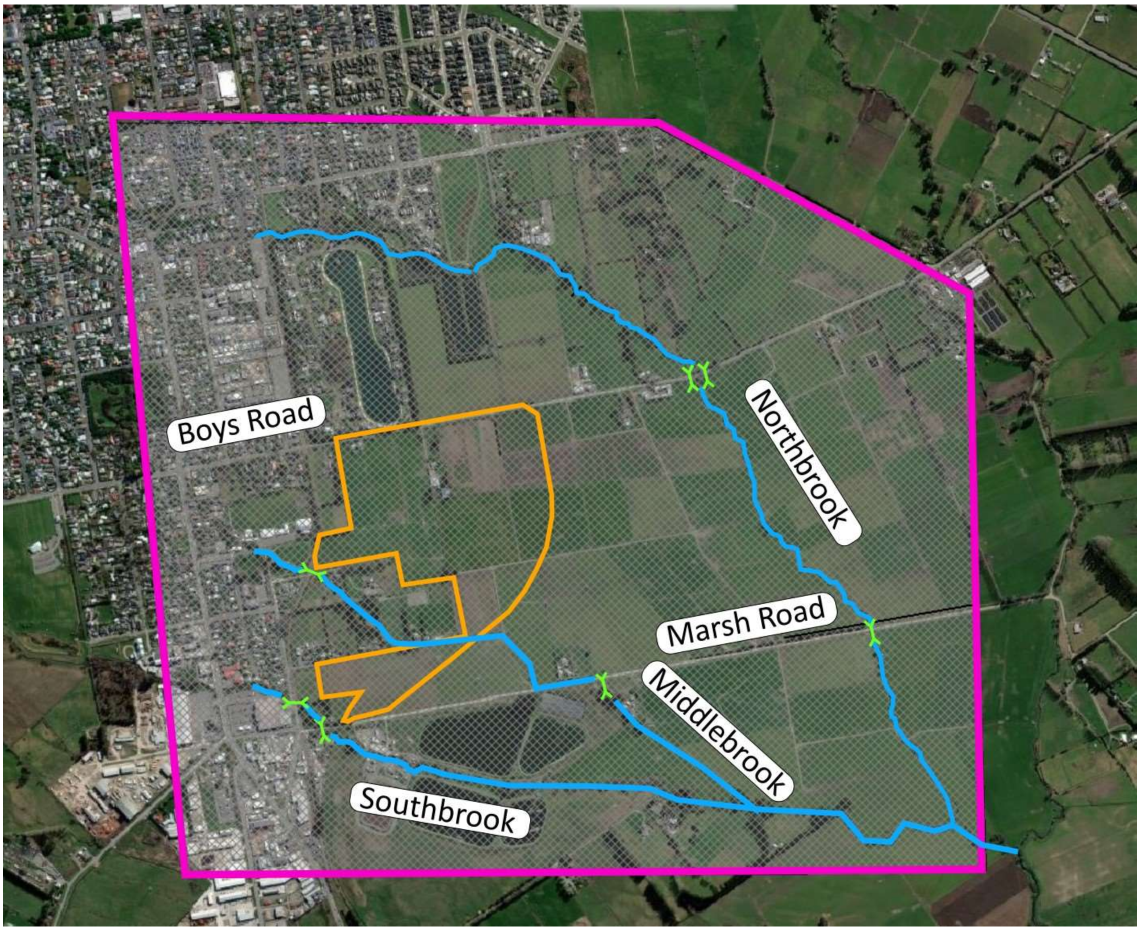

Figure 6: FTL's HEC-RAS 2D hydraulic Model Extents Shown in Pink

57. A Mannings roughness of 0.1 was applied for the majority of the area. A Mannings roughness of 0.06 was applied to all streams and stream banks. For the proposed overland flow path diversion within the site, a Mannings roughness of 0.04 was assumed. This will be reviewed at the detailed design stage once a proposed design for the diversion is known.

58. The model was run as a full 2D model with varying cell sizes. A 20m by 20m grid was used for the majority of the model, and a grid size of 4m or 5m was used for features such as streams, roads, railways, and wastewater ponds.

Waimakariri District Council Hydrological Inputs

59. The Waimakariri District Council (WDC) provided inflow hydrographs from relevant models and essential hydrological parameters. FTL has integrated the supplied WDC data into its model to ensure consistency between WDC and FTL modelling. The key elements of the received data include:

(a) WDC provided hydrological data for the 200-year storm event, including inflow hydrographs from Northbrook, Middlebrook, and Southbrook.

(i) Hydrographs are primarily sourced from WDC's urban model, with additional inputs from the district-wide model for specific locations, such as the eastern stream by Camside Road.

(ii) Areas not covered by the urban model, like the eastern stream, may experience underestimated flows along Northbrook.

(b) Ashley Breakout scenario hydrographs were derived from relevant locations based on "Wet run" modelling results recommended by the Council.

(c) WDC supplied a nested storm hyetograph for the 200-year ARI storm event, developed by DHI using rainfall values from NIWA HIRDS version 4.

(i) The 80-year RCP8.5 emissions scenario was adopted for all WDC modelling.

(ii) The 24-hour storm was selected due to alignment with the critical time of concentration for coastal areas from foothill rainfall behind Oxford and Okuku.

(d) Infiltration rates for the site were provided by WDC:

(i) Initial rate: 20.6mm/hr.

(ii) Final rate: 1.7mm/hr.

(iii) Assumed decay time: 12 hours.

Stormwater Device Attenuation Modelling Approach

60. As discussed in item 44, it is proposed to mitigate the effects of storms up to the 50 year ARI storm event. Given that the proposal is at concept level design, the flows through the site have not been modelled, and an assumed site outflow has been estimated instead.

61. Predevelopment and post development catchments for the 50 year and 200 year ARI storm events were modelled within Storm Water Management Model (SWWM 5.2). Predevelopment catchments were assumed to have no impervious area, and post development areas were assumed to be 65% impervious. Impervious area runoff characteristics for the development has been based on NZBC E1 Table 1 for “Industrial, commercial, shopping areas, and town house developments” which has a C runoff

coefficient of 0.65. This takes into account road and building coverage for the entire development.

62. For the Ashley Breakout Scenario, no outflows from the site were assumed, as the site will have a different time of concentration than the Ashley River, and therefore will have a lesser impact. This assumption will be checked at the resource consent stage once outflows from the site have been modelled.

Flood Modelling Results–Predevelopment Model, 200 Year ARI Storm

63. Predevelopment flood modelling results for Block A are very similar to that shown on the WDC District model results. Flood waters pass down Northbrook without extending significantly onto the subject site, and pond up behind the Boys Road culvert. There is some ponding water that enters the subject site. Downstream of the site, there is predicted to be significant ponding of water behind Marsh Road (Figure 8).

64. The results show that the twin 2m diameter culverts under Boys Road and the box culvert with a 7.72 width and 1.65 height under Marsh Road are under capacity during the 200-year storm event in the existing condition.

65. Predevelopment flood modelling results for Block B align with the WDC District model results. Flooding is observed from Middlebrook, traversing through the centre of the site and discharging across the fields toward the eastern site boundary. Additionally, flooding is indicated to pass through the very southern area of the site, predominantly along the region north of Marsh Road.

66. The results show that the 7.72m wide and 1.65m height box culvert under Marsh Road is under capacity during the 200-year storm event in the existing condition.

67. As discussed in item 47, considering the criticality of the Gefkins Road culvert, two model scenarios were based on the fully open and fully blocked conditions for the culvert. The fully blocked scenario represents the worst case, resulting in most of the Middlebrook flow diverting towards Block B. The maximum spill flow to Block B is estimated to be $6.4m^3/s$ for the fully blocked scenario and $3.2m^3/s$ for the fully open scenario (Figure 8).

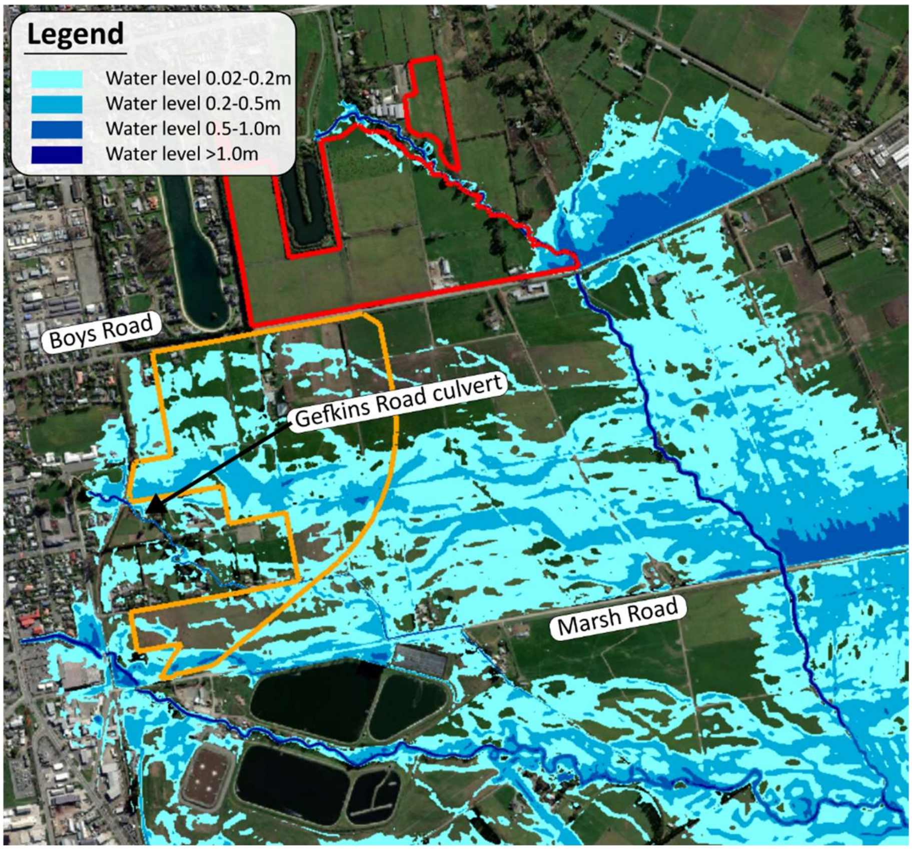

Figure 7: FTL Flood Model Results- Pre Development 200 Year ARI Storm Event

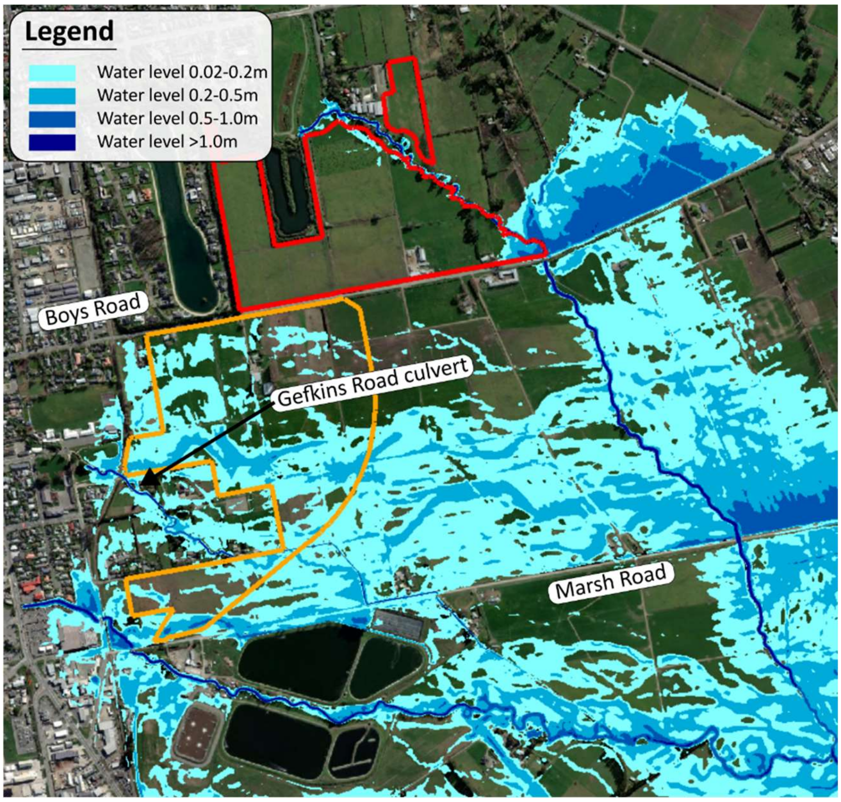

Figure 8: FTL Flood Model Results- Pre Development 200 Year ARI Storm Event fully blocked scenario for Gefkins Road culvert

Flood Modelling Results– Post Development Model, 200 Year ARI Storm

68. Post development flood modelling results for Block A show the site is not impacted by flooding from Northbrook. Some flooding due to the ponding behind Boys Road has been prevented from entering the site (Figure 9).

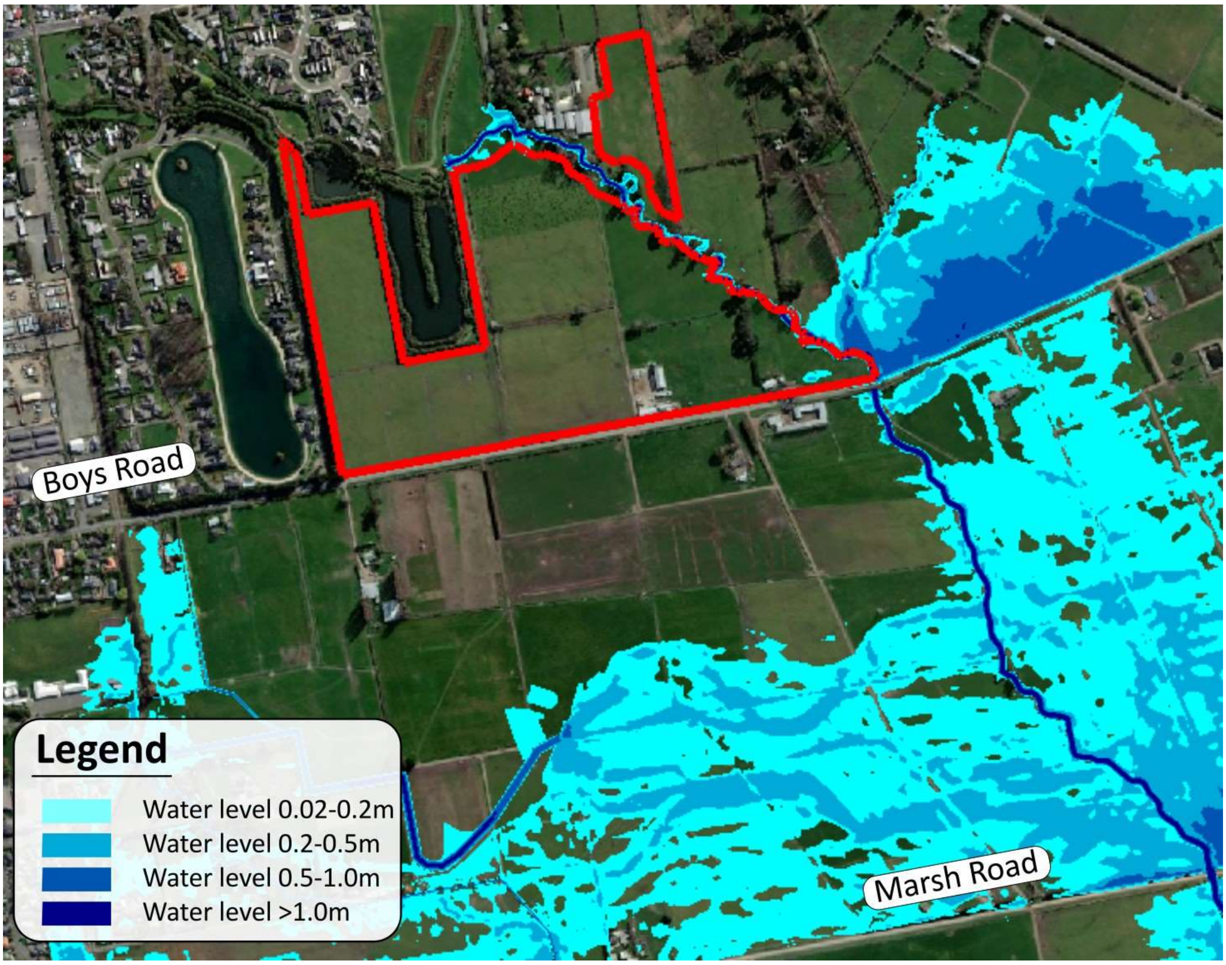

Figure 9: Post Development 200 Year Flood Extent- Block A

69. Post-development flood modelling results for Block B demonstrate the effectiveness of the proposed flood mitigation measures (up to a 50-year ARI) and the implementation of a diversion cut-off channel within the site. This channel is designed to manage overland flow from the contributing catchment along the western boundary and mitigate overtopping from Middlebrook. Notably, the proposed development area remains unaffected by flooding.

70. No alterations to finished ground levels have been made in the region where Southbrook floods the site (specifically, the very south portion of Block B), resulting in no change to the flooding conditions in this area.

71. As discussed in item 47, two model scenarios were based on the fully open and fully blocked conditions for the Gefkins Road culvert. The fully blocked scenario represents the worst case, resulting in most of the Middlebrook flow diverting towards Block B, especially in the post-development scenario with the cut-off channel. While the fully blocked culvert (3.3m width x 0.78m height) is a conservative scenario, given the predominantly urban upstream conditions, its critical location just downstream of the spill point from Middlebrook stream necessitates its use as the worst-case scenario in flood modelling. This approach ensures thorough testing of the cut-off channel's capacity to manage floodwater effectively (Figure 10 and Figure 11).

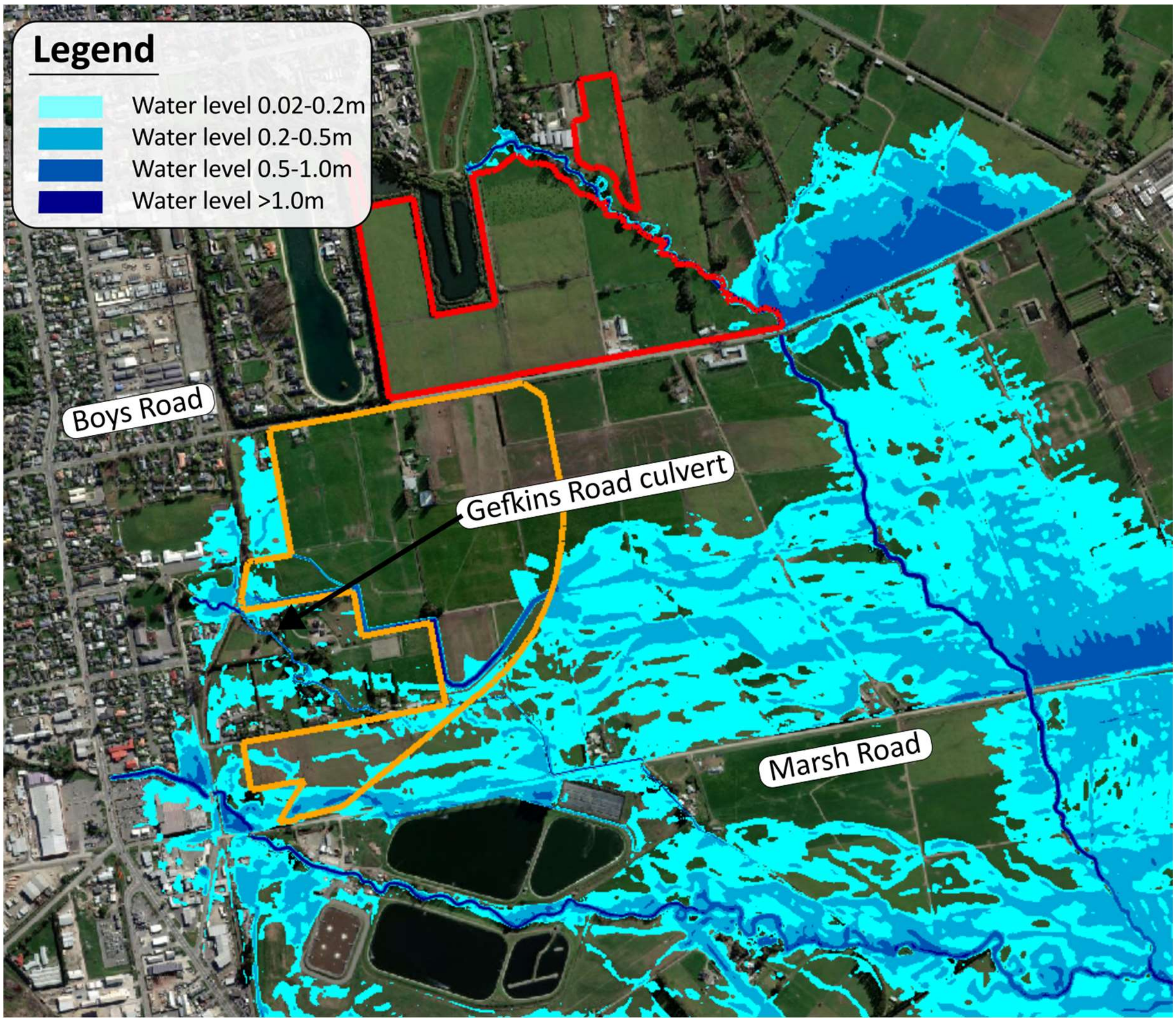

Figure 10: Post Development 200 Year Flood Extent- fully blocked scenario for Gefkins Road culvert-Block B

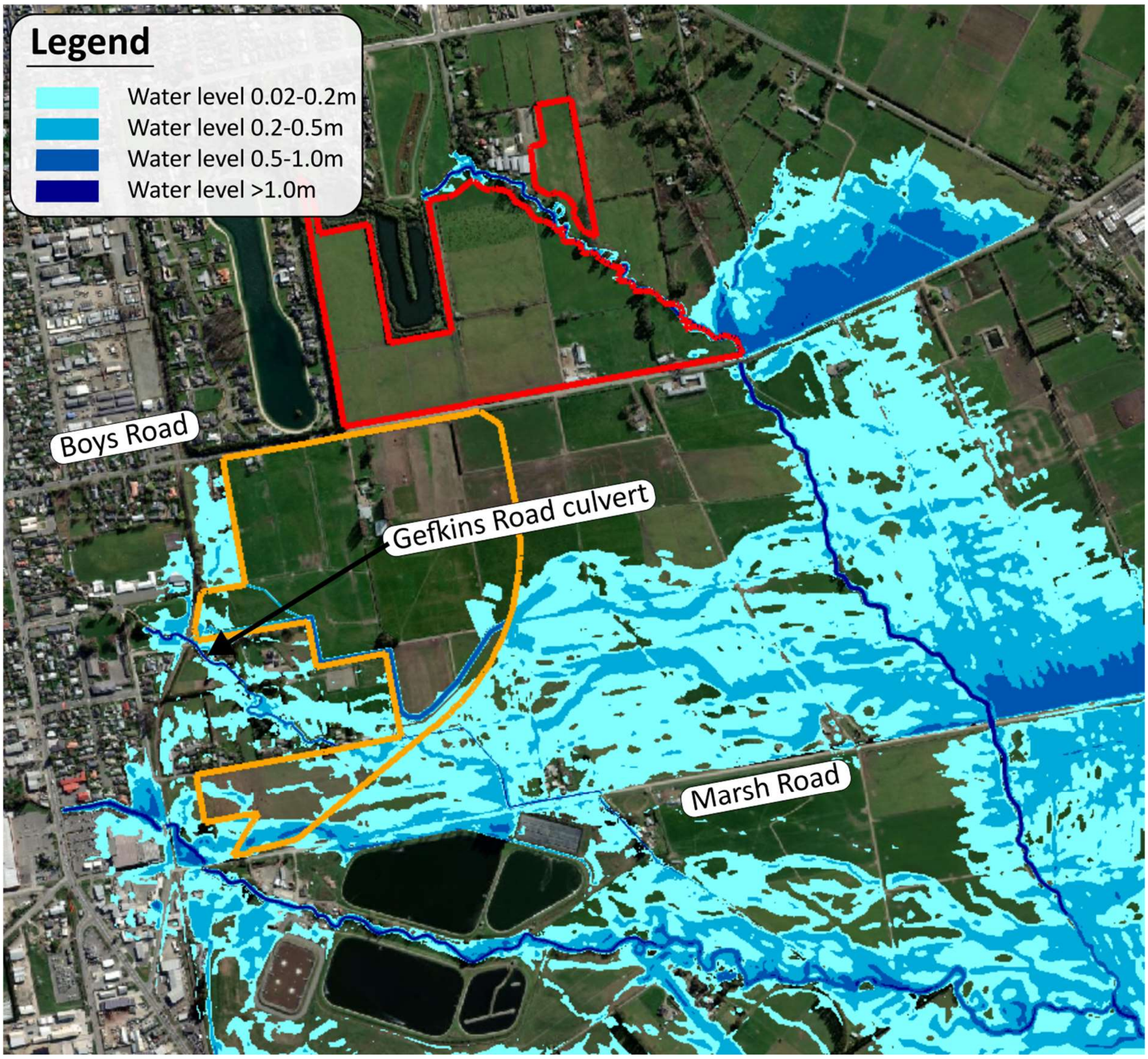

Figure 11: Post Development 200 Year Flood Extent- unblocked scenario for Gefkins Road culvert-Block B

Impact Assessment of Post-Development Flooding on Neighbouring Properties/ Structures (200-Year ARI Storm Event)

72. The flood modelling results, looking at the difference between pre and post-development scenarios during the 200-year storm event, indicate no impact upstream of Block A and B.

73. The flood modelling considered the worst-case scenario, fully blocking the culvert under Gefkins Road. Consequently, the flow diverted to Block B from the spill point of Middlebrook is estimated to be 6.6m³/s (compared to 3.8m³/s in the fully open culvert scenario) in the post-development scenario. The results indicate that the cut-off channel has sufficient capacity to manage the flow without adverse impacts on flooding in Block B.

74. The peak flood levels surrounding habitable dwellings are not increased by more than 20mm, post development scenario. However, there is an increase in flood depth of up to 60mm in non-habitable areas.

75. The proposed development has no adverse impact on the wastewater ponds.

76. The flood map difference between pre and post development at the Northbrook Stream peak flow time indicates no impact of Block A and B post-development on the downstream (Figure 12 and Figure 13).

77. However, ponding occurs in areas north of Boys Road and Marsh Road before the peak flow of Northbrook stream. This highlights the difference in time to peak between the subject site and the contributing catchment from the east of the roads, discharging to the same position. The modelling results demonstrate that ponding in these areas is exacerbated during the post-development scenario.

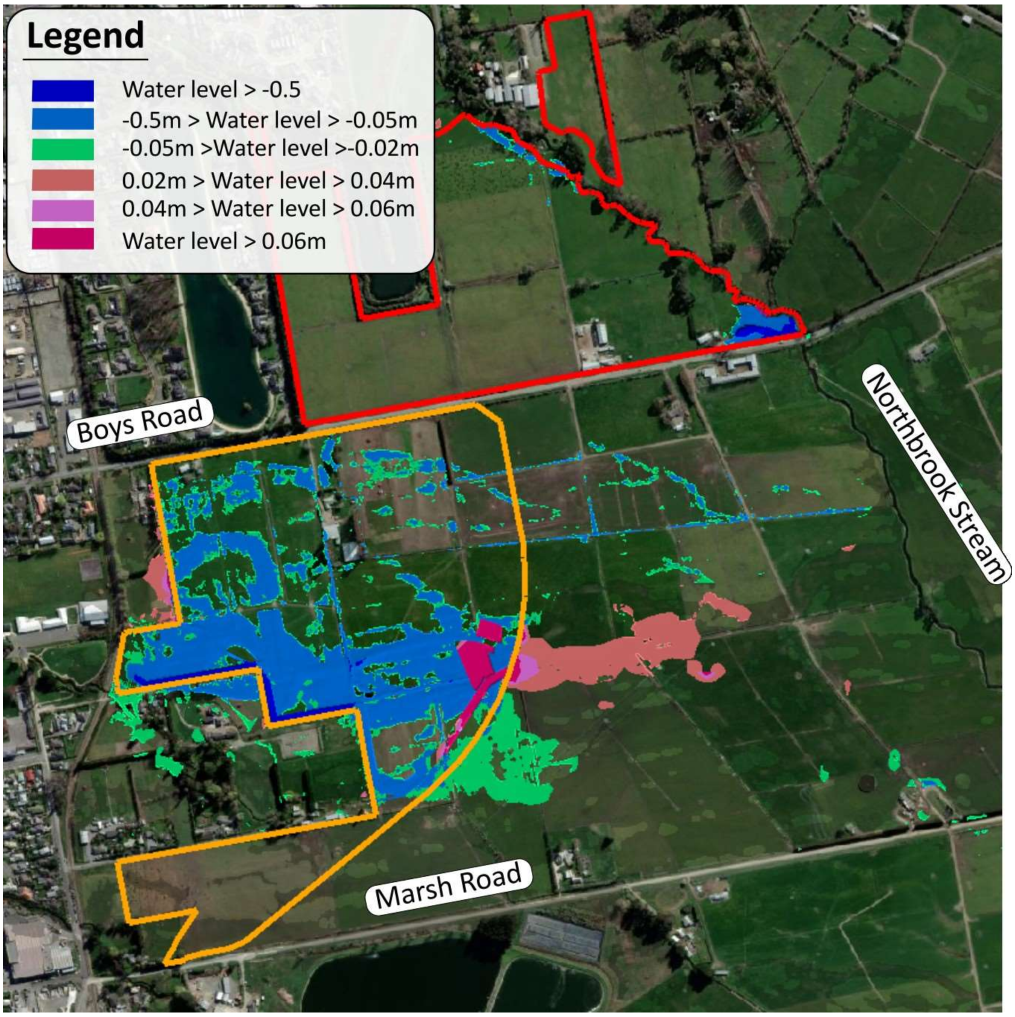

Figure 12: Difference between pre and post-development (at peak water levels): 200-year flood extent with Gefkins Road culvert blocked

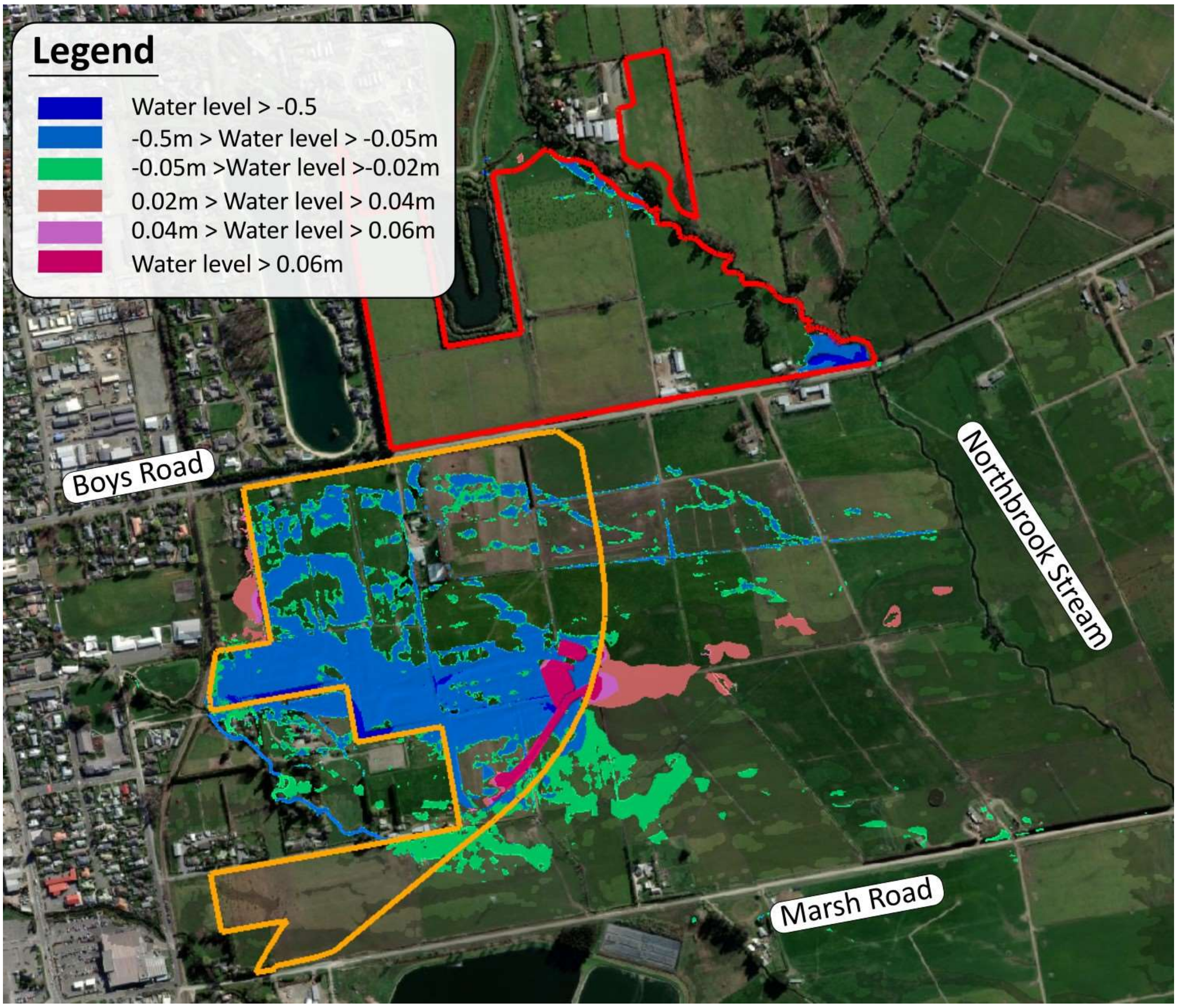

Figure 13: Difference between pre and post-development (at peak water levels): 200-year flood extents with Gefkins Road culvert unblocked

Ashley Breakout Modelling – Predevelopment Model

78. Predevelopment flood modelling for Block A shows that the majority of the Ashley Breakout flows will pass from west to east below Boys Road. It is not anticipated that these flows will affect the site. Some flows from Northbrook will pond up behind Boys Road, with very minor overtopping of the road. The impeded flood waters here are less than the 200 year storm. See Figure 154 for model results.

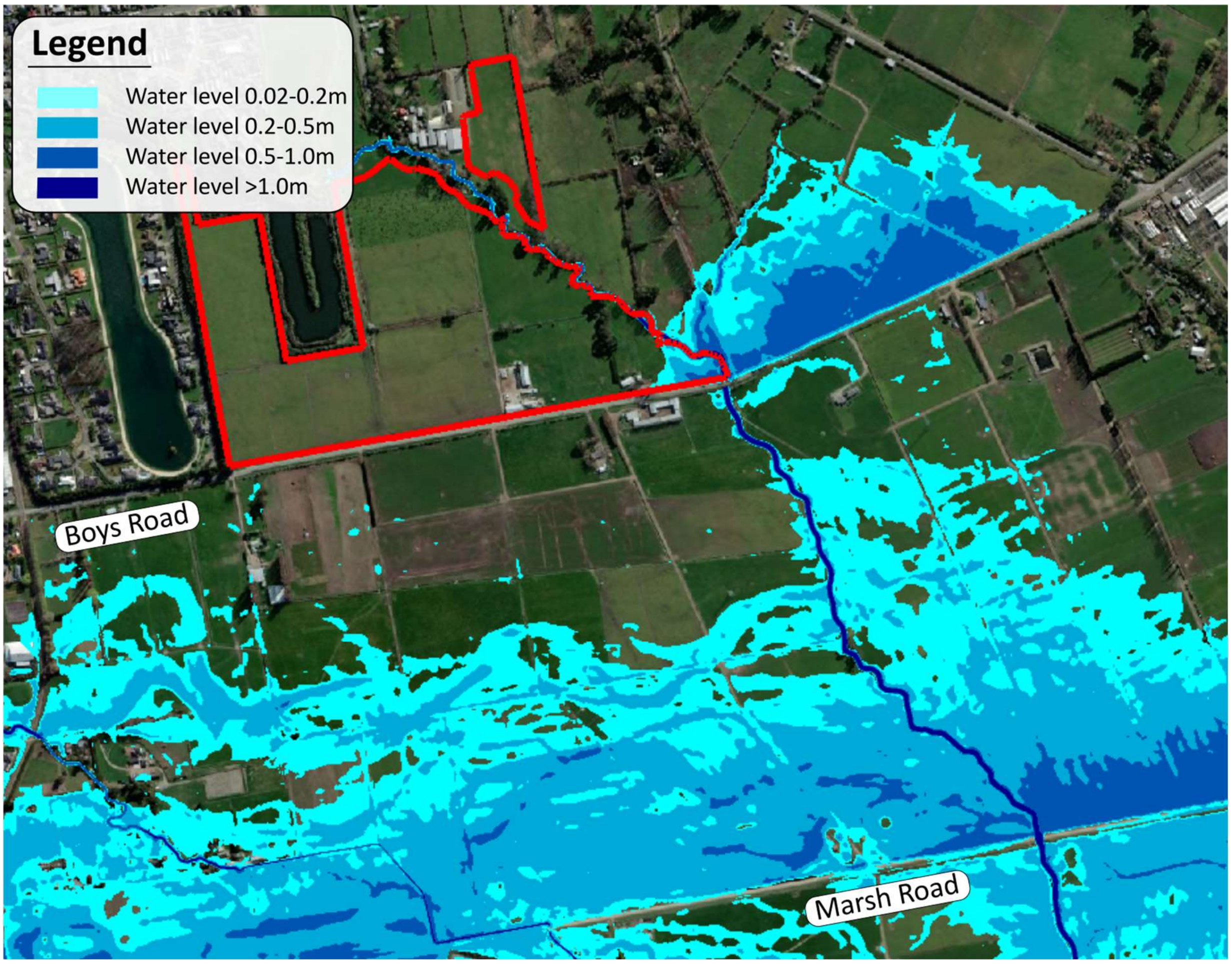

Figure 14: Predevelopment Ashley Breakout Flood Modelling Results- Block A

79. Predevelopment flood modelling for Block B shows that the majority of the Ashley Breakout flows will pass from west to east below Boys Road. Flows will pass through the centre of the site from breakout of Middlebrook Stream, and significant flows will pass over the very south area of the site. See Figure 15 for model results.

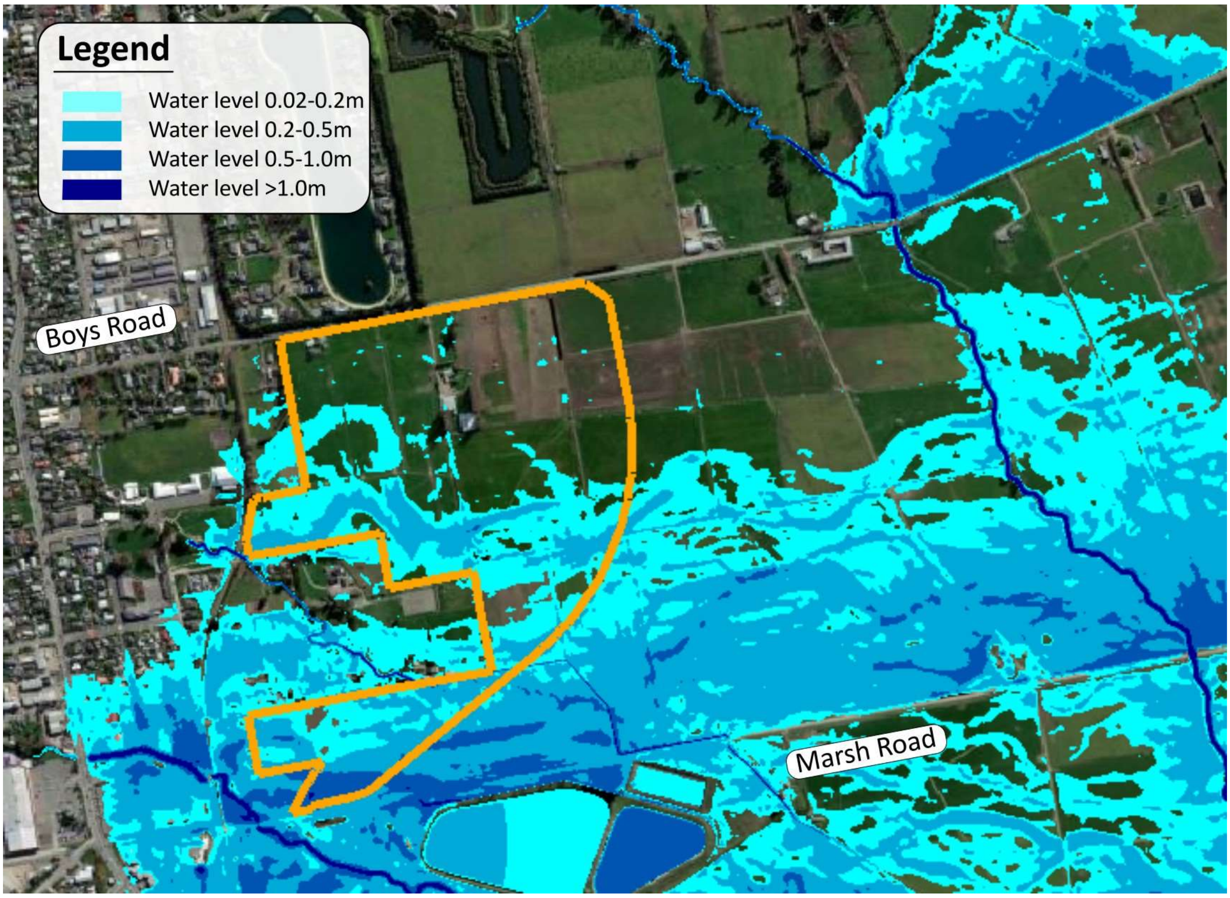

Figure 15: Predevelopment Ashley Breakout Flood Modelling Results- Block B

Ashley Breakout Modelling – Post Development Model

80. For Block A, reduced flooding levels are shown on the site itself near the Boys Road Culvert. Very small areas are shown to have an increase of 20mm on the downstream side of Boys Road. This is considered to be a less than minor effect. No increases in flood level are shown behind Marsh Road. Change in flood levels are shown on Figure 16.

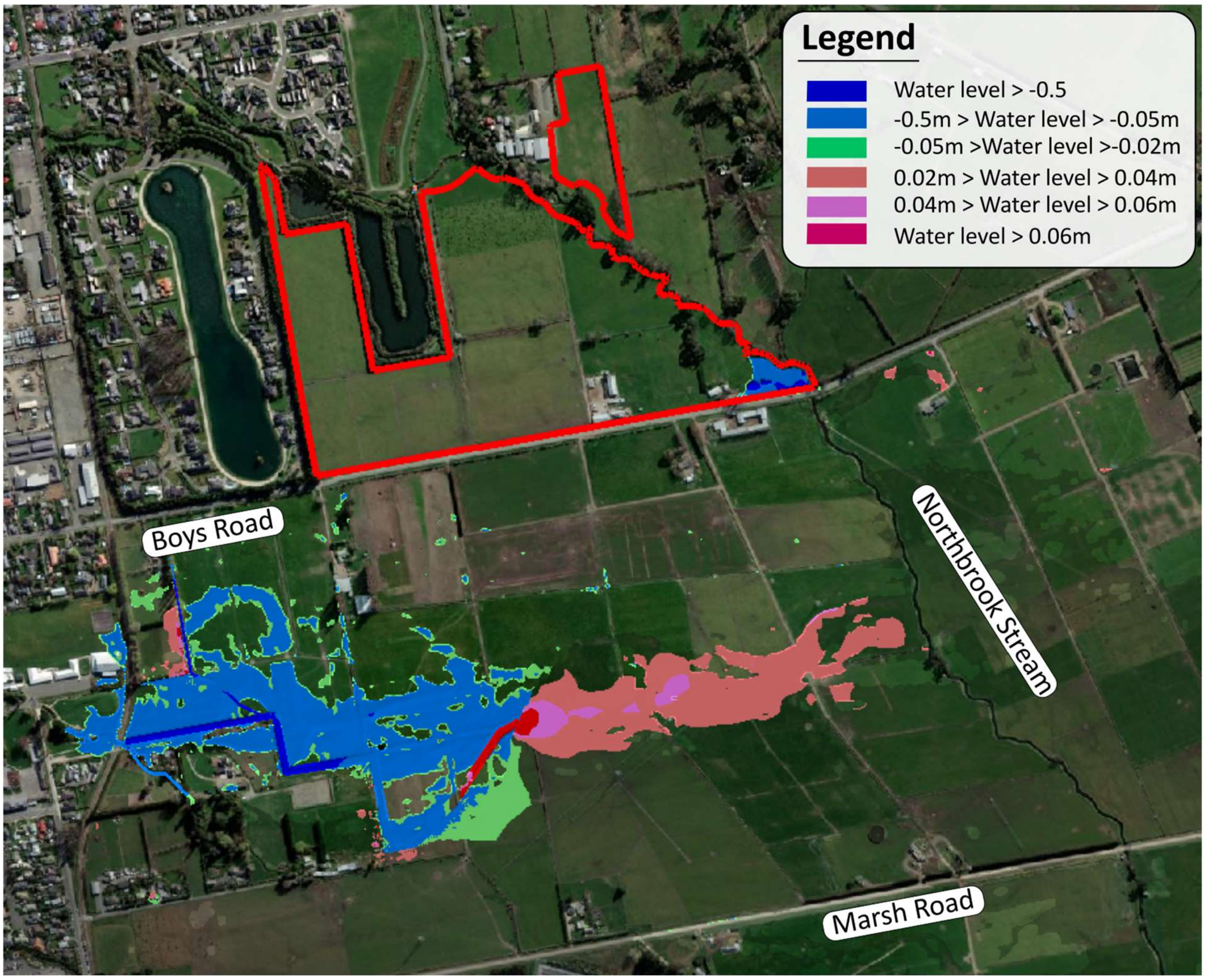

Figure 16: Changes In Flood Levels During Ashley Breakout Event

81. No changes in flows are anticipated in the southern section of the site. This indicates that the proposed development area of Block B will not be subject to flooding due to a breakout of the Ashley River (Figure 17).

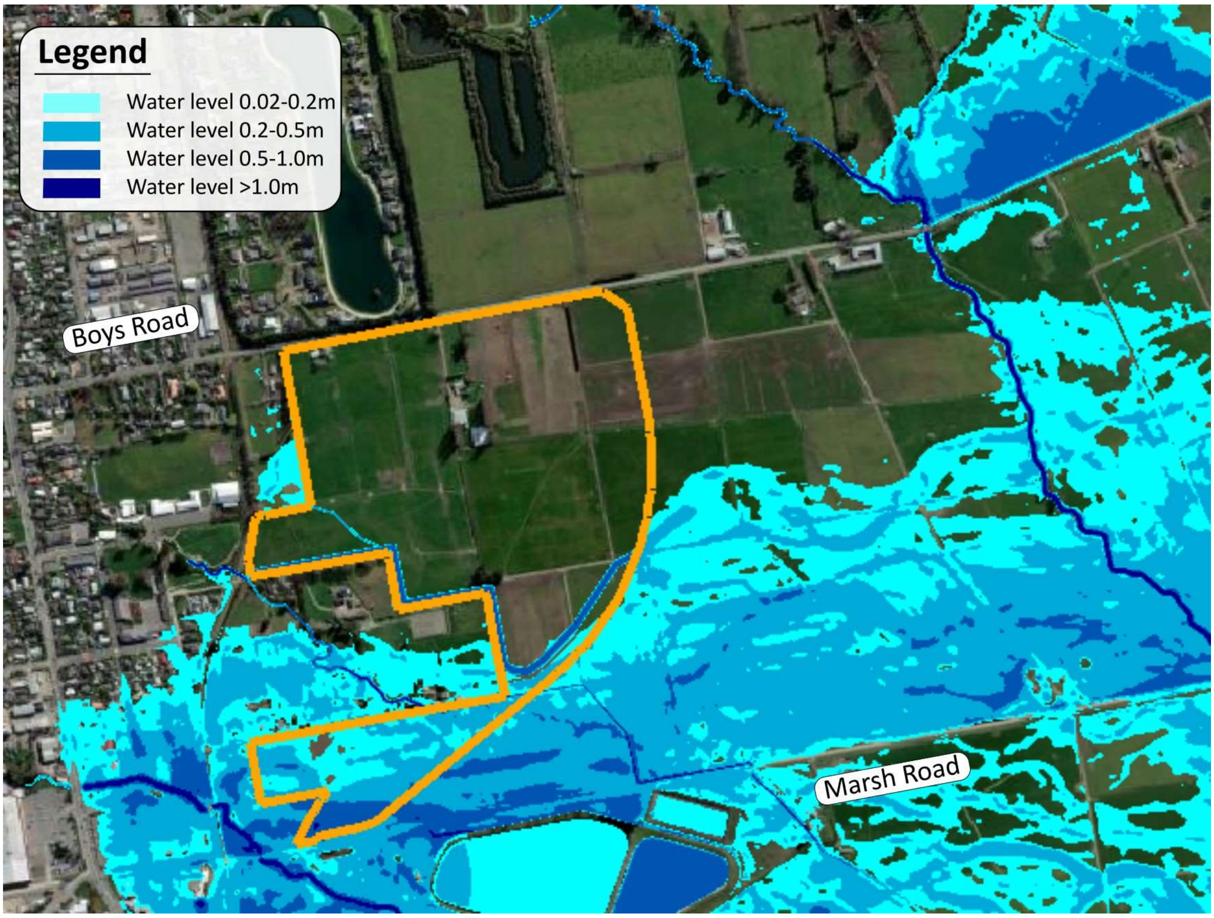

Figure 17: Post Development Ashley Breakout Flood Modelling Results

Possible Future Development in the Southern Portion of Block B (Potential Block C)

82. As explained earlier in my evidence, the flood modelling to date has not allowed for any development in the very southern section of Block B, referred to here as Block C for clarity, as shown in Figure 18. However, discussions are underway regarding potential future development in this area, considering a change in land use, potentially designating it as a separate block, Block C, as above. If such development occurs, thorough flood modelling will be required to assess post-development conditions and devise effective mitigation strategies. This is likely to involve designing a significant conveyance channel to redirect floodwater from the upstream contributing catchment, minimising the impact of the development on flooding, but also reducing the land area available for redevelopment. The dimensions and location of the channel must be carefully designed, considering on-site constructability, topography, and evaluating performance through flood modelling to confirm the optimal and efficient size and location. Special attention will be necessary to prevent any risk of flooding for the public wastewater pond, which could be affected by Southbrook Stream.

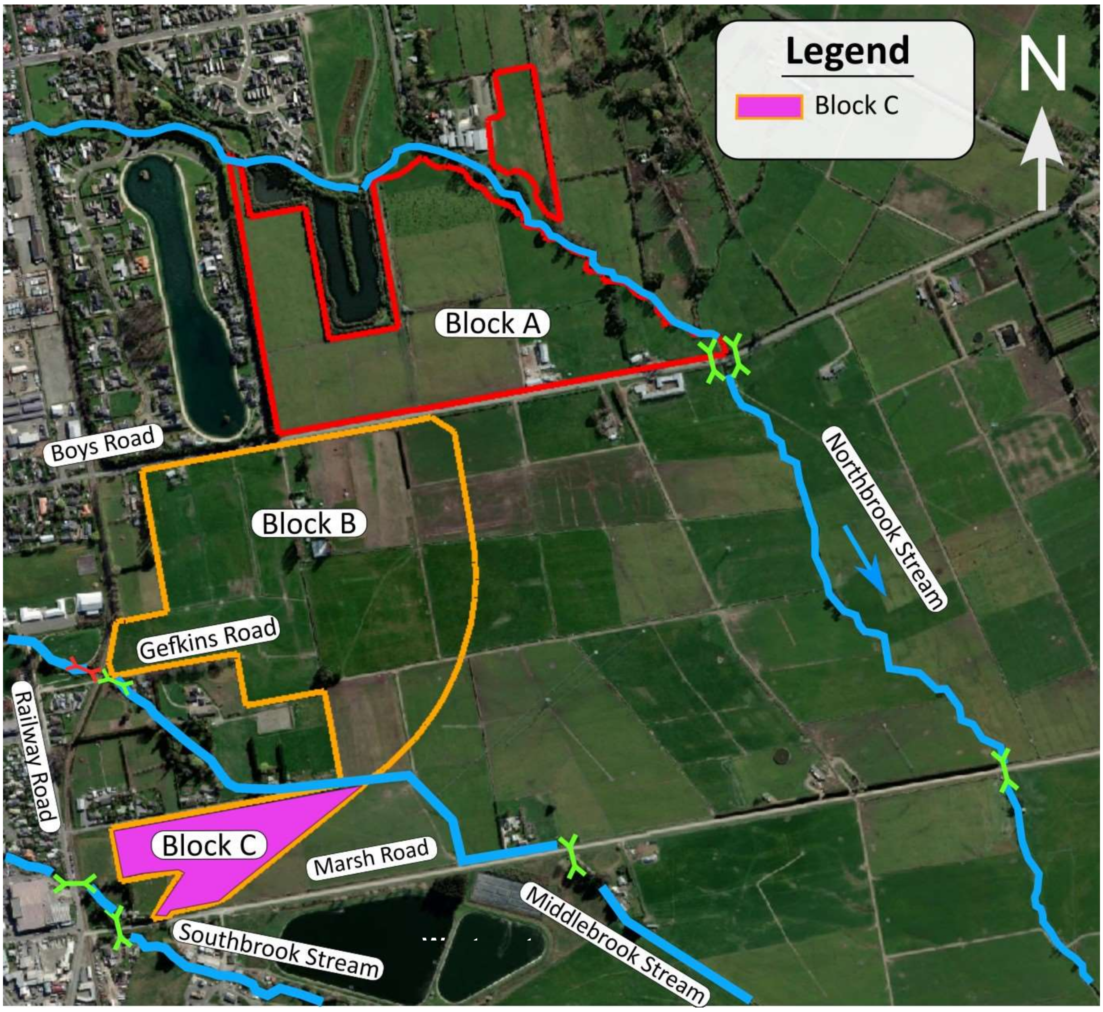

Figure 18 Possible Future Development in The Southern Portion of Block B (Potential Block C)

Conclusion

83. Fraser Thomas has conducted flood hazard modelling utilising HEC-RAS 2D software for the subject site and adjacent properties, considering both pre and post-development scenarios for the 200-year storm. Additionally, the post-development scenario incorporates flood attenuation measures for up to a 50-year ARI storm event, along with an assessment of the Ashley River Breakout scenario. Both predevelopment and post development situations were modelled to provide an indication on the effect the development would have on flood hazard within the site and upstream, adjacent, and downstream of the site.

84. It was found that the during a 200 year storm event:

(a) The development area within Block A and B will not be subject to flooding.

(b) The development at Block A and B has no adverse impact on the upstream catchment areas.

(c) In the post-development scenario, there is negligible impact on maximum flood depth at Marsh Road

(d) The flood modelling for the 200 year storm event shows that the development complies with Waimakariri District Council requirements, as the peak flood levels surrounding habitable dwellings both upstream and downstream of the site are not increased by more than 20mm.

(e) It was found that the development will have no impact on the flood levels or flows within Middlebrook and Southbrook.

(f) It is anticipated that the proposed development will have no effect on the Council wastewater ponds south of Block B. The cut off channel will ensure no additional flows are discharged to the contributing catchment of the wastewater ponds.

(g) The culvert under Gefkins Road is located just downstream from the Middlebrook spill point into Block B. Blocking this culvert could result in increased flooding in Block B. However, the conservative fully blocked culvert scenario was run, demonstrating no adverse impact on flooding in Block B. The cut-off channel has proven effective in managing the flow without compromising flood mitigation.

85. It was found that during the Ashley River breakout scenario:

(a) The development area within Block B will not be subject to flooding. The majority of the Ashley breakout flows occur in the very south of the site where no development is proposed.

(b) It is anticipated that the proposed development will have no effect on the Council wastewater ponds south of Block B. The flood mitigation channel will ensure no additional flows are discharged to the contributing catchment of the wastewater ponds.

86. The analysis revealed that the primary source of flooding in Block B originates from water in the upstream catchment along the western boundary, including overflow from the Railway and overtopping from the Middlebrook stream bank, particularly near the spill point of the Gefkins Road Driveway culvert. The proposed cut-off channel in the post-development scenario is intended to manage these floodwaters with the aim of minimizing adverse impacts both upstream and downstream. It is imperative to highlight the critical role of the cut-off channel in the model, where any modifications to its design have a substantial impact on the overall model. Despite the existing high-level design, a careful approach in the detailed design stage is essential to ensure minimal impact.

87. Any future development of Block C (the southern portion of Block B) will necessitate flood modelling and implementation of flood mitigation and/or conveyance measures to manage floodwaters through this area. This will likely entail establishing a substantial conveyance channel to direct these waters from west to east, consequently diminishing the available land in this block for development.

88. In my opinion, from a flood hazard perspective, the site is suitable for rezoning for urban development. Further modelling will be required once outflows from the site have been defined and the site plan finalised. This will be required during the Resource Consent stage.

Amir Montakhab
4 March 2024

Appendix A

Fraser Thomas Ltd “Flood Assessment Report”, dated 22 February 2024

RICHARD AND GEOFF SPARK

Over 50 Years Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

PROPOSED DISTRICT PLAN
REZONING REQUEST
SPARK DAIRY FARM, BOYS ROAD
RANGIORA

FLOOD ASSESSMENT REPORT

RICHARD AND GEOFF SPARK

PROPOSED DISTRICT PLAN
REZONING REQUEST
SPARK DAIRY FARM, BOYS ROAD
RANGIORA

FLOOD ASSESSMENT REPORT

Project No.	33263	Approved for Issue	
Version No.	2	Name	Dr Sean Finnigan
Status	Draft	Signature	
Authors	Tim Bohles		
Reviewer	Dr Amir Montakhab	Date	22 February 2024

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PROPOSED DISTRICT PLAN, REZONING REQUEST
SPARK DAIRY FARM, BOYS ROAD,
RANGIORA

FLOOD ASSESSMENT REPORT

RICHARD AND GEOFF SPARK

TABLE OF CONTENTS

APPENDICES

C Input Data

PROPOSED DISTRICT PLAN, REZONING REQUEST
SPARK DAIRY FARM, BOYS ROAD,
RANGIORA

FLOOD ASSESSMENT REPORT

RICHARD AND GEOFF SPARK

1.0 INTRODUCTION

This report presents the results of a flood risk assessment undertaken for the site at 197 Boys Road, Rangiora. It is understood that it is proposed, subject to Council approval, to develop the current farm at 197 Boys Road to create a residential (and possibly commercial/industrial) subdivision.

Council GIS (Canterburymaps.govt.nz) shows significant flooding in the area during a 200-year Annual Return Interval (ARI) storm event. Further information provided by Waimakariri District Council indicates that the site is also subject to flooding from the Ashley River Breakout scenario.

The objective of this flood risk assessment is to understand the following:

- Flood impacts on the proposed development for the 200-year ARI extreme storm event and Ashley Breakout Scenarios;
- Upstream and downstream impacts on flooding due to the development for both the 200-year ARI extreme storm event and Ashley Breakout Scenarios

In addition, the flood modelling has been used to design the flood mitigation strategy for the development to prevent the developed areas from being inundated in extreme storm events.

2.0 SITE LOCATION AND SURROUNDS

The subject site comprises multiple titles and is best broken down into two separate areas, these areas being:

(a) Block A: North of Boys Road (approximately 25.7 ha),

(b) Block B: South of Boys Road and west of a future Eastern Bypass Arterial Road (approximately 36.4 ha).

Block A is located north of Boys Road, adjacent to Northbrook Stream and two stormwater ponds from other recent subdivisions to the north and west of the site. Block B is situated south of Block A, positioned between Boys Road and Marsh Road. See Figure 1 for the existing site layout.

This report assumes that the southernmost part of Block B, between Middlebrook Stream and Southbrook Stream, remains undeveloped, consistent with the current modelling. The future use of this area is undetermined, and for the purposes of this report, it is assumed to remain in its existing condition.

Block A is a greenfield area primarily used for farming purposes. Its existing drainage system comprises several farm drains positioned within the site, diverting surface water flow towards the Northbrook Stream. Northbrook stream follows the northern and eastern boundaries of the site and then discharges through a twin 2-meter diameter culvert under Boys Road. Northbrook stream the flows to Marsh Road, where it passes through a 7.72m wide by 1.65m high box culvert.

The Middlebrook stream crosses from the western corner of Block B, as depicted in Figure 1, passing under the Railway Bridge and a box culvert beneath the Gefkins Road driveway (3.3m width x 0.78m height). Gefkins Road provides access from Railway Road to properties at 64, 62, 60, 17, and 21 Gefkins Road. The culvert on Middlebrook stream at Gefkins Road specifically serves properties at 17 and 21 Gefkins Road, continuing through 24, 10, and 2 Dunlops Road — it is noted that there might be private culverts within these properties that are currently unknown. After briefly re-entering the site, the stream crosses under 150 Marsh Road and exits through a 0.9m square box culvert under Marsh Road.

Southbrook Stream flows through a 3.1m wide, 1.93m high box culvert under Railway Road. Continuing, it traverses under Marshes Road via a 2.6m wide, 1.64m high box culvert. Subsequently, the stream follows a path between the Council wastewater ponds.

The Middlebrook Stream and Southbrook Stream converge and subsequently join Northbrook. Northbrook, in turn, plays a part in the formation of the Cam River, also known as Ruataniwha. Flowing through western Kaiapoi, the Cam River then merges with the Kaiapoi River, ultimately joining the Waimakariri River before discharging into the coast.

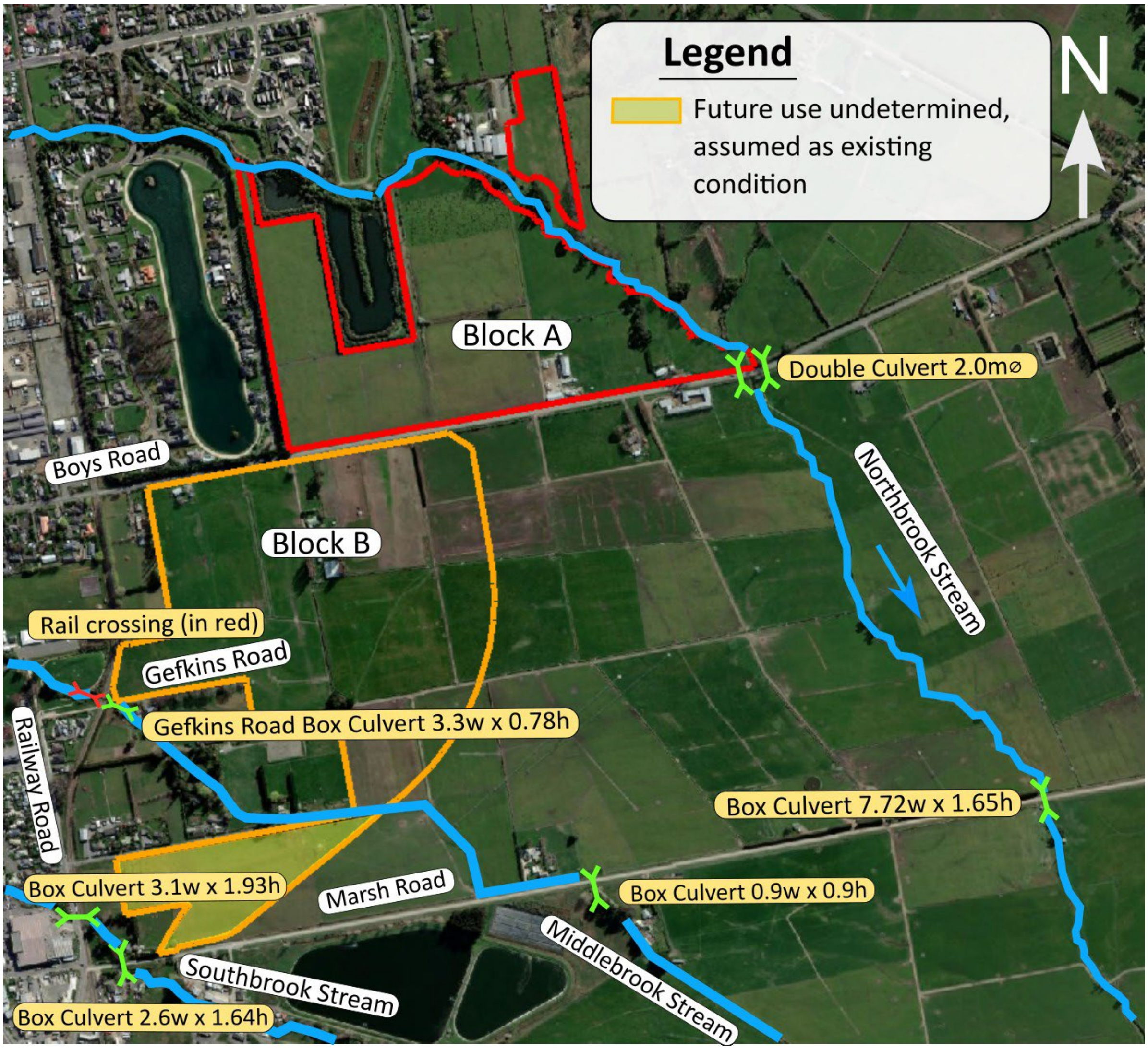


Figure 1: Block Delineation, with blue showing streams and green showing culverts

3.0 EXISTING COUNCIL FLOOD MODELLING

Waimakariri District Council commissioned DHI to undertake flood modelling between 2019 and 2020. The scope of modelling included two District Wide MIKE 21 models and the local urban flood models for Woodend, Kaiapoi, Oxford and Rangiora townships. These were all modelled for the 200-year ARI storm event. Models for the North Ashley and South Ashley breakout scenarios were also completed.

In the DHI modelling report, it is stated that:

"The results of these models will be used in preparing the upcoming district plan changes by identifying flood hazard risk and flood extents for low probability flood events, 1%, 0.5% and 0.2% AEP design rainfall events of a 24hr duration. The models also account for climate change using the HIRDS v4 RCP 8.5 rainfall. The current modelling has been peer reviewed and accepted by WSP."

The models relevant to this site are the Rangiora Township urban flood model (from herein referred to as "urban model"), South Ashley Breakout, and the district wide modelling. The site is located near the bottom end of the Rangiora Township model.

WDC has provided three model results for the 200-year ARI storm event, adjusted for climate change (RCP 8.5):

(a) The local urban model, referred to as the "local model", uses a 1D/2D approach with MIKE DHI. It focuses on the Rangiora urban area, and flood maps are shown below the site (See Figure 2).

(b) The district-wide flood model, referred to as the "district model", utilises the wider catchment size for modelling. The flood results can be found in Figure 3.

(c) The Ashley River Breakout model, is referred to as the "Ashley Breakout model". The flood results are shown in Figure 4.

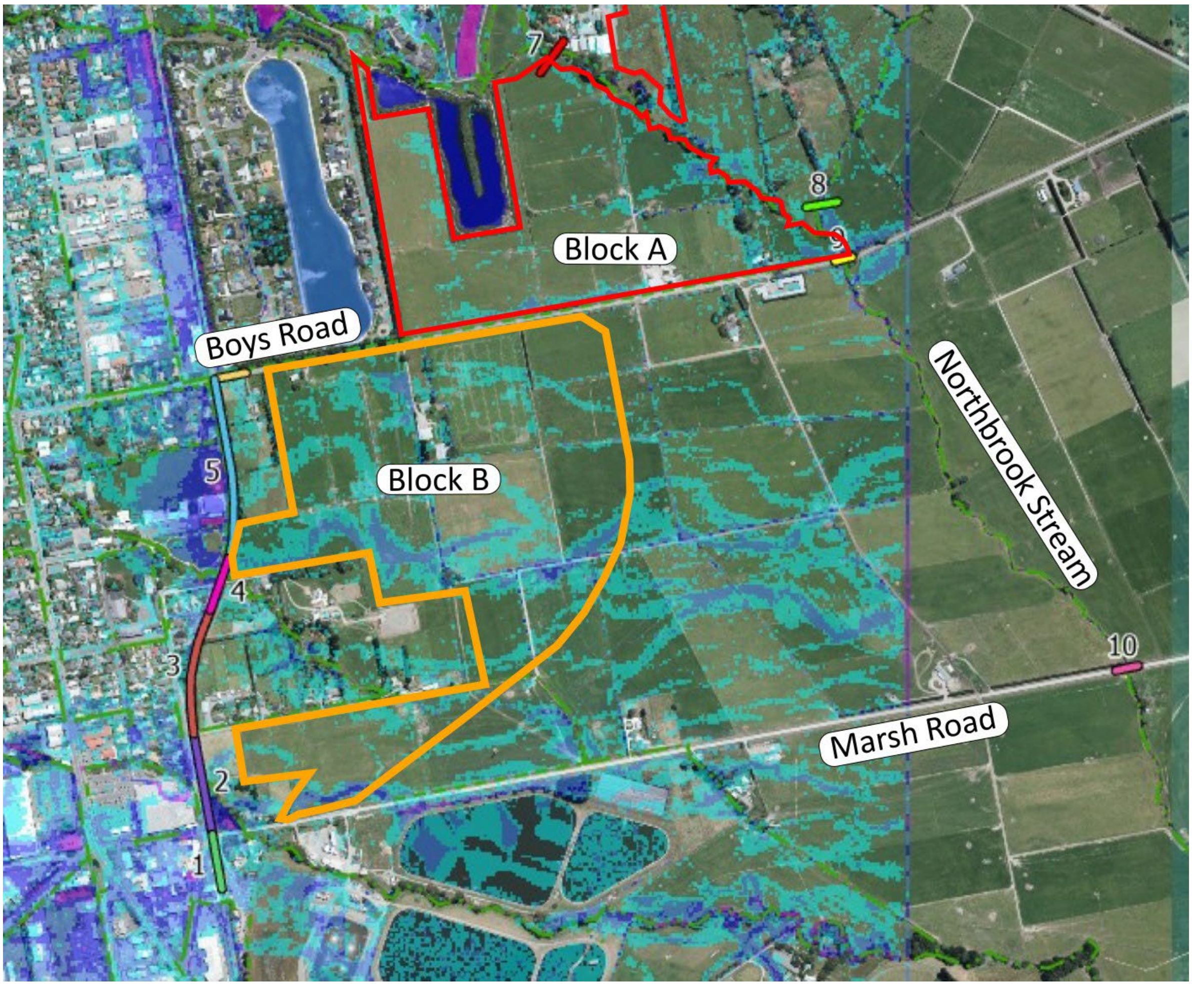


Figure 2: Local Urban Model Results (Local Model), 200 year ARI storm event + CC (Flood Maps provided by Waimakariri District Council 22/06/2023

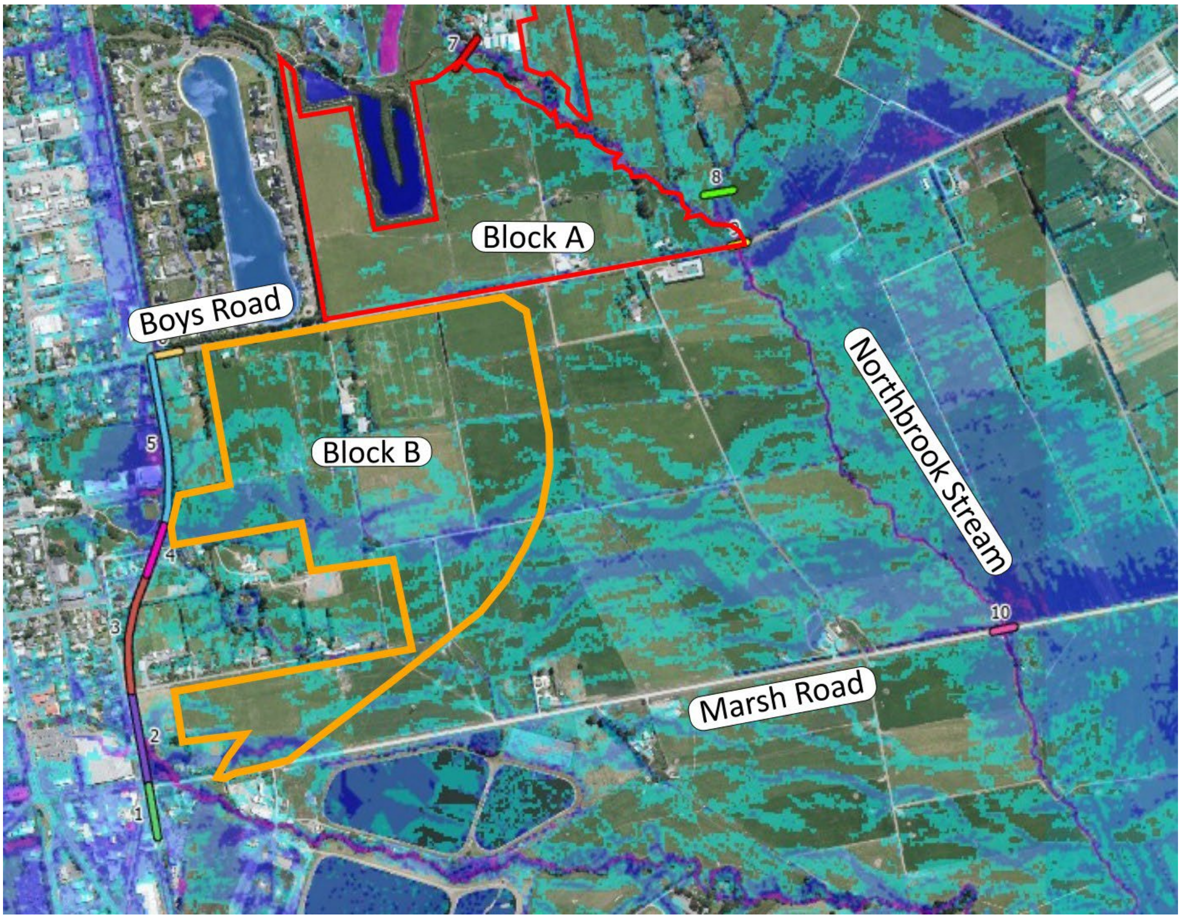


Figure 3: District Wide Flood Model Results (District Model), 200 year ARI storm event + CC (Flood Maps provided by Waimakariri District Council 22/06/2023)

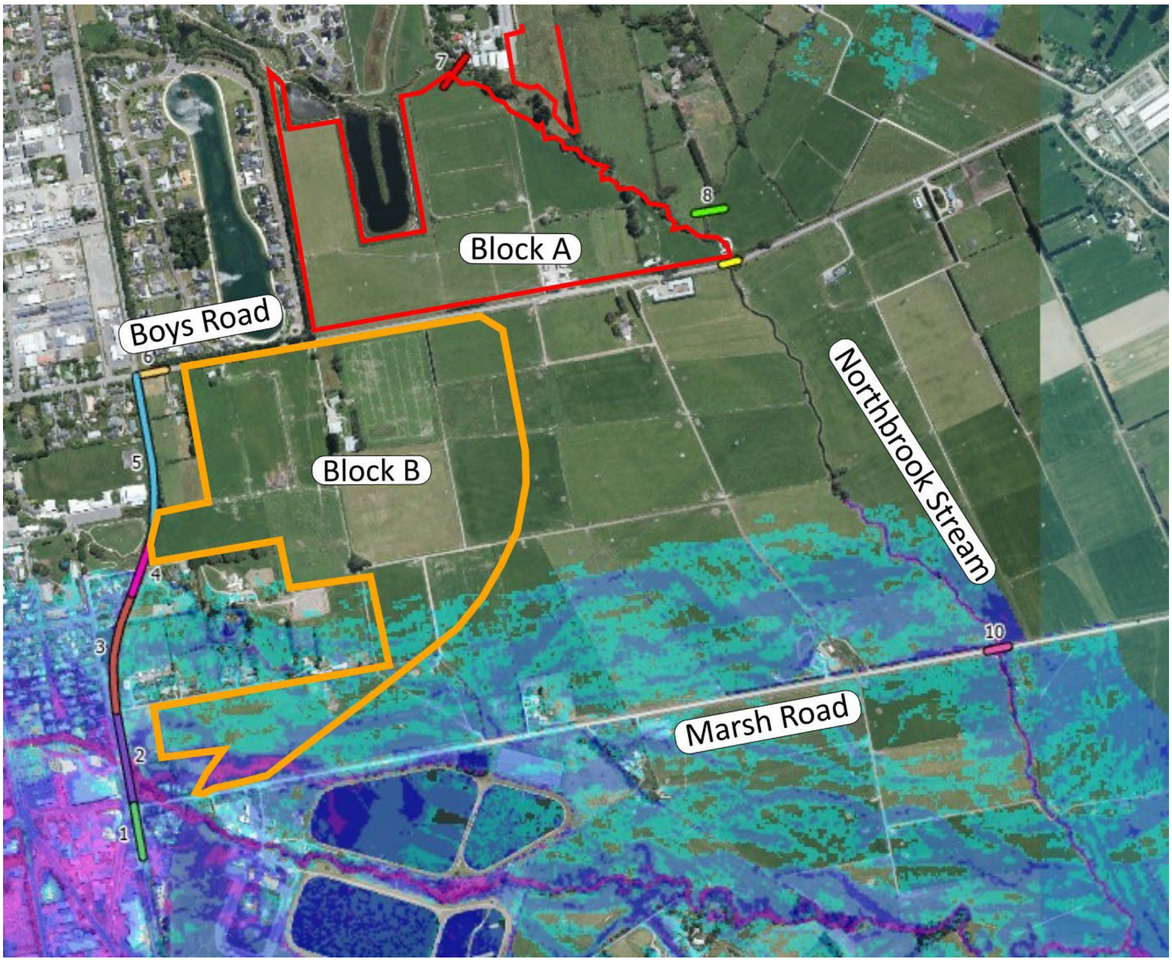


Figure 4: Ashley Breakout Model Results, 200 year ARI storm event + CC (Flood Maps provided by Waimakariri District Council 22/06/2023)

3.1 BLOCK A EXISTING FLOOD MODEL RESULTS

The results from all three WDC models consistently indicate minimal to no flooding impact on Block A. However, a discrepancy arises between the district and local models, with the former suggesting a more severe situation than the local model. This discrepancy is partly attributed to floodwaters backing up behind Boys Road from the stream flowing under Boys Road to the east (adjacent to Camside Road). Nevertheless, flooding within the site remains minor in both scenarios. In the district model's worst-case scenario, there is more overland flow generated by rainfall on the site itself. The site is not at risk of flooding from areas upstream. Additionally, the Ashley Breakout model indicates no impact of flooding for Block A.

3.2 BLOCK B EXISTING FLOOD MODEL RESULTS

The results from the District model indicate worsening conditions compared to the Local model, despite similar flood behaviour. Stream-specific outcomes are as follows:

(a) Northbrook:

Northbrook overtopping minimally impacts Block B, although all flow through the site eventually discharges into Northbrook.

(b) Middlebrook:

i. The modelling results show floodwaters from the breakout of Middlebrook stream entering the site, flowing from west to east across the railway crossing. Modelling indicates that Middlebrook begins overtopping before reaching the culvert under Gefkins Road, following the natural overland flow path within Block B and ultimately discharging into Northbrook at a spill level of approximately 17.9mRL.

ii. The District model depicts exacerbated flooding from Middlebrook across the site.

iii. It is unclear if the council model includes the culvert under Gefkins Road, contributing to overtopping flow toward Block B, especially in the culvert blockage scenario.

(c) Southbrook:

Ponding occurs at the corner of Railway Road and Marsh Road. Overtopping flow from the Southbrook bank continues along the natural overland flow path adjacent to Marsh Road, crossing the very southern portion of Block B (future use of this area undetermined, assumed same as existing condition). The flow ultimately discharges into the 900mm square box culvert under Marsh Road.

The results of the District and Local models show that surface water enters the site as sheet flows from the western boundary, from the railway side. However, a notable portion of floodwater accumulates in ponding areas behind the railway on the urban side due to the elevated railway bank.

The Ashley breakout model results show significant flooding only in the lowest section of Block B, which is currently not proposed for any development and will remain as per existing conditions. This model scenario does not impact the remaining area of Block B.

4.0 WAIMAKARIRI DISTRICT COUNCIL REQUIREMENTS

During the pre-application meeting held on 3 February 2023, it was stated that flood modelling of the 50 year ARI storm event was not required at this stage, as this involves more detail within the site itself and can wait until the resource consent stage. Instead, Council required the 200 year ARI storm event (0.5% AEP event) to be modelled and for the results to show that there are less than minor effects on properties both upstream and downstream of the site.

Advice regarding flood modelling and permitted effects on neighbouring properties was received from Chris Bacon, Network Planning Team Leader at WDC, on 21 November 2023, stating:

"The Council's requirement is to mitigate all effects in a 50 year event. That is normally achieved by simply attenuating flows back to pre-development levels. However, if you are demonstrating an increase in flooding in a 50 year event despite attenuating flows then you will need to do some additional work to mitigate those effects.

For the 200 year event it is acceptable to have an increase in flooding on neighbouring properties provided that

a. The flood level around any habitable dwelling is not increased by more than 20mm or

b. If you are increasing the flood level to any habitable dwelling, then you need to demonstrate that the freeboard (measured from the maximum flood level to the finished floor level) is more than 500mm.

To reflect the inherent uncertainties with this sort of work we normally apply an allowance of up to 20mm for an acceptable increase in flood depth. So provided you are showing an increase of less than 20mm then we would consider this to be a less than minor effect under the RMA."

In subsequent correspondence with Chris Bacon (email of 13/2/24), he has advised:

"there are no special requirements surrounding the Ashley Breakout. For all intents and purposes we treat the two events the same and depending on the site one or the other will govern."

5.0 PROPOSED DEVELOPMENT

It is proposed to implement several flood mitigation devices, such as constructed wetlands or detention basins within Stormwater Management Areas (SMAs) on the downstream areas of the site. The aim of these devices would be to provide flood attenuation up to a 50-year ARI storm event for the site itself, effectively returning flows to pre-development levels before discharge into Northbrook Stream, aligning with WDC requirements. In the event of excess flow, a bypass mechanism will be activated, directing the excess flow into Northbrook Stream as shown in the diagrams in Figure 5 and Figure 6. For Block A, it is expected that these excess flows will derive from the site itself, while for Block B, they will include an upgradient catchment component as well.

The primary stormwater system for the proposed development utilises a piped network to collect surface water, diverting it to a SMAs. The secondary stormwater system for the proposed development manages surface water through overland flow paths (OLFPs), primarily utilising proposed roads and constructed open channel. The OLFP safely diverts surface water to the SMAs, ultimately discharging it into Northbrook Stream (refer to Figure 5 and Figure 6 for diagrams of the Proposed Stormwater Management System for Block A and B).

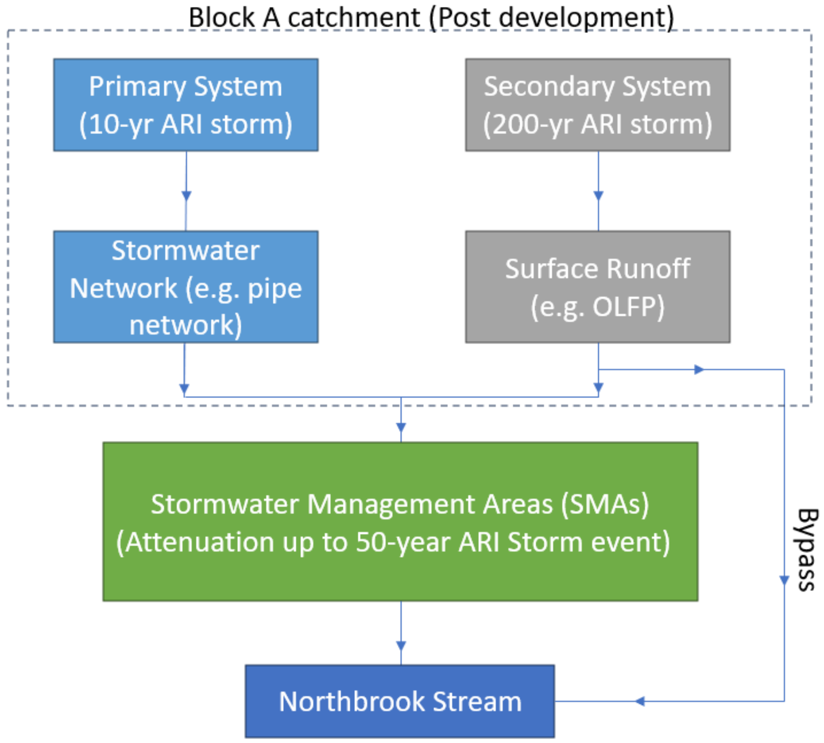


Figure 5: Diagram of the Proposed Stormwater Management System- Block A

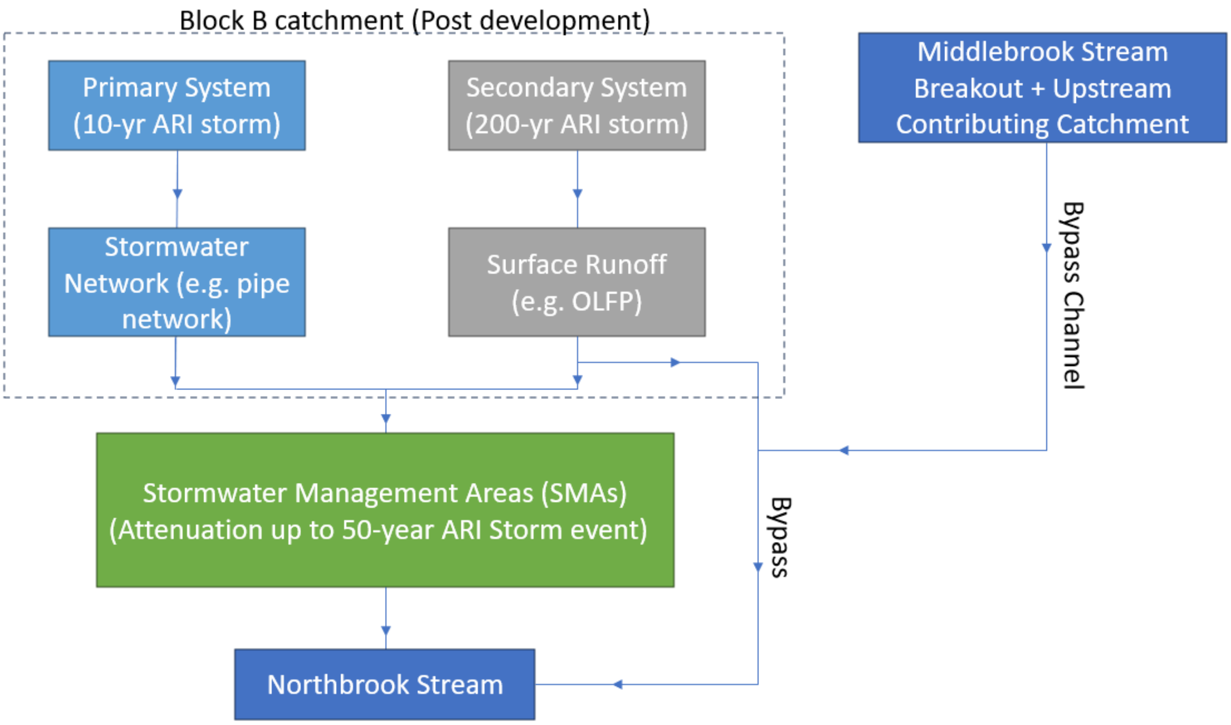


Figure 6: Diagram of the Proposed Stormwater Management System- Block B

5.1 BLOCK A DEVELOPMENT

The proposed discharge point for Block A to the Northbrook stream will be almost directly to the culvert under Boys Road, rather than sheet flow from the site itself. This is considered to be a less than minor change. It is proposed to raise ground levels within the site, particularly adjacent to Northbrook Stream, to provide a minimum 500mm freeboard above the flood levels in the stream. This will essentially prevent any overland flow breaching the stream from entering the site.

5.2 BLOCK B DEVELOPMENT

The modelling outcomes for Block B indicate that surface water predominantly enters the site from the western boundary as sheet flow, along with a breakout point from Middlebrook stream towards Block B. In response to these flows, the stormwater management plan introduces an open flood mitigation channel as shown in Figure 7. It's important to note that the proposed constructed cut-off channel is currently at the conceptual level. The actual design, including the feasible location and channel dimensions, will be developed in the detailed design stage. The performance of the detailed design cut-off channel will be assessed through a comprehensive flood modeling exercise at that time. This channel originates at the western boundary, extends along the southern boundary of Block B, and ultimately exits from the eastern boundary, discharging into the existing farm drain and, subsequently, into Northbrook. In alignment with existing conditions, the plan offers a safe and manageable solution within the site to guide flow during extreme flood events. Importantly, the flood mitigation channel size increases significantly from the point of receiving overtopping flow from Middlebrook, identified as the primary contributor to flooding within Block B.

For constructability reasons, the exit point of the channel from Block B to the farm drain might require adjustment, potentially extending to neighbouring property owned by the same owner as Block A and B for reconnection with the natural farm drain. The design is believed not to adversely impact the current modelling results, yet any potential effects will be thoroughly investigated during the detailed design phase, with mitigating measures implemented if necessary.

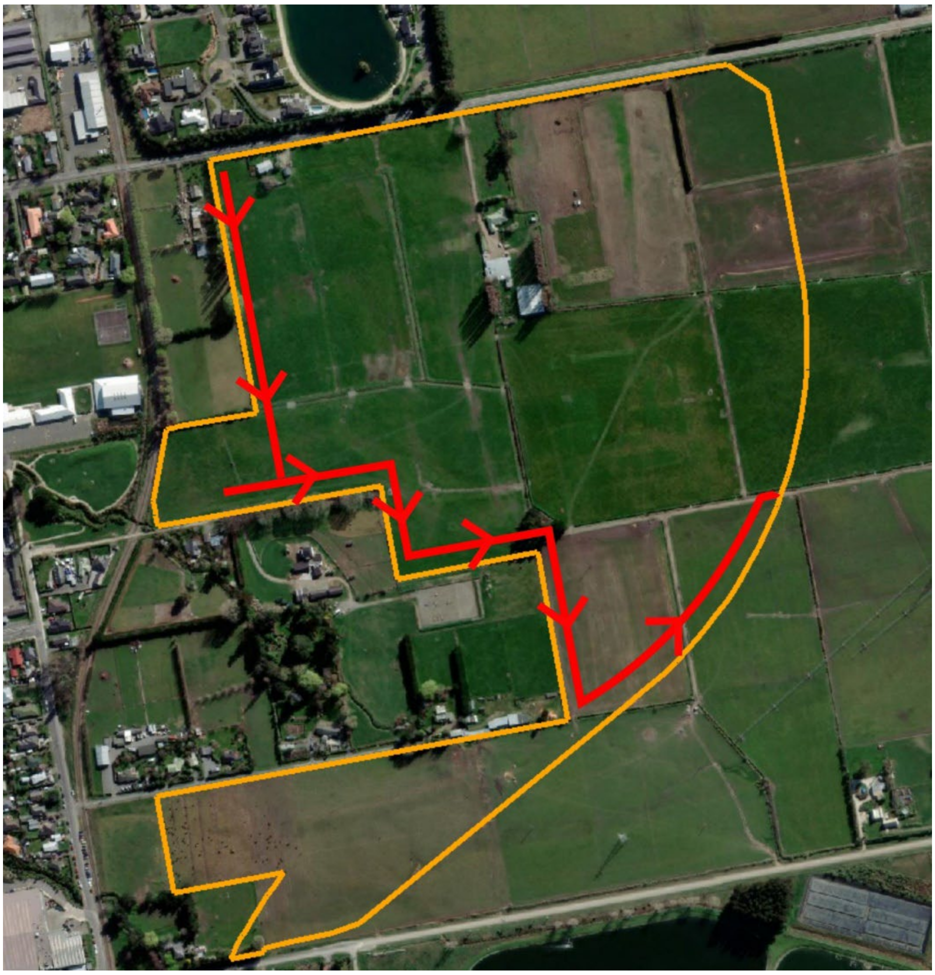


Figure 7: Approximate Location of Modelled Flood Mitigation Channel- Block B

6.0 COMPUTATIONAL HYDRAULIC MODELLING

FTL have modelled the flooding using the US Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) software. The flooding situation has been modelled completely as a 2D model, with Northbrook flows being verified using a 1D model. Model inputs and the model setup are explained below.

6.1 RAINFALL HYTEROGRAPH

For the 0.5% AEP (200 year) extreme storm event case, WDC provided the same nested storm hyetograph used by DHI in their modelling. This hyetograph has been based on rainfall values from NIWA HIRDS version 4, for the 80 year RCP8.5 emissions scenario which has been adopted for all WDC modelling work. The hyetograph was formed using the 'Alternating Block Method' and is constructed using rainfall depths from the 1, 3, 6, 9, 12, 18, and 24 hour storm events, resulting in a nested storm. The 24 hour storm was selected as this is approximately the critical time of concentration for the coastal parts of the district from rainfall originating in the foothills behind

Oxford and Okuku. See the DHI Flood Hazard Models Update Report (May 2020) Appendix C for further information.

6.2 INFILTRATION RATE

WDC provided infiltration rates for the site. The initial infiltration rate of 20.6mm/hr and a final infiltration rate of 1.7mm/hr were provided. It was assumed that the approximate time to decay was 12 hours. Borehole logs for the site indicated that the site geology comprises 1.6m of silt overlaying gravel.

6.3 EXTERNAL FLOWS

WDC have provided inflow hydrographs at key locations for input into the FTL model. Hydrographs were taken from the relevant models as described below.

6.3.1 200-YEAR ARI MODEL

Hydrographs were taken from several locations, including Northbrook, Middlebrook and Southbrook. The majority of hydrographs were taken from the local model. However, several locations required inputs from the District model. In particular, the eastern stream alongside Camside Road showed significant flows impacting the northern culvert under Boys Road. The local model did not extend to this area, and thus, it is likely underestimating flows along Northbrook.

6.3.2 ASHLEY BREAKOUT MODEL

Hydrographs were again taken from all relevant locations. Both “dry run” and “wet run” hydrographs were provided by Waimakariri District Council. The dry run is the breakout occurring over a dry DEM, whereas the wet run is the same breakout occurring in conjunction with a 5% AEP event storm. WDC recommended using the wet run results, and we have followed their advice by modelling the wet run scenario.

6.4 INTERNAL FLOWS AND STORMWATER DEVICE ATTENUATION MODELLING APPROACH

Pre- and post-development catchments for the 50 year and 200 year ARI storm events were modelled within Storm Water Management Model (SWWM 5.2). Pre-development catchments were assumed to have no impervious area, and post-development areas were assumed to be 65% impervious. Impervious area runoff characteristics for the development has been based on NZBC E1 Table 1 for

"Industrial, commercial, shopping areas, and town house developments" which has a C runoff coefficient of 0.65. This takes into account road and building coverage for the entire development.

As discussed, it is proposed to mitigate the effects of storms up to the 50 year ARI storm event. Given that the proposal is at concept design level, the flows through the site have not been modelled, and an assumed site outflow has been estimated instead, adopting a conservative approach suitable for the Plan Change, as set out below:

- In the 50 year storm event, the stormwater management system will reduce peak-flows to pre-development flows. Reduction in flow = 50yr post development flow – 50yr pre-development flow
- In the 200 year storm event, any additional flow attenuation has been ignored and the achieved flow reduction has been assumed to be 50% of (50yr post development flow – 50yr pre-development flow).

Therefore:

Site outflow = Post development 200yr flows – 50% x (50yr post development flow – 50yr pre development flow)

For pre-development flows offsite, the total flow was simply the 200 year ARI pre-development flows, as no detention would be in place.

For the Ashley Breakout Scenario, no outflows from the site were assumed, as the site will have a different time of concentration than the Ashley River and, therefore, will have a lesser impact. This assumption will be checked at the resource consent stage once outflows from the site have been modelled.

It is important to note that further work for resource consent would use proposed attenuation device design data for preliminary and detailed design work to ensure the design objectives are achieved.

6.5 CULVERTS

FTL have surveyed all major culverts both upstream and downstream of the site. These culverts were added to the model. The culverts are shown in Figure 1.

6.6 TOPOGRAPHY

2020 LiDAR was downloaded from the LINZ website. Surface topography was generated in Autodesk Civil3D, and a 1m DEM was exported for use in HEC RAS. The majority of the site and surrounding area was then modelled with a cell size of 20m. Streams, roads and other significant objects in the catchment, such as the wastewater ponds, were modelled with break lines (lines delineating site features to ensure that they are incorporated into the model topographical mesh) with a 4m cell size. Breaklines were used for all stream bottom and top banks to ensure these were modelled correctly.

For the post-development case, the estimated finished ground levels were exported as a 1m grid DEM and overlaid over the existing ground levels.

6.7 STREAMS

It was found that the LiDAR did not accurately pick up the depth of the streams. Trees, water and other vegetation obstruct the LiDAR, so reliable stream bed information cannot usually be obtained. An average stream size was estimated for each of Northbrook, Middlebrook, and Southbrook based on FTL stream survey data. The DEM topography was edited within HEC-RAS to account for the depth and size of the streams as per the surveyed cross-sections.

6.8 MANNINGS ROUGHNESS

A Mannings roughness of 0.1 was applied for the majority of the area. A Mannings roughness of 0.06 was applied to all streams and stream banks. For the proposed overland flowpath diversion within the site, a Mannings roughness of 0.04 was assumed considering a grassed channel. This will be reviewed at the detailed design stage once a proposed design for the diversion is known and will potentially need to have sensitivity test scenarios for the Mannings number. This includes testing the lower and higher range Mannings values to investigate the maximum flow velocity in the lower range and peak flow depth in the higher range Mannings value.

6.9 POST DEVELOPMENT FLOOD MITIGATION CHANNEL

Overland flowpath flood mitigation channels were designed for the site area south of Boys Road to accommodate peak flows entering the site and conveying them to an existing drainage channel downstream. The flood mitigation channels are shown in Figure 7.

6.10 MODEL EXTENT

The upstream model extent includes the area upstream of Northbrook, Middlebrook and Southbrook Stream, including a small area west of Southbrook Road. The downstream extent has been taken south of Marsh Road and the wastewater treatment ponds, such that the effects on the development are able to be considered by the model. The model extent is shown in Figure 8.

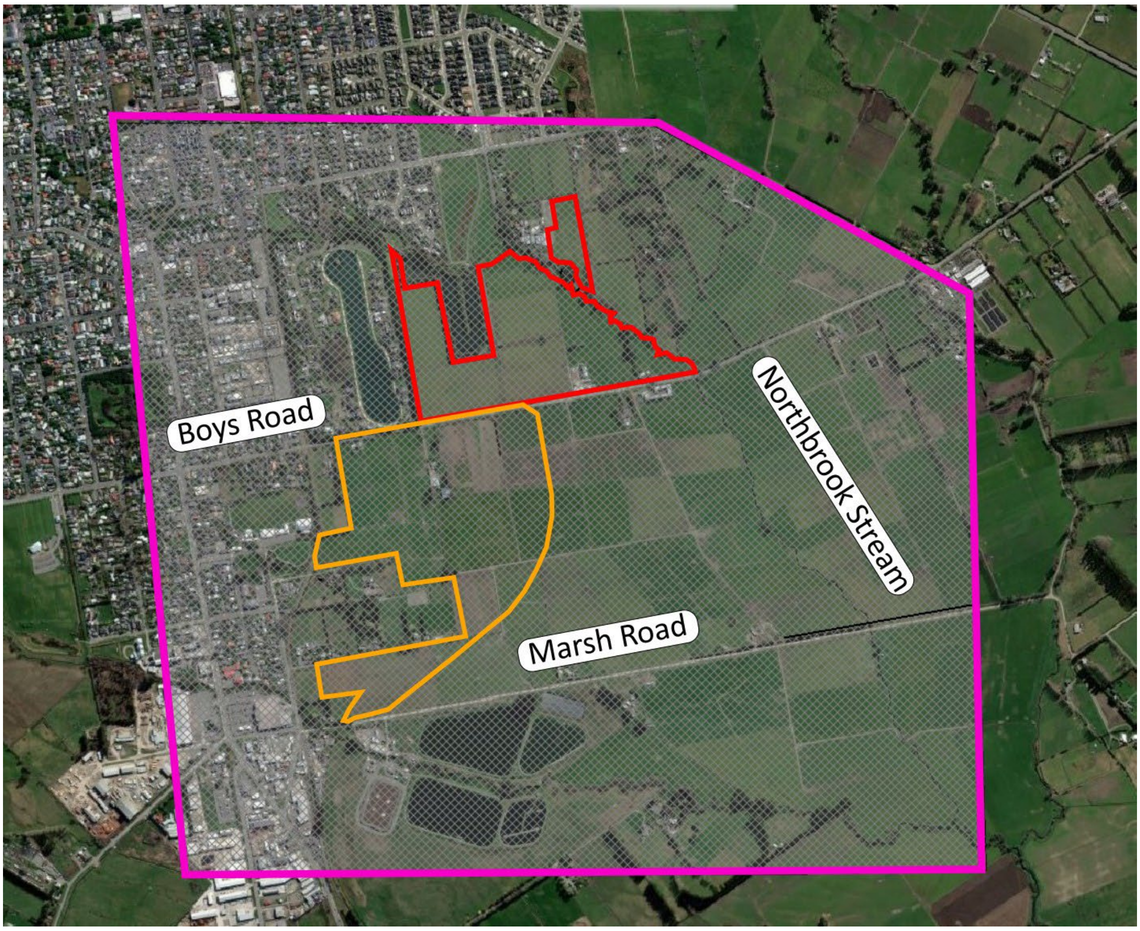


Figure 8: FTL's HEC-RAS 2D Hydraulic Model Extents

7.0 FLOOD MODELLING RESULTS – PRE-DEVELOPMENT MODEL, 200 YEAR ARI STORM

Figure 9 and Figure 10 show the modelled flood water levels in relation to the pre-development scenario of Block A and B for the 200 year ARI storm. Two scenarios were modelled; the first allows for the Gefkins Road culvert to be fully blocked, and the second if the culvert is fully operational. This has an effect on flooding at, and downstream of, Block B.

Figure 11 illustrates the difference in pre-development 200-Year ARI storm event flood depths between the fully blocked and unblocked scenarios for Gefkins Road Culvert, emphasizing the potential impact on Block B in the event of culvert blockage.

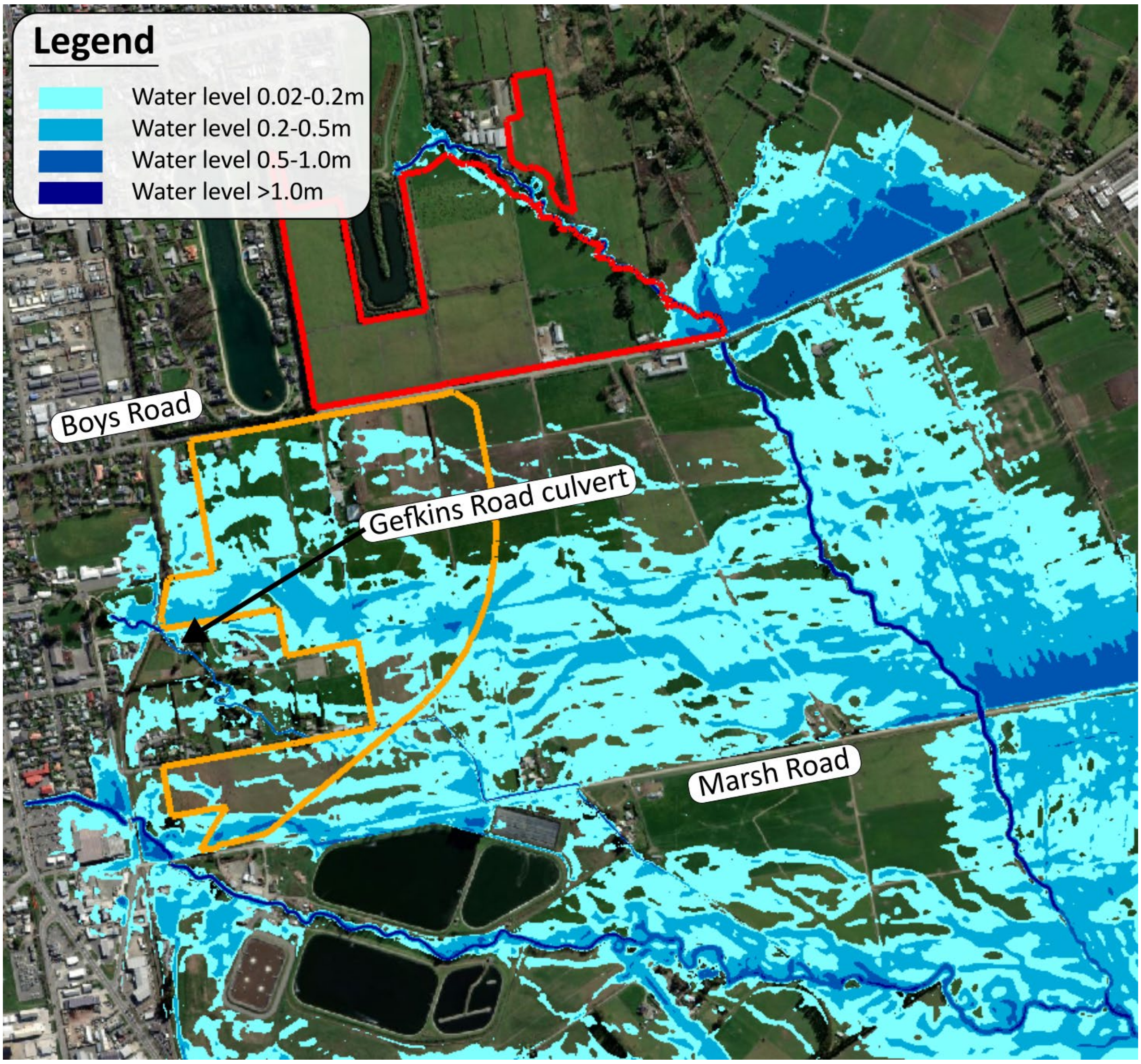


Figure 9: FTL Flood Model Results- Pre Development 200 Year ARI Storm Event Fully Blocked Scenario For Gefkins Road Culvert

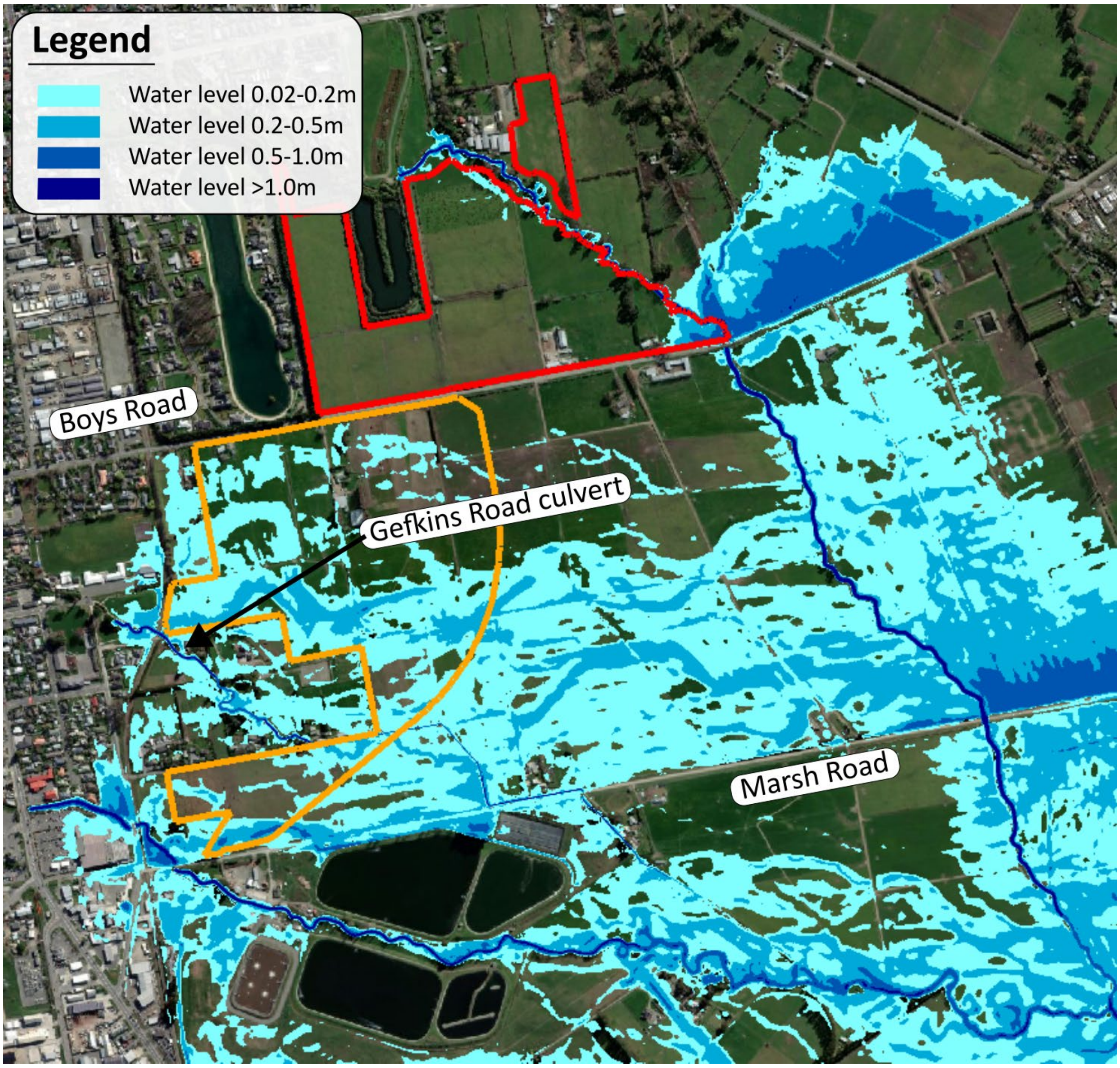


Figure 10: FTL Flood Model Results- Pre Development 200 Year ARI Storm Event Unblocked Scenario for Gefkins Road Culvert

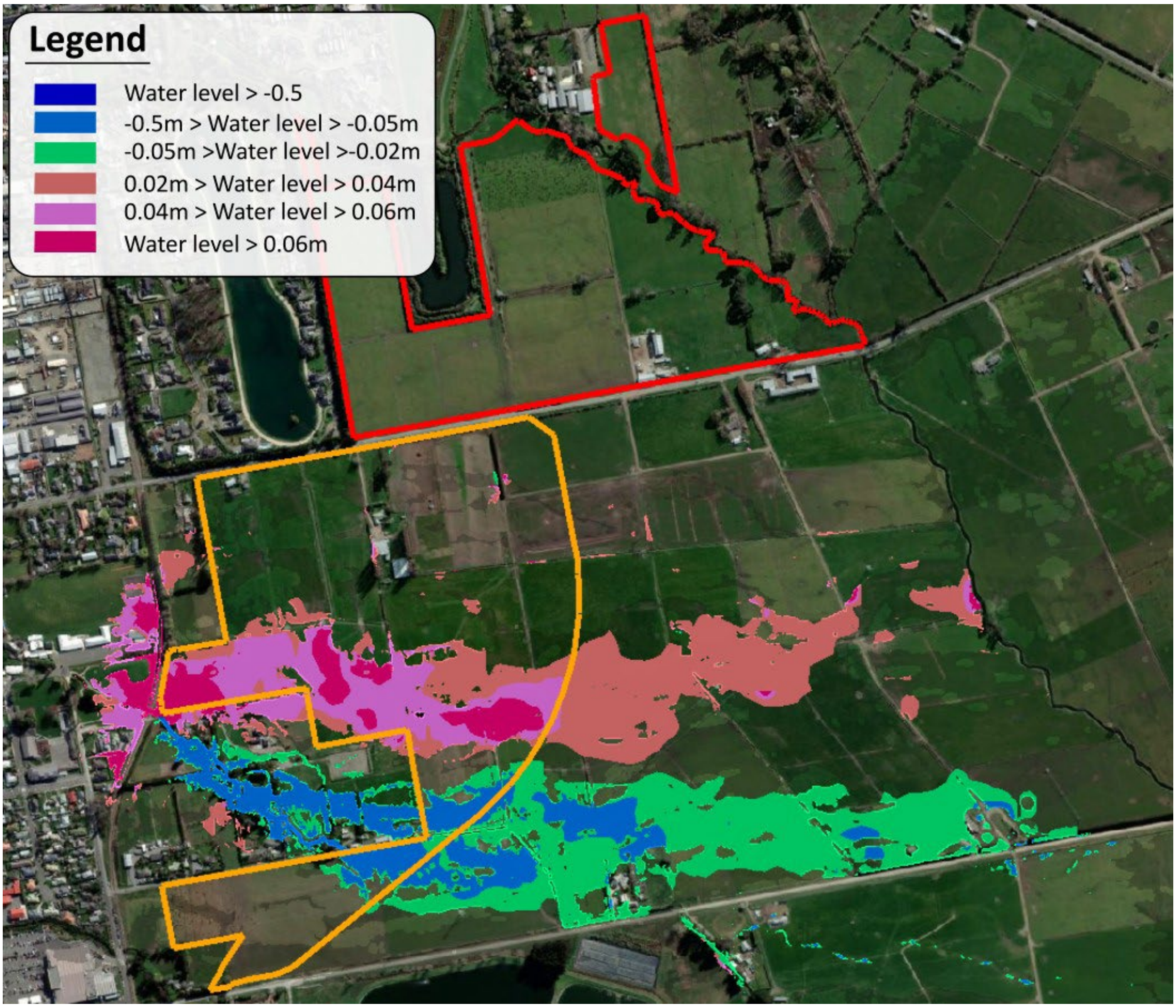


Figure 11 Difference in Pre-development 200-Year ARI Storm Event Flood Depths: Fully Blocked vs. Unblocked Scenario for Gefkins Road Culvert

7.1 BLOCK A

Pre-development flood modelling results are similar to those shown on the WDC District model results. Flood waters pass down Northbrook without extending significantly onto the subject site, and a pond up behind the Boys Road culvert. Downstream of the site, there is predicted to be significant ponding of water behind Marsh Road.

The results show that the twin 2m diameter culverts under Boys Road and the box culvert with a 7.72 width and 1.65 height under Marsh Road are under capacity during the 200-year storm event in the existing condition.

7.2 BLOCK B

Pre-development flood modelling results align with the WDC District model results. Flooding is observed from Middlebrook, traversing through the centre of the site and discharging across the fields toward the eastern site boundary. Additionally, flooding is indicated to pass through the very southern area of the site, predominantly along the region north of Marsh Road. The results show that the 7.72m wide and 1.65m height box culvert under Marsh Road is under capacity during the 200-year storm event in the existing condition, resulting in water backing up behind this culvert and then overtopping the stream banks slightly upstream of this culvert and flowing eastwards through Block B.

As discussed earlier, considering the criticality of the Gefkins Road culvert, two model scenarios were based on the fully open and fully blocked conditions for the culvert. The fully blocked scenario represents the worst case, resulting in most of the Middlebrook flow diverting towards Block B. The maximum spill flow to Block B is estimated to be 6.4m^3/s for the fully blocked scenario and 3.2m^3/s for the fully open scenario.

8.0 FLOOD MODELLING RESULTS– POST-DEVELOPMENT MODEL, 200 YEAR ARI STORM

Figure 12 and Figure 13 show the modelled flood water levels in relation to the post-development scenario of Block A and B for the 200 year ARI storm. Two scenarios were modelled, the first allows for the Gefkins Road culvert to be fully blocked, and the second if the culvert is fully operational. This has an effect on flooding downstream of Block B.

Figure 14 illustrates the difference in post-development 200-Year ARI storm event flood depths between the fully blocked and unblocked scenarios for Gefkins Road Culvert, emphasizing the potential impact on Block B in the event of culvert blockage. The results show that the floodwater can be managed safely with the proposed constructed channel in both blocked and unblocked scenarios. There are some areas where the increase in flood depth due to the blockage of the culvert is not worse than the pre-development scenario. Even in the post-development situation, the impact of culvert blockage is improved by reducing the flood extent upstream.

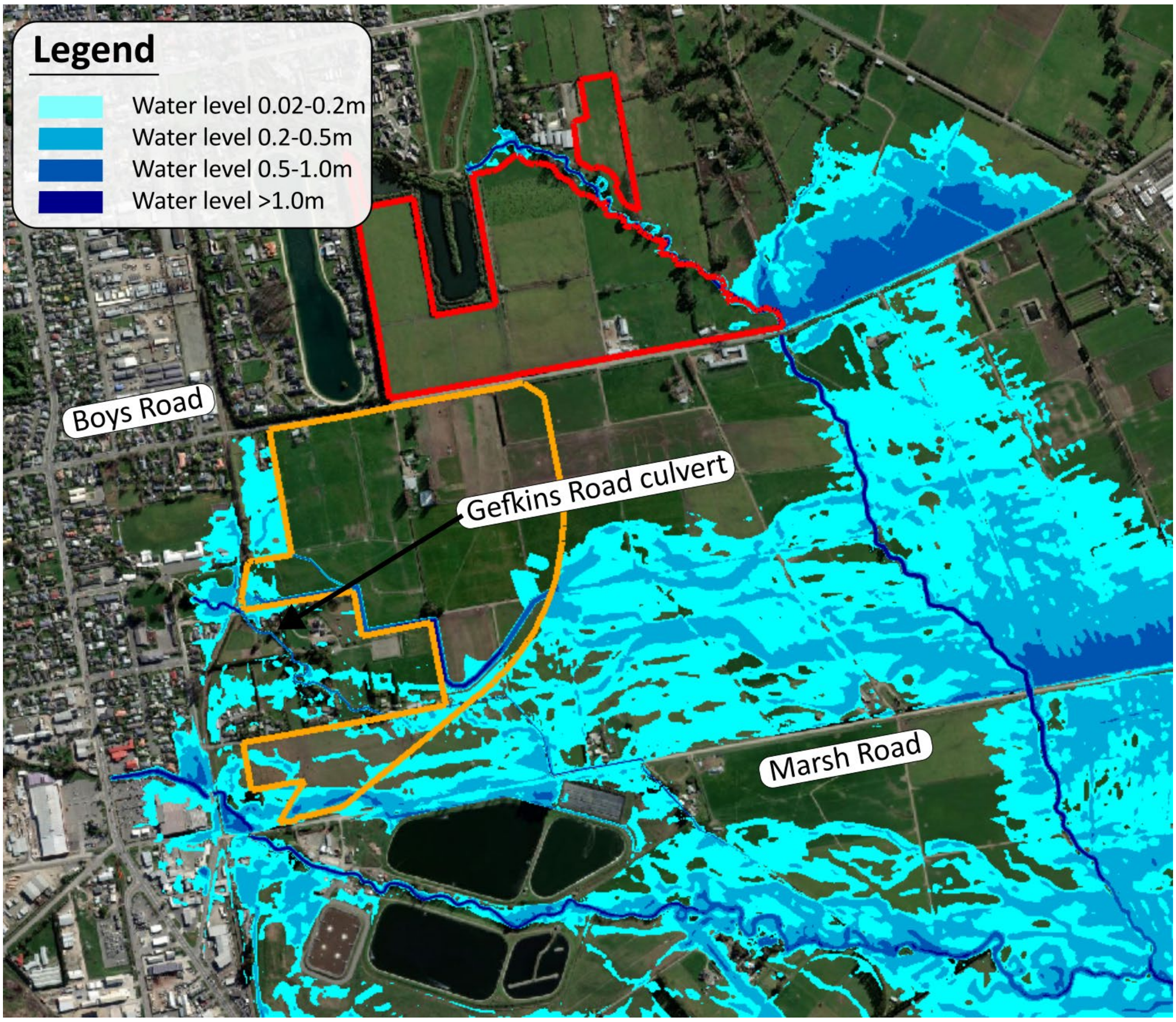


Figure 12: Post Development 200 Year Flood Extent- Fully Blocked Scenario for Gefkins Road Culvert

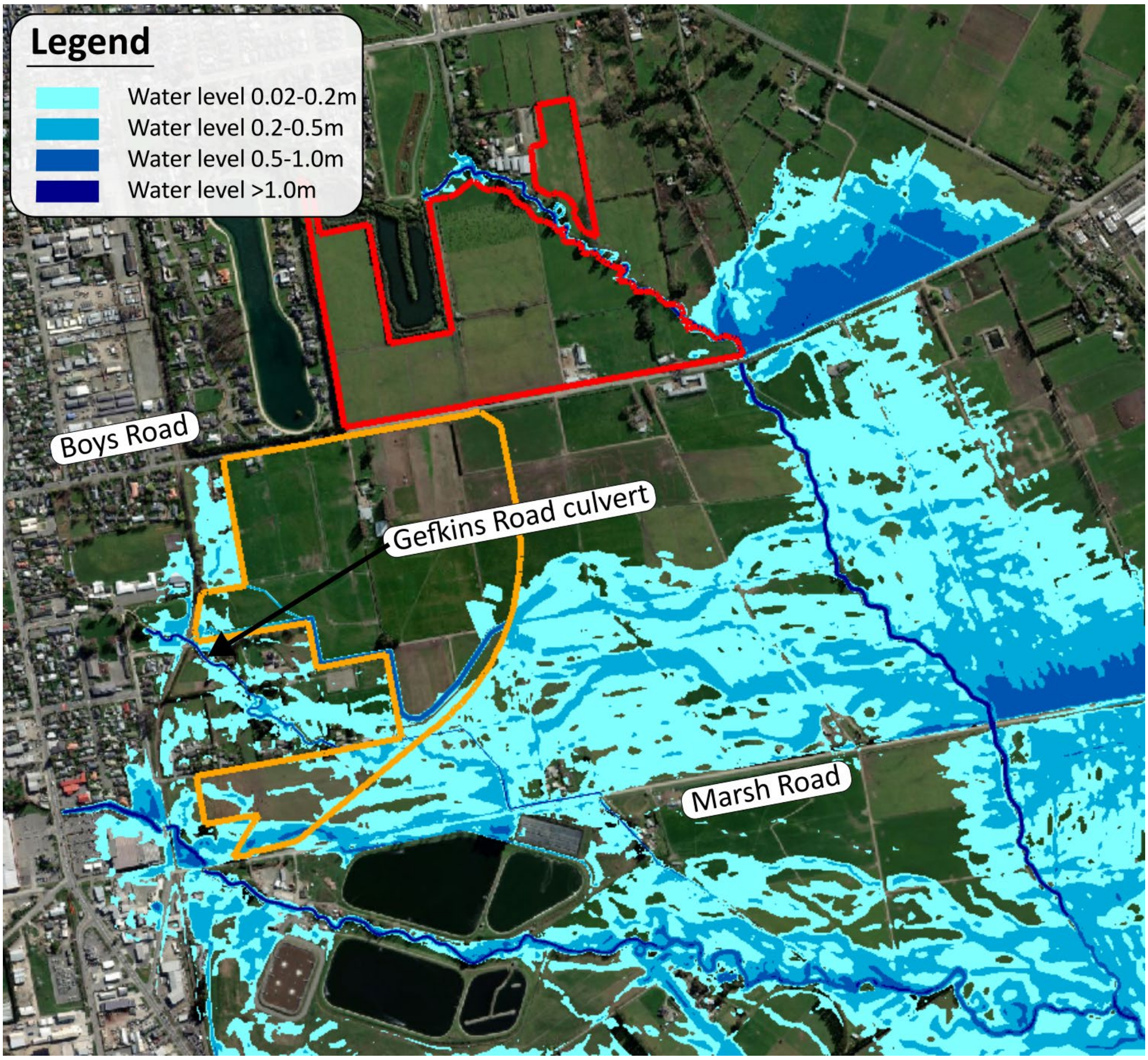


Figure 13: Post-Development 200 Year Flood Extent- Unblocked Scenario for Gefkins Road Culvert

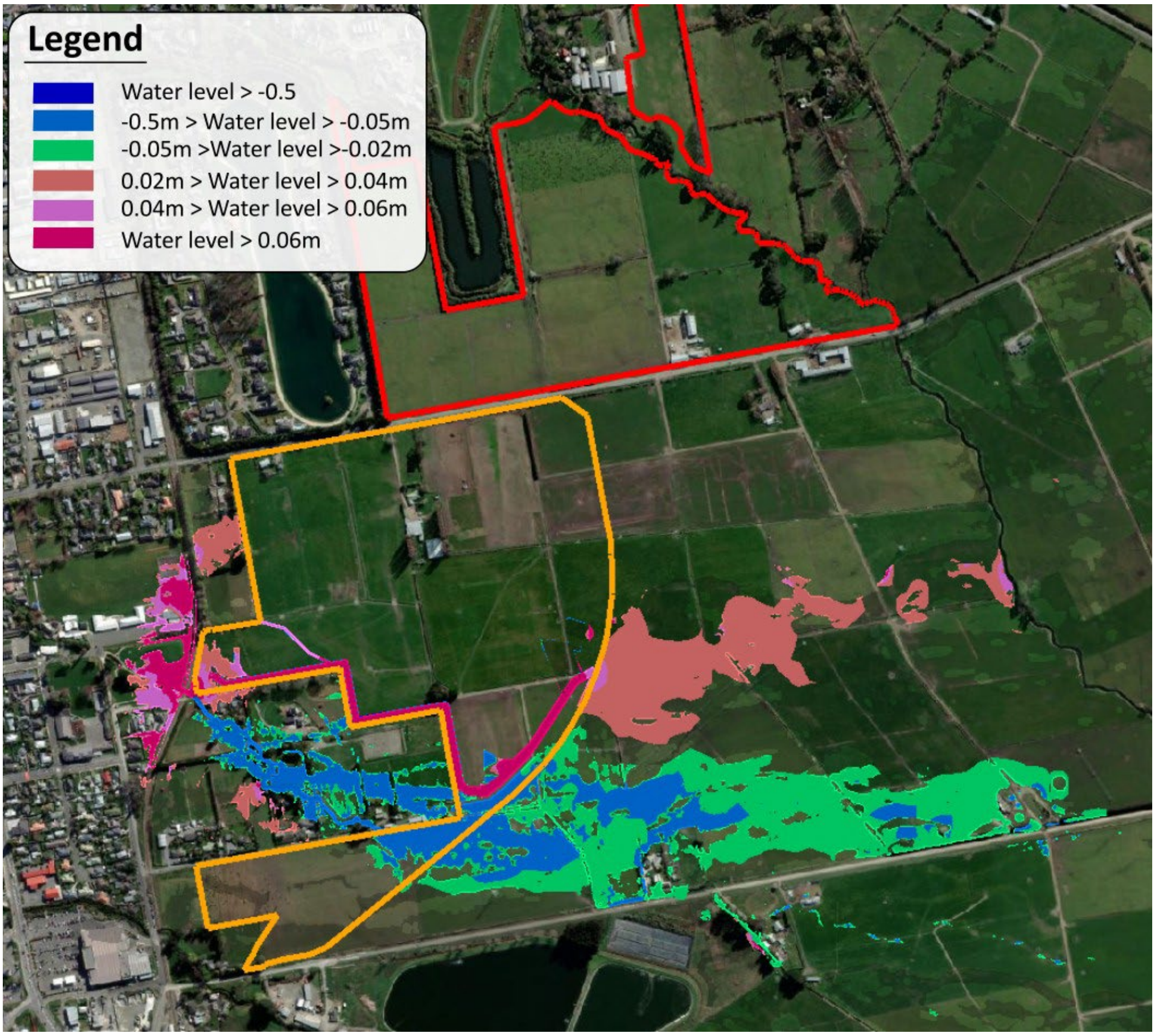


Figure 14 Difference in Pre-development 200-Year ARI Storm Event Flood Depths: Fully Blocked vs. Unblocked Scenario for Gefkins Road Culvert

8.1 BLOCK A

Post-development flood modelling results show the site is not impacted by flooding from Northbrook.

8.2 BLOCK B

Post-development flood modelling results demonstrate the effectiveness of the proposed flood mitigation measures (up to a 50-year ARI) and the implementation of a flood mitigation channel within the site. This channel is designed to manage overland flow from the contributing catchment along the western boundary and mitigate overtopping from Middlebrook. Notably, the proposed development area remains unaffected by flooding.

As discussed, two model scenarios were based on the fully open and fully blocked conditions for the Gefkins Road culvert. The fully blocked scenario represents the worst case, resulting in most of the Middlebrook flow diverting towards Block B, especially in the post-development scenario with the flood mitigation channel. While the fully blocked culvert (3.3m width x 0.78m height) is a conservative scenario, given the predominantly urban upstream conditions, its critical location just downstream of the spill point from Middlebrook stream necessitates its use as the worst-case scenario in flood modelling. This approach ensures thorough testing of the flood mitigation channel's capacity to manage floodwater effectively.

9.0 IMPACT ASSESSMENT OF POST-DEVELOPMENT FLOODING ON NEIGHBOURING PROPERTIES/ STRUCTURES (200-YEAR ARI STORM EVENT)

Comparison of the difference in flood levels between pre and post-development scenarios during the 200-year storm event, indicates no impact upstream of Blocks A and B, other than a small area on the northwestern side of Block B, where minor residual flooding is shown in an area with no habitable dwelling. Downstream, flood levels are increased.In either case. peak flood levels surrounding habitable dwellings are not increased by more than 20mm in the post-development scenario. However, there is an increase in flood depth of up to 60mm in non-habitable areas.

The flood modelling considered the worst-case scenario, fully blocking the culvert under Gefkins Road. Consequently, the flow diverted to Block B from the spill point of Middlebrook is estimated to be 6.6m³/s (compared to 3.8m³/s in the fully open culvert scenario) in the post-development scenario. The results indicate that the flood mitigation channel has sufficient capacity to manage the flow without adverse impacts on flooding in Block B.

The flood map difference between pre and post-development at the Northbrook Stream peak flow time indicates no impact of Block B post-development on the downstream (Figure 15 and Figure 16).

However, ponding occurs in areas north of Boys Road and Marsh Road before the peak flow of Northbrook stream, as illustrated in Figure 17 and Figure 18, which show two different timesteps prior to the peak flood levels being reached. This highlights the difference in time to peak between the subject site and the contributing catchment from the east of the roads, discharging to the same position. The modelling results demonstrate that ponding in these areas occurs for a longer duration in the post-development scenario.

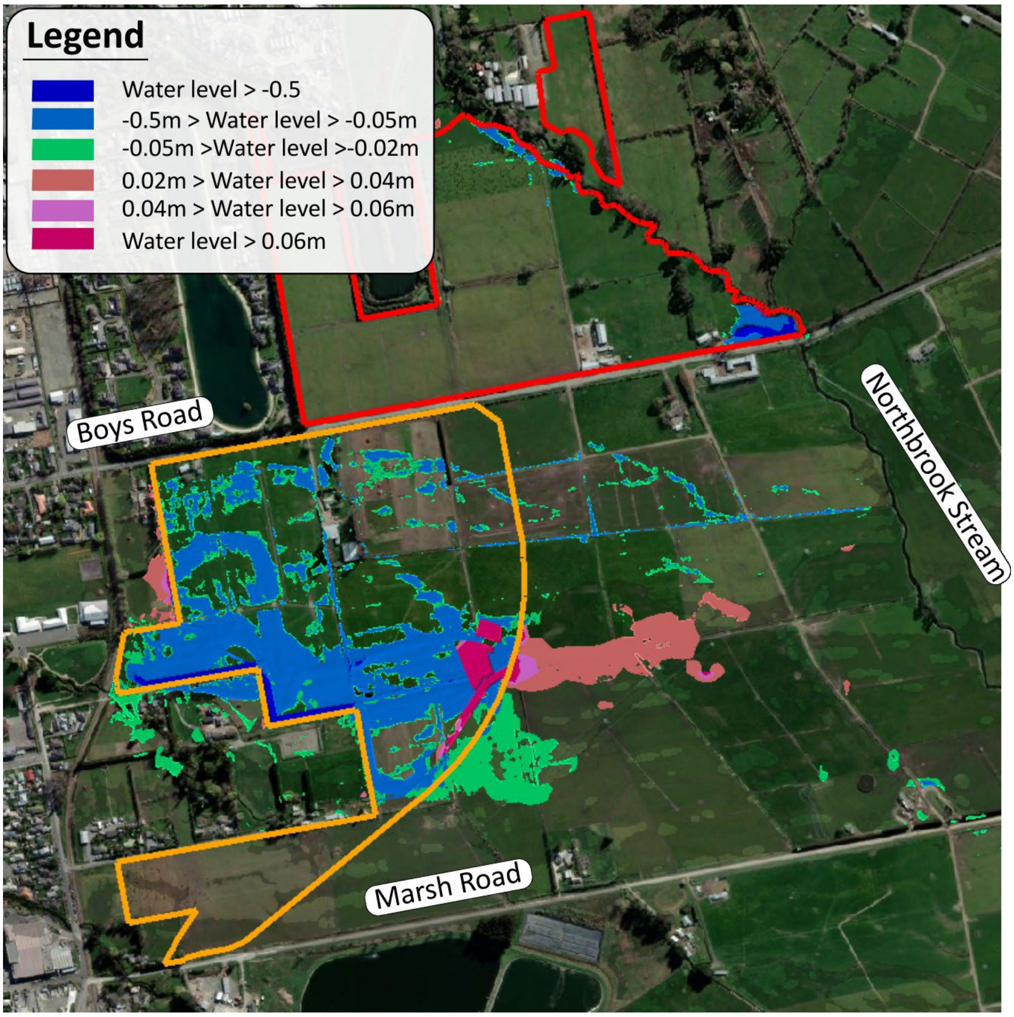


Figure 15: Difference Between Pre and Post-Development (At Peak Water Levels): 200-Year Flood Extent With Gefkins Road Culvert Blocked

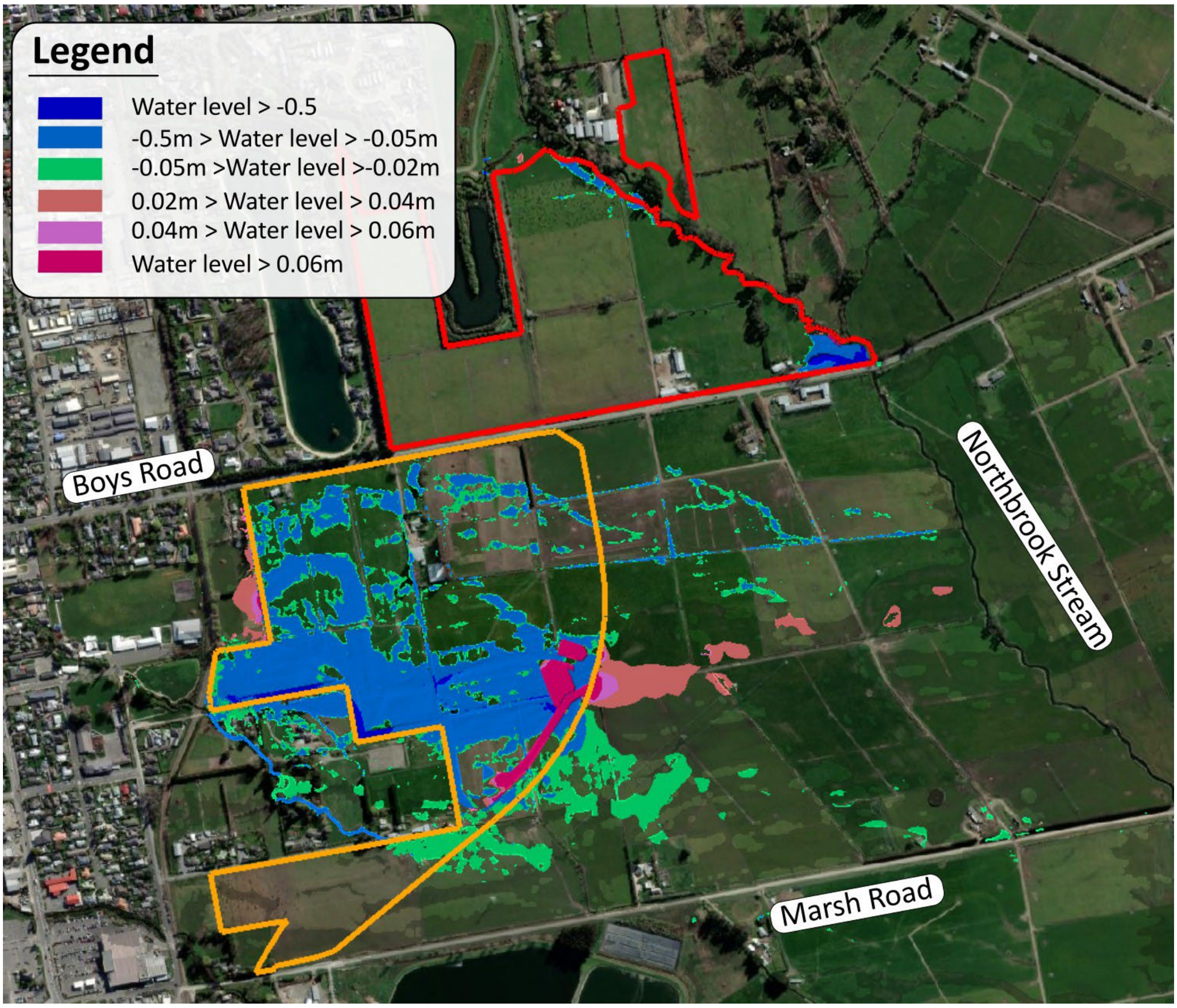


Figure 16: Difference Between Pre and Post-Development (At Peak Water Levels): 200-Year Flood Extents With Gefkins Road Culvert Unblocked

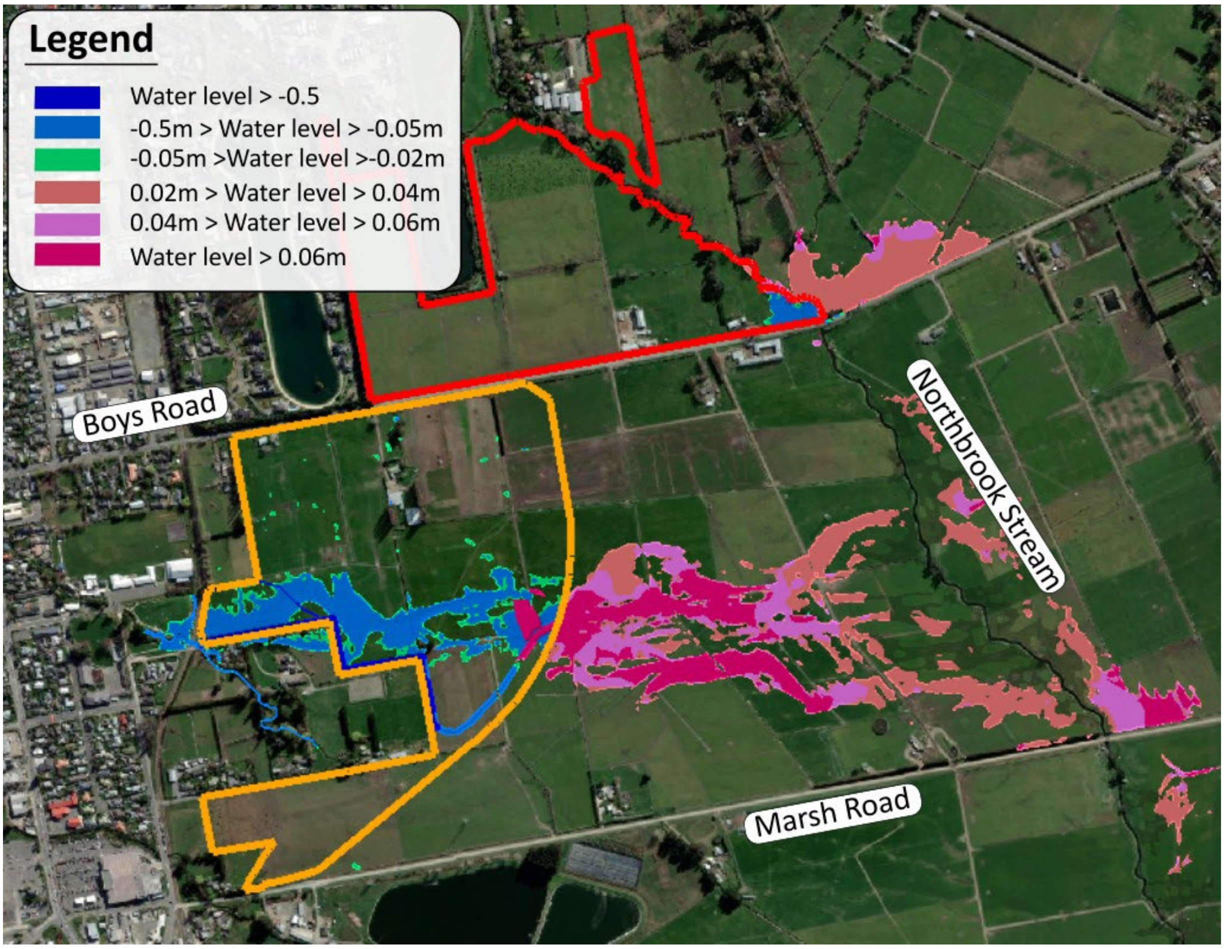


Figure 17: Difference Between Pre and Post-Development- Assuming Gefkins Road Culvert Blocked (13:30 Model Timestep): 200-Year Flood Extents.

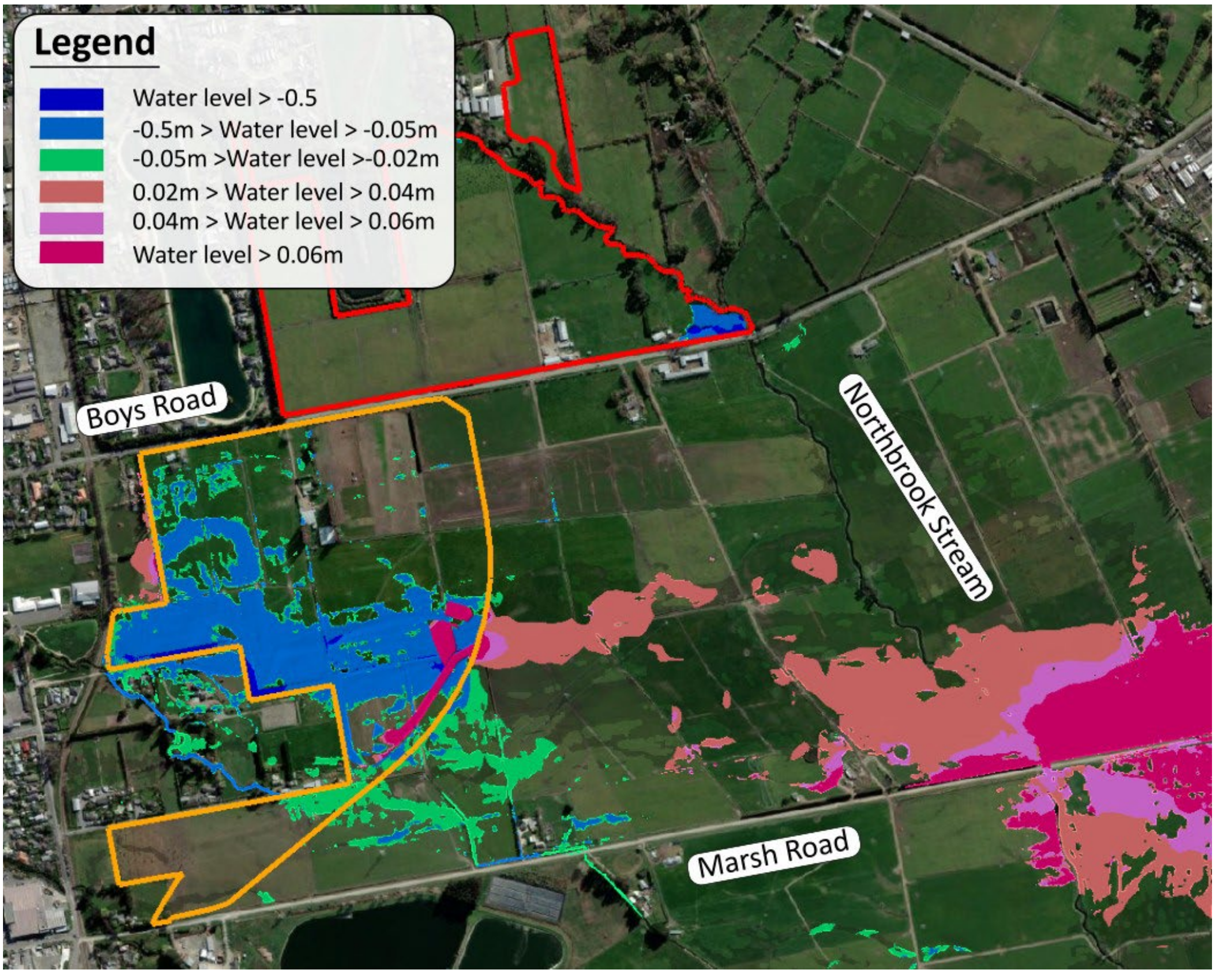


Figure 18: Difference Between Pre and Post-Development - assuming Gefkins Road Culvert Blocked (15:00 Model Timestep): 200-Year Flood Extents.

10.0 FLOOD MODELLING RESULTS– PRE-DEVELOPMENT MODEL, ASHLEY BREAKOUT SCENARIO

Figure 19 shows the flood modelled flood water levels in relation to the pre-development scenario of Block A and B for the 200 year ARI storm. Only the scenario for which the Gefkins Road culvert is blocked was modelled, as this is the critical scenario for the development.

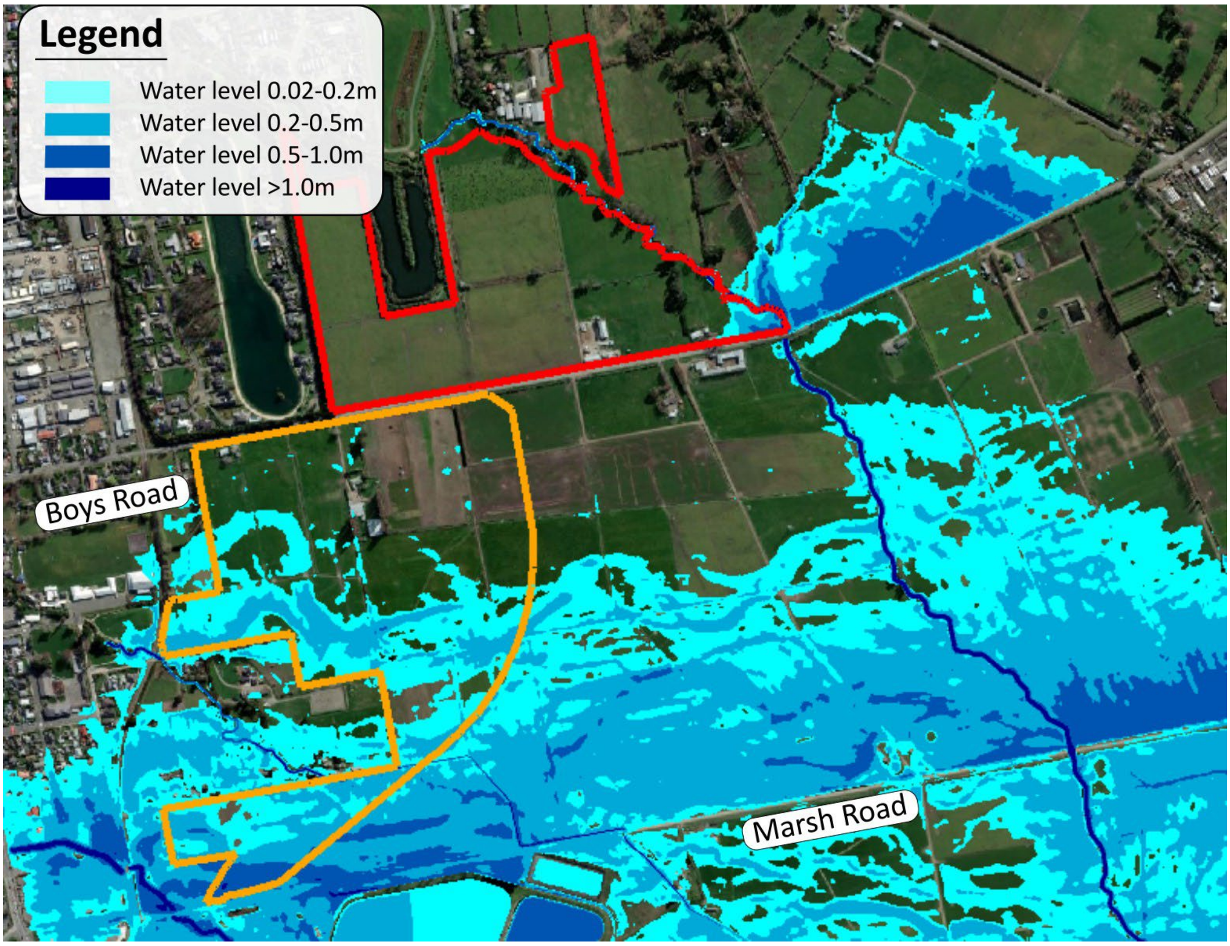


Figure 19: Pre-development Ashley Breakout Flood Modelling Results

10.1 BLOCK A

Pre-development flood modelling shows that the majority of the Ashley Breakout flows will pass from west to east below Boys Road. It is not anticipated that these flows will affect the site. Some flows from Northbrook will pond up behind Boys Road, with very minor overtopping of the road. The impeded flood waters here are less than the 200 year storm.

10.2 BLOCK B

Pre-development flood modelling shows that the majority of the Ashley Breakout flows will pass from west to east below Boys Road. Flows will pass through the centre of the site from breakout of Middlebrook Stream, and significant flows will pass over the very south area of the site.

11.0 FLOOD MODELLING RESULTS– POST-DEVELOPMENT MODEL, ASHLEY BREAKOUT SCENARIO

Figure 20 shows the flood modelled flood water levels in relation to the post-development scenario of Block A and B for the 200 year ARI storm. Only the scenario for which the Gefkins Road culvert is blocked was modelled, as this is the critical scenario for the development.

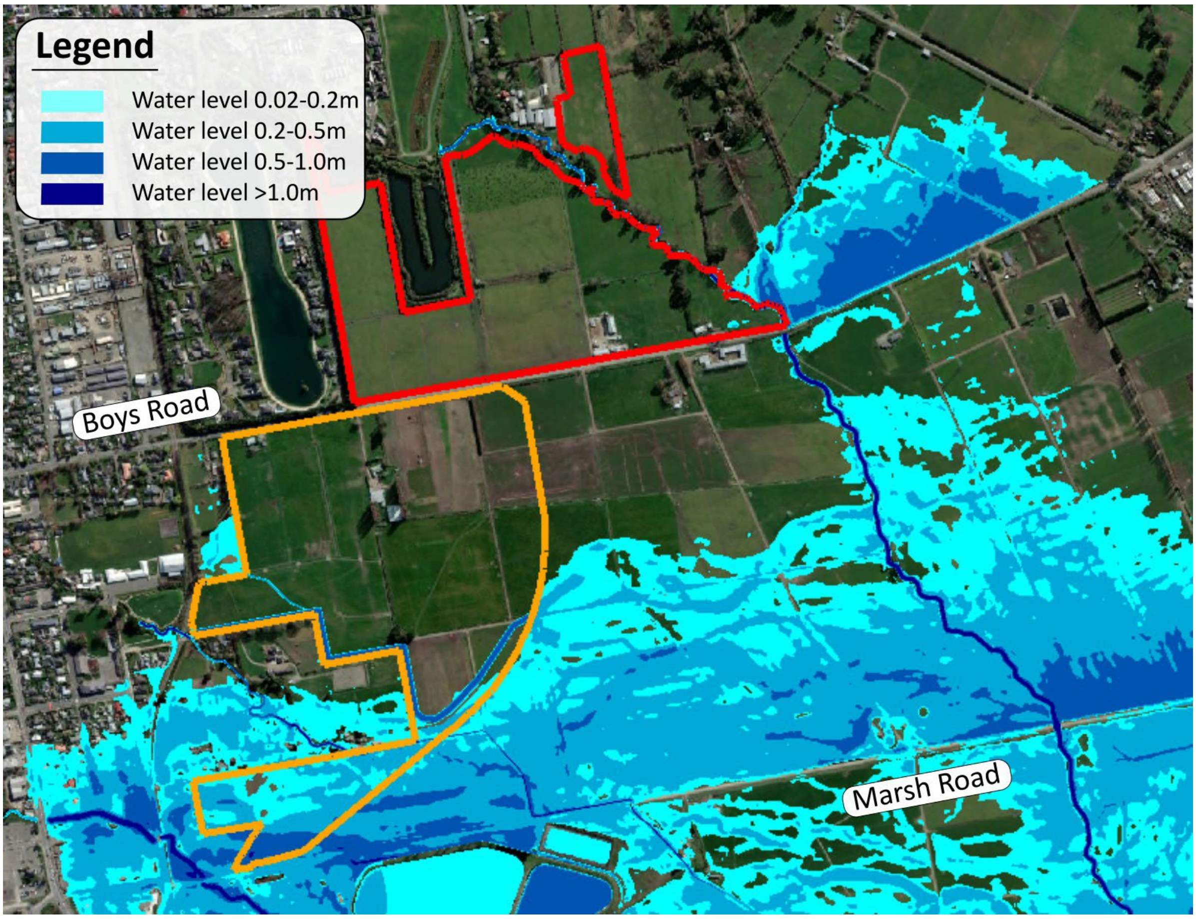


Figure 20:Post Development Ashley Breakout Flood Modelling Results

11.1 BLOCK A

Post-development flooding is very similar to pre-development, as shown in Figure 20. Some flooding is reduced on the site next to the culvert under Boys Road. Flows across Boys Road will be very minor.

11.2 BLOCK B

No changes in flows are anticipated in the southern section of the site. This indicates that the proposed development area of Block B will not be subject to flooding due to a breakout of the Ashley River.

12.0 IMPACT ASSESSMENT OF POST-DEVELOPMENT FLOODING ON NEIGHBOURING PROPERTIES/ STRUCTURES (ASHLEY BREAKOUT SCENARIO)

Flood levels were found to increase downstream of the flood mitigation channel. This is due to increased flows being concentrated due to the channel rather than being spread out over the entire width of land. This is not considered an issue as there are no habitable dwellings in this area. This is shown in Figure 21.

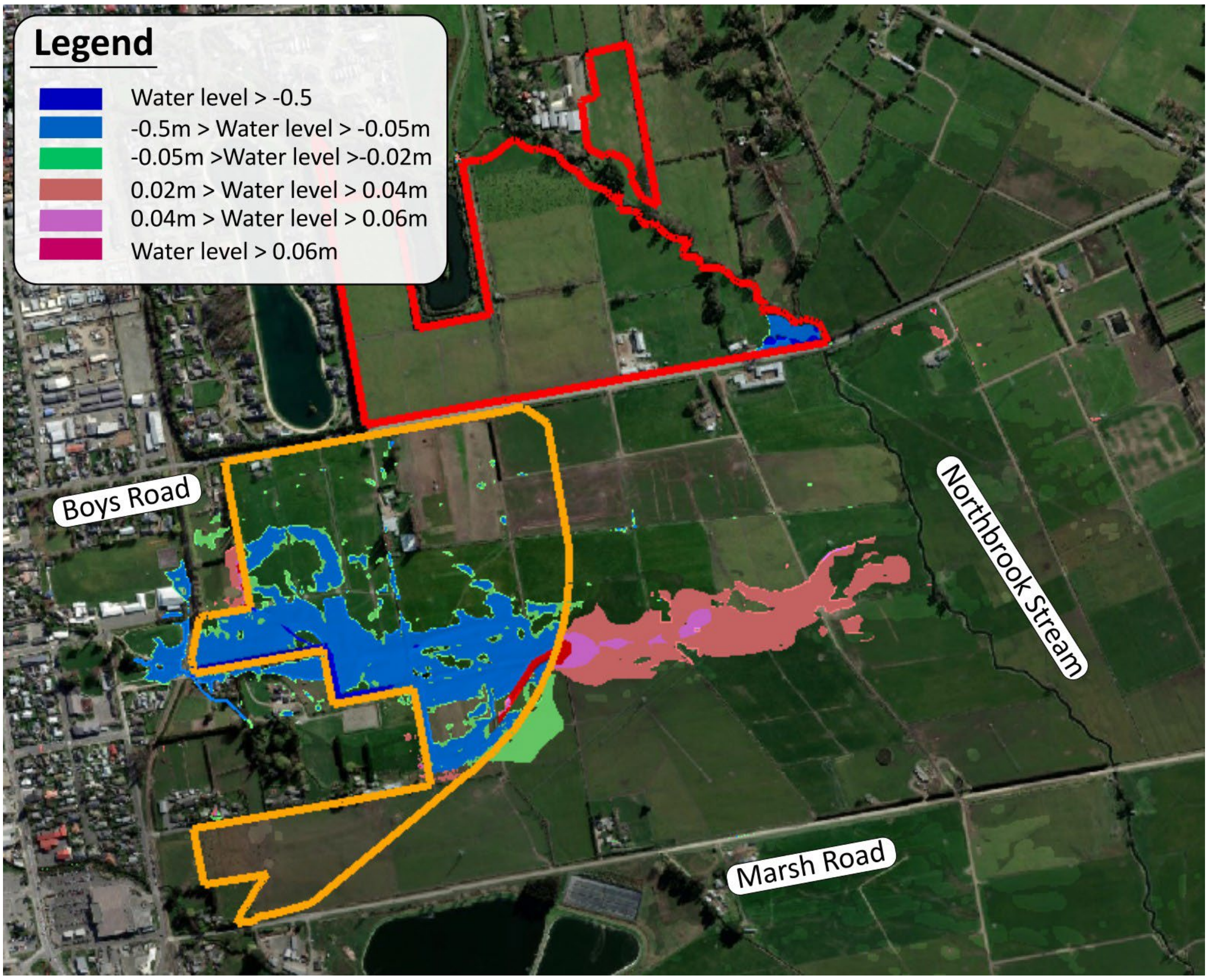


Figure 21: Difference Between Pre and Post-Development (At Peak Water Levels): Ashley Breakout Scenario with Gefkins Road Culvert Blocked

13.0 FLOOD HAZARD ASSESSMENT

13.1 FLOOD HAZARD ASSESSMENT CRITERIA

To assess the flood hazard, we have generated maps showing the flood hazard on and nearby the site. These are based on the Australian Rainfall-Runoff Guidelines (2019) hazard assessment methodology. Colours within the maps correspond to Figure 22 for flood hazard. The flood risk for both blocks is higher for the 200 year ARI storm than the Ashley Breakout scenario, hence, only the 200 year ARI storm flood risk has been assessed.

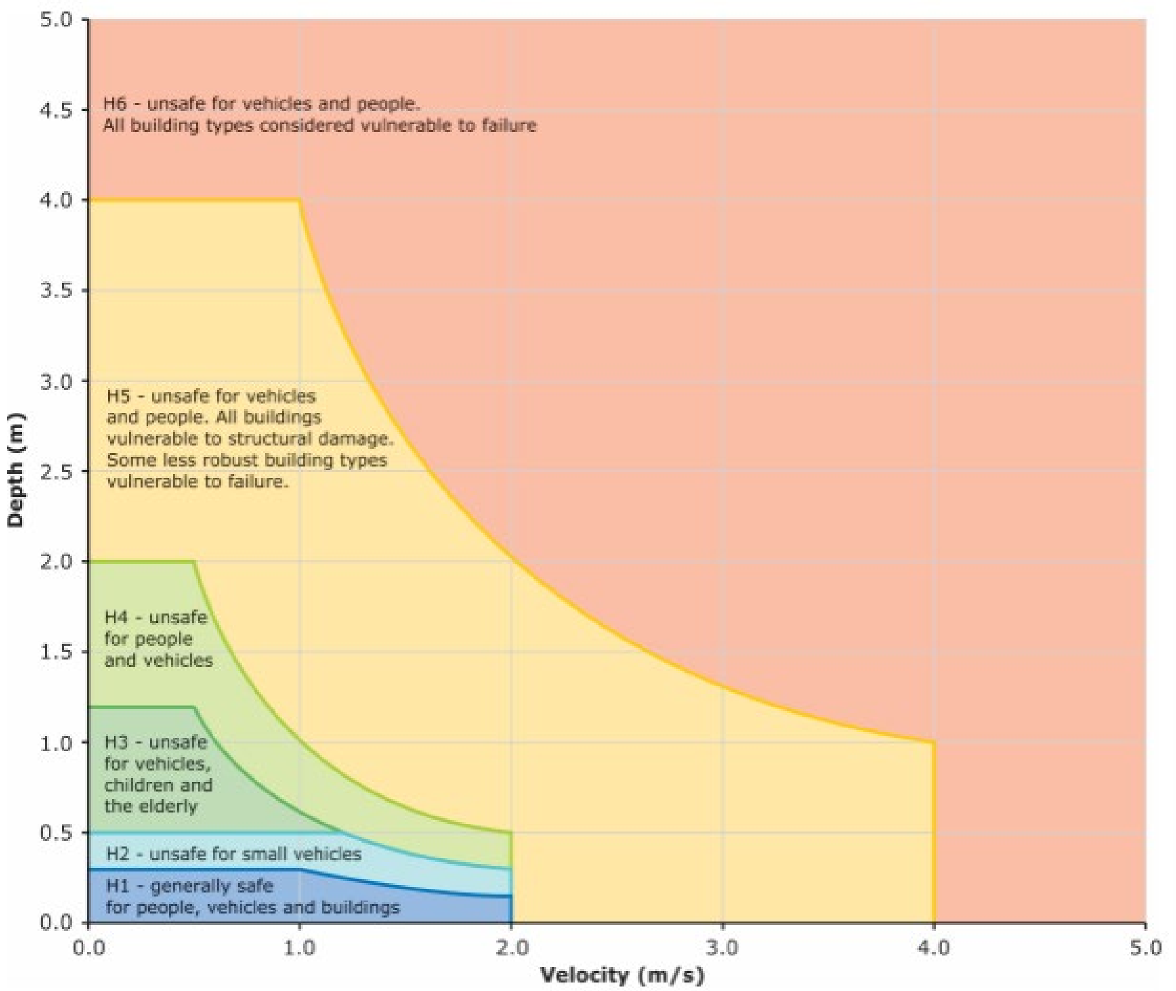


Figure 22: Flood Hazard Curves From The Australian Rainfall-Runoff Guidelines (2019)

13.2 BLOCK A

The main risk to block A is within Northbrook stream, as shown in Figure 23. The risk category is 5, indicating high risk. However, the flood flows are contained with Northbrook, and the development will be outside its extent. It is not anticipated that this will be a risk to the development or people within it. The flood hazard risk is confined to the stream and SMAs.

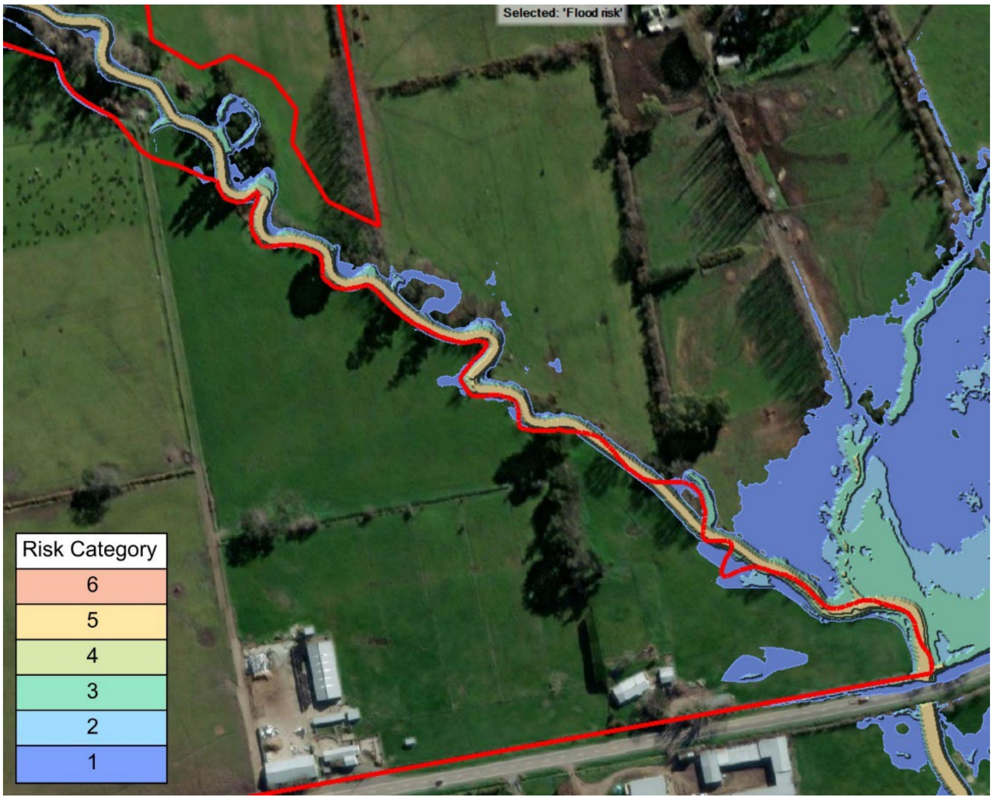


Figure 23: Flood Risk Assessment - Block A – 200 Year ARI Storm

13.3 BLOCK B

The main risk to Block B is within the flood mitigation channel, as shown in Figure 24. Flood results below are indicative of if the Gefkins culvert is blocked, resulting in the highest flows through the channel. The risk category is 4, indicating high risk. At this stage, the channel dimensions have been assumed, and as such, the risk category may change depending on the channel dimensions but indicate that the channel will be of a high risk. A safety in design approach will be used during further design of this channel to minimise associated health and safety risks. Given that it is proposed that the channel is located away from the development, it is not anticipated that this will be a risk to the development or people within it.

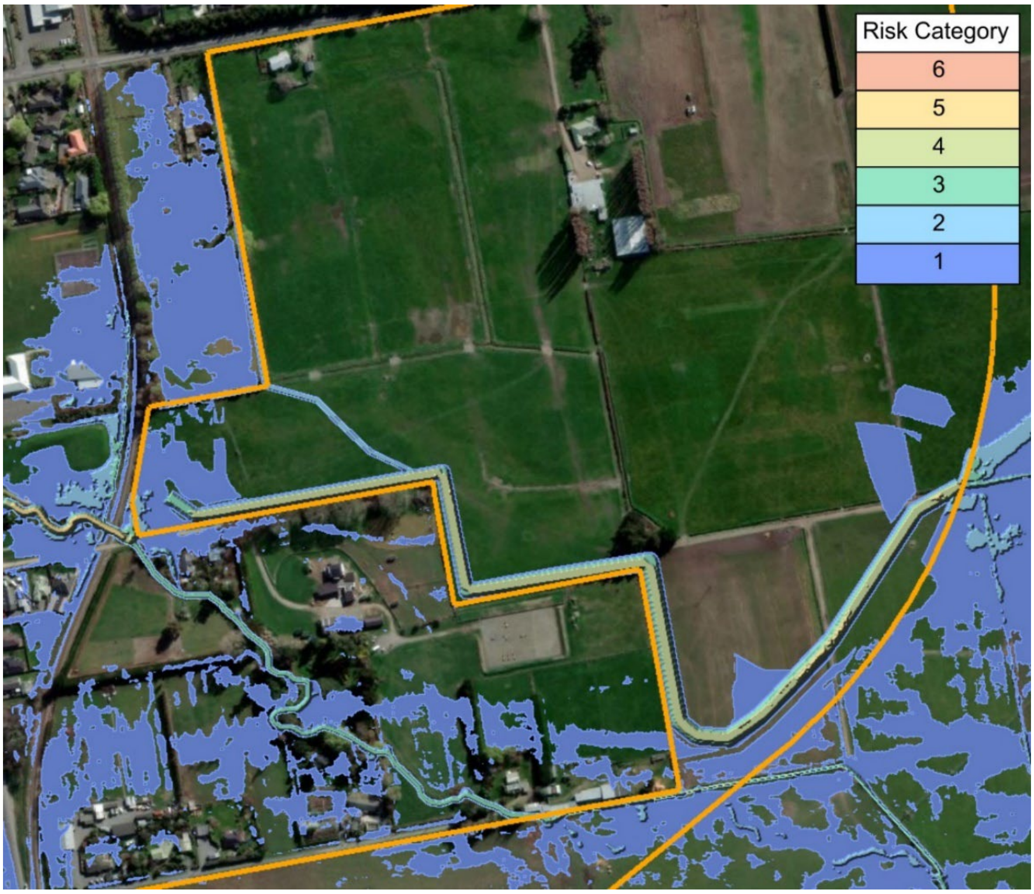


Figure 24: Flood Risk Assessment - Block B – 200 Year ARI Storm

14.0 BENEFITS OF DEVELOPMENT ON FLOODING

Currently, storm flows passing over the site south of Boys Road are spread widely over the land. The proposed flood mitigation diversion channel will divert stormwater flows into a single point, which can then be safely piped underneath the proposed future highway. This would allow a significant decrease in stormwater measures needing to be designed and built under the highway.

15.0 SOUTHERN PORTION OF BLOCK B (POTENTIAL BLOCK C)

As explained earlier in this report, the flood modelling to date has not allowed for any development in the very southern section of Block B, referred to here as Block C for clarity, as shown in Figure 25. The future use of Block C is undetermined and assumed to be in its existing condition in this report. If such development occurs, thorough flood modelling will be required to assess post-development conditions and devise effective mitigation strategies. This is likely to involve designing a significant conveyance channel to redirect floodwater from the upstream contributing catchment, minimising the impact of the development on flooding, but also reducing the land area available for redevelopment.

The dimensions and location of the channel must be carefully designed, considering on-site constructability, topography, and evaluating performance through flood modelling to confirm the optimal and efficient size and location. Special attention will be necessary to prevent any risk of flooding for the public wastewater pond, which could be affected by Southbrook Stream.

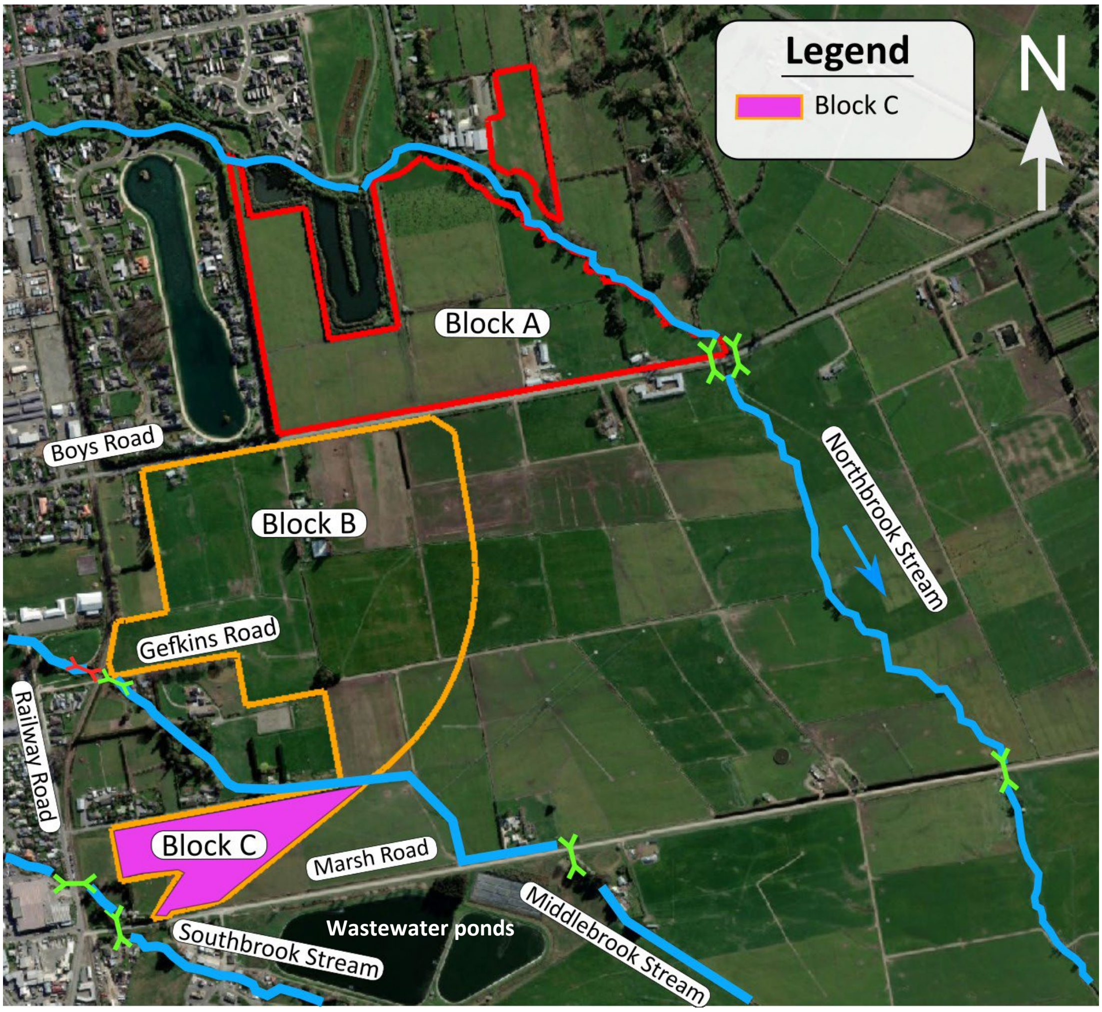


Figure 25 Southern Portion of Block B (Potential Block C)- Future use undetermined, assumed as existing condition

16.0 FURTHER WORKS AT DETAILED DESIGN STAGE

It is anticipated that as part of detailed design, the flood mitigation channel will be modified to better integrate with the development, likely being utilised as a green walkway or similar feature. It is also anticipated that ground levels and the overall design of the development will change. In both cases, the flood modelling should be updated for changes made. In addition to this, the stormwater system will be modelled, which will allow a better estimation of downstream effects to be accounted for.

Sensitivity testing will need to be carried out, allowing for higher Mannings roughness values, and stream/culvert blockages, to ensure that the development will not be affected in extreme cases. To date, only the most critical culvert (Gefkins Road culvert) has been considered blocked and it is not anticipated that other culvert blockages will have a significant impact on flooding of the development.

At this stage, only the 200 year ARI storm has been run within the model. As mentioned by Council during the pre-application meeting, further modelling of smaller storm events will be necessary at the Resource Consent stage. It will also be necessary to model the developments effects on the Ashley breakout scenario, once flows from the development are known.

Lastly, the modelling could be expanded to take into account the stream to the east of the site (beside Camside Road), to better understand the effect this might have on the flooding in the surrounding areas. However, this has not been added to date because it is unlikely to affect flood levels significantly, as Boys Road and Marsh Road are both shown to be overtopped with flooded waters. Spilling across these roads is likely to control the flood levels, and additional flow will only result in small increases to the flood level.

It is anticipated that further discussion with WDC will be undertaken to confirm additional modelling requirements for resource consent.

17.0 CONCLUSION

Fraser Thomas has conducted flood hazard modelling utilising HEC-RAS 2D software for the subject site and adjacent properties, considering both pre and post-development scenarios for the 200-year storm. Additionally, the post-development scenario incorporates flood attenuation measures for up to a 50-year ARI storm event, along with an assessment of the Ashley River Breakout scenario. Both pre-development and post-development situations were modelled to indicate the effect the development would have on flood hazards within the site and upstream, adjacent, and downstream of the site.

It was found that during a 200 year storm event:

(a) The development area within both Blocks A and B will not be subject to flooding.

(b) The development at Blocks A and B has no adverse impact on the upstream catchment areas.

(c) In the post-development scenario, there is negligible impact on maximum flood depth at Boys Road or Marsh Road.

(d) The flood modelling for the 200 year storm event shows that the development complies with Waimakariri District Council requirements, as the peak flood levels surrounding habitable dwellings both upstream and downstream of the site are not increased by more than 20mm.

(e) It was found that the development will have no impact on the flood levels or flows within Middlebrook and Southbrook.

(f) It is anticipated that the proposed development will have no effect on the Council wastewater ponds south of Block B. The proposed flood mitigation channel will ensure no additional flows are discharged to the contributing catchment of the wastewater ponds.

(g) The culvert under Gefkins Road is located just downstream from the Middlebrook spill point into Block B. Blockage of this culvert could result in increased flooding in Block B. However, the conservative fully blocked culvert scenario was run, demonstrating no adverse impact on flooding in Block B. The proposed flood mitigation channel has proven effective in managing the flow without compromising flood mitigation.

(h) Heightened flood hazard risk is confined to Northbrook stream and the flood mitigation channel. These have a reasonable setback to any development, and there should be no reason for people to be nearby these areas during a peak storm event. Hence, these are not considered to be a high risk overall to the development. The flood hazard risk is confined to the stream and SMAs.

(i) The analysis revealed that the primary source of flooding in Block B originates from water in the upstream catchment along the western boundary, including overflow from the Railway and overtopping from the Middlebrook stream bank, particularly near the spill point of the Gefkins Road Driveway culvert. The proposed flood mitigation channel in the post-development scenario is intended to manage these floodwaters with the aim of minimising adverse impacts both upstream and downstream. It is imperative to highlight the critical role of the flood mitigation channel in the model, where any modifications to its design have a substantial impact on the overall model. Despite the existing high-level design, a careful approach in the detailed design stage is essential to ensure minimal impact.

It was found that during the Ashley River breakout scenario:

(a) The development area within Block A will not be subject to flooding. The majority of the Ashley breakout flows occur south of the site, and will not affect Block A area.

(b) The development area within Block B will not be subject to flooding. The majority of the Ashley breakout flows occur in the very south of the site (potential Block C), Block B (northern half) can be kept free from flooding by the installation of a flood mitigation channel.

(c) It is anticipated that the proposed development will not affect the Council wastewater ponds south of Block B. The flood mitigation channel will ensure no additional flows are discharged to the contributing catchment of the wastewater ponds.

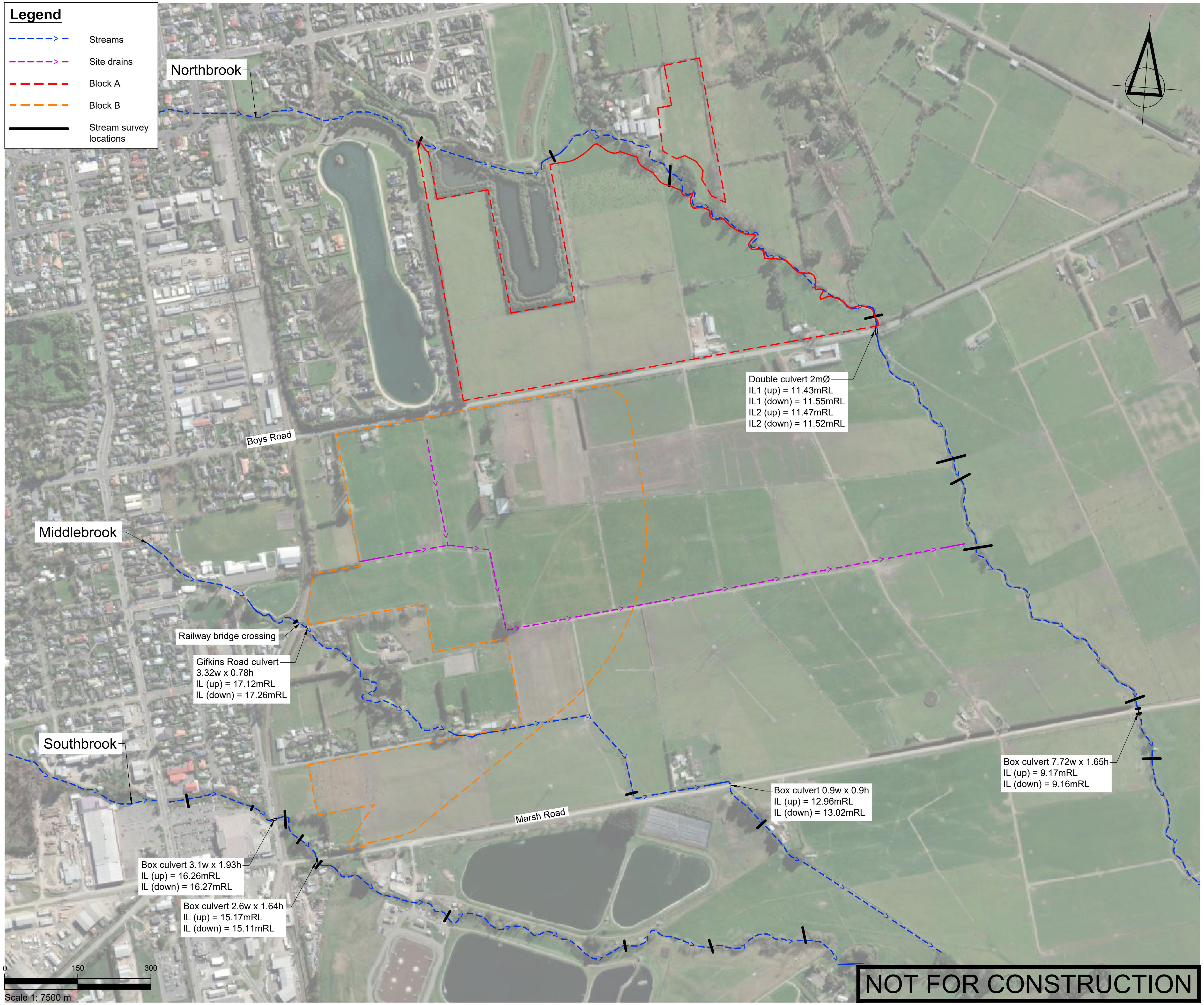
(d) Flood hazard risk for blocks A and B is lower than the 200 year ARI storm event flood risk, subject to implementation of the flood mitigation measures referred to in this report.

Any future development of Block C (southern portion of Block B) will require flood modelling and flood mitigation and/or conveyance measures to convey upgradient flood waters through this area. This will most likely involve providing a significant conveyance channel to direct these flows from west to east through this area which will reduce the land available in this block for redevelopment. The future use of Block C is undetermined and assumed to be in its existing condition in this report.

Fraser Thomas, therefore, believes that the site is suitable for rezoning for urban development with regard to flooding. Further modelling will be required once the site layout and finished ground level plan has been finalised to check stormwater management device sizing and confirm the design objectives are achieved. This will ensure that flood risk is minimised within the development, and does not exacerbate upstream or downstream effects. This should be done during the Resource Consent stage.

Appendix A

Input Data Plan



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SURVEYED			APPROVED / DATE
DESIGNED	TB	06/09/23	
DRAWN	TB	06/09/23	
CHECKED			

REVISION	CHANGES	CHECKED	DATE

NOTES

CLIENT
SPARK BROTHERS LIMITED

PROJECT
NORTHBROOK SUBDIVISION

TITLE
PREDEVELOPMENT SITE PLAN AND SURVEY INFORMATION

Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

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HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
BLENHEIM	03 428 3292
NELSON	03 222 1132
TAURANGA	020 4118 9465

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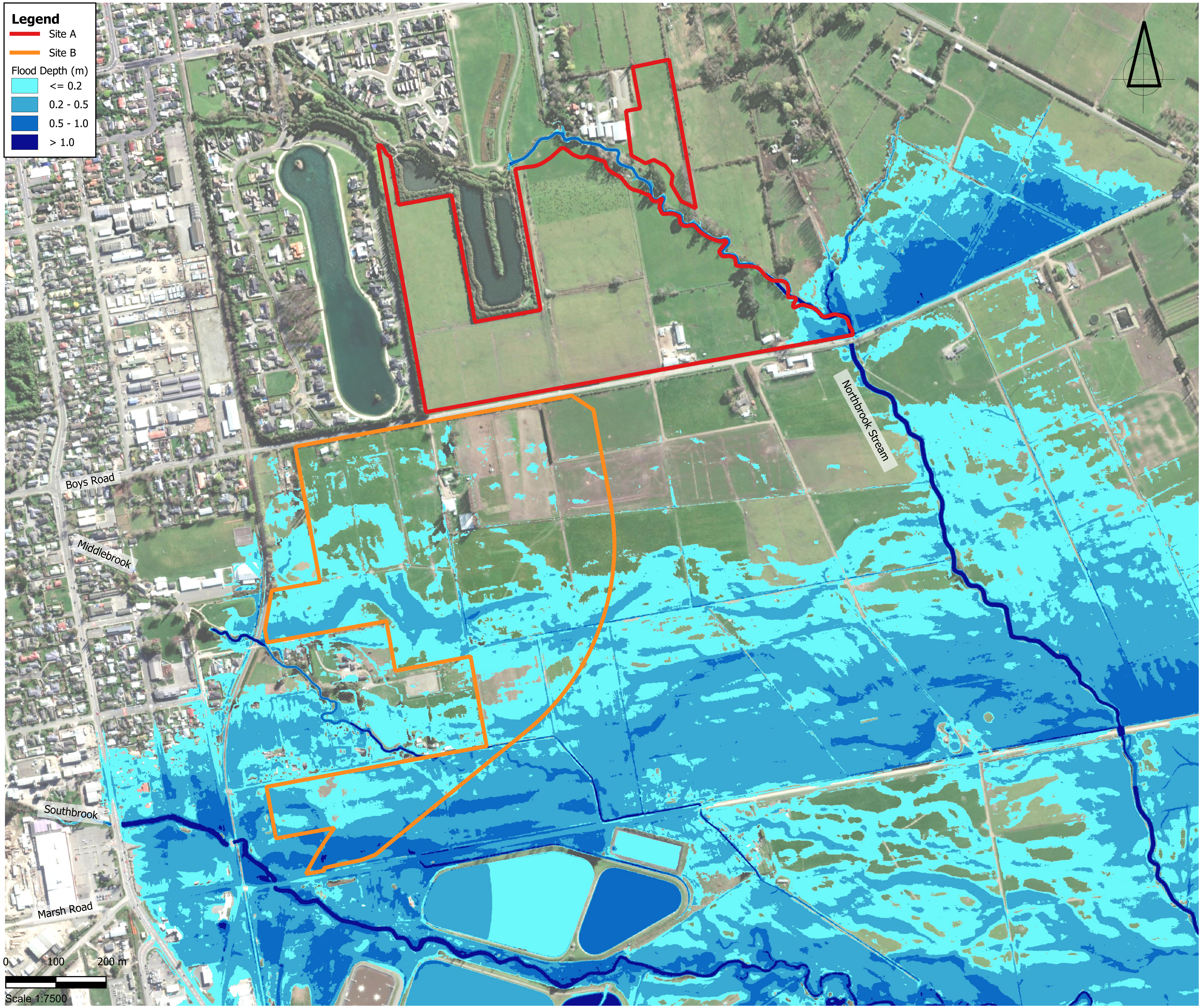
SCALE 1:7500 (A3)

DRAWING No CH01058/FR/001
REVISION -

Appendix B

Flood Maps



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SURVEYED			APPROVED	DATE
DESIGNED	TB	26/01/2024		
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REVISION	CHANGES	CHECKED	DATE

NOTES

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PROJECT
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TITLE
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PREDEVELOPMENT SITUATION

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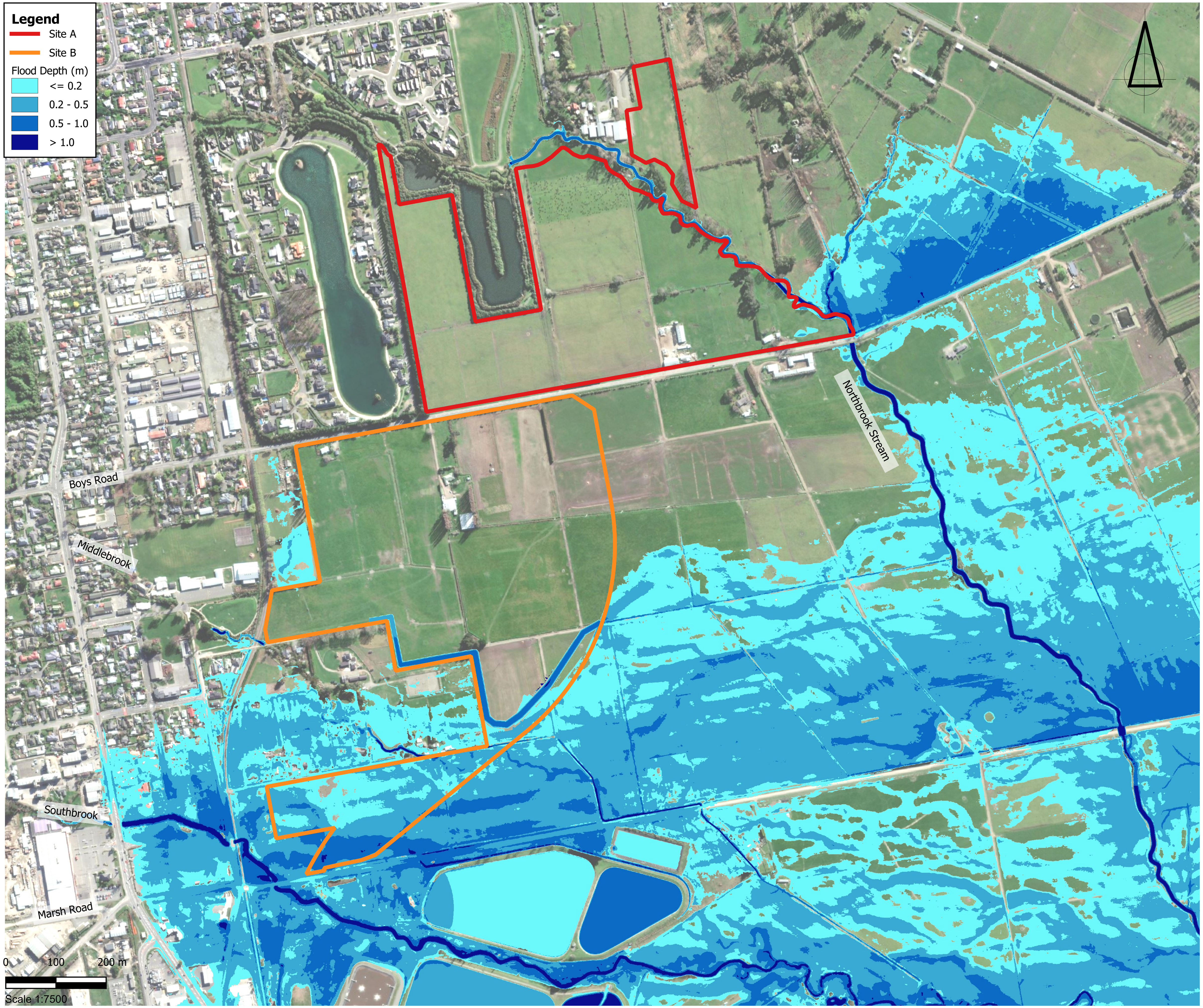
REVISION



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SURVEYED			APPROVED	DATE
DESIGNED	TB	26/01/2024		
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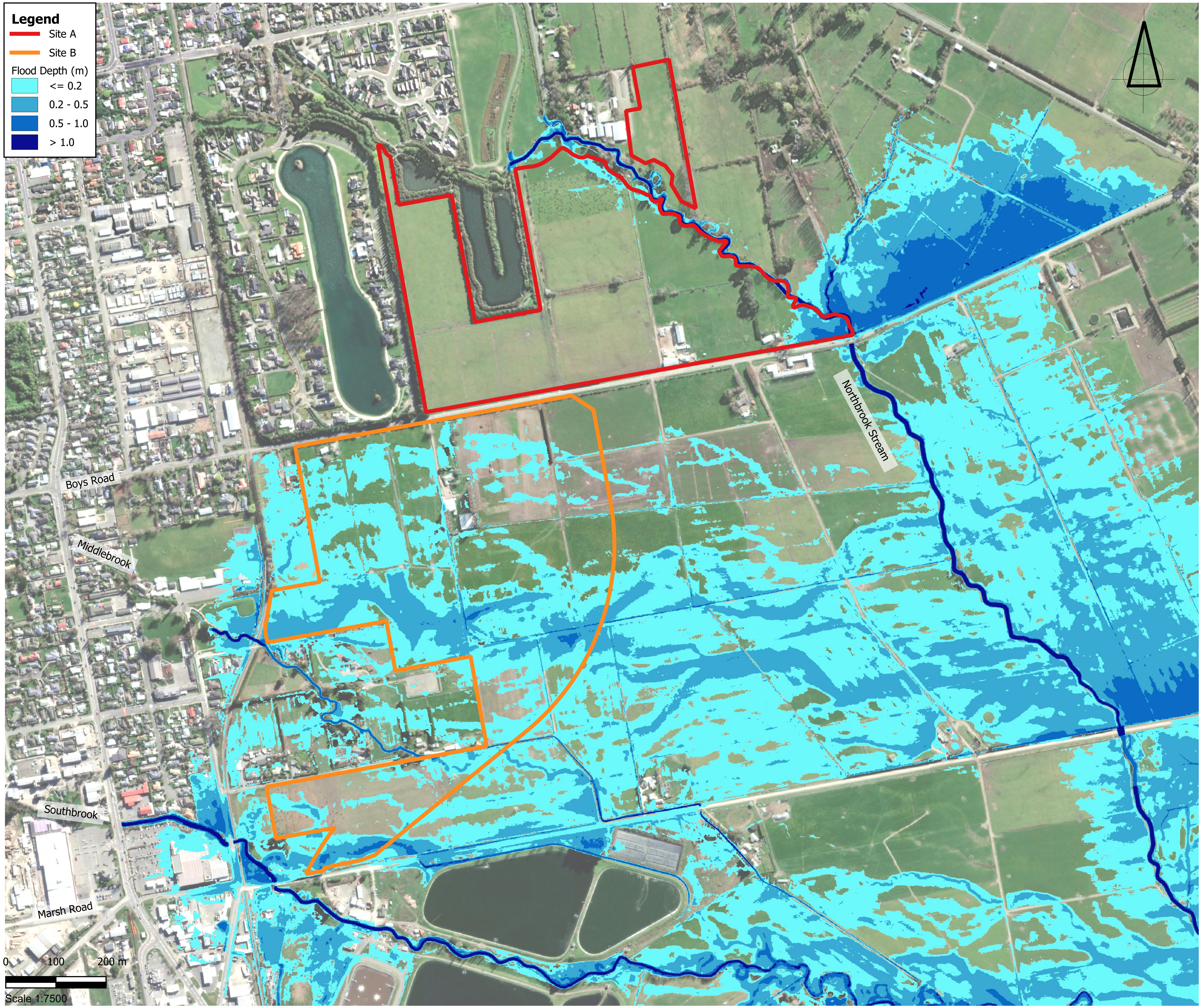

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PRE DEVELOPMENT 200ARI GIFKINS ROAD - CULVERT BLOCKED

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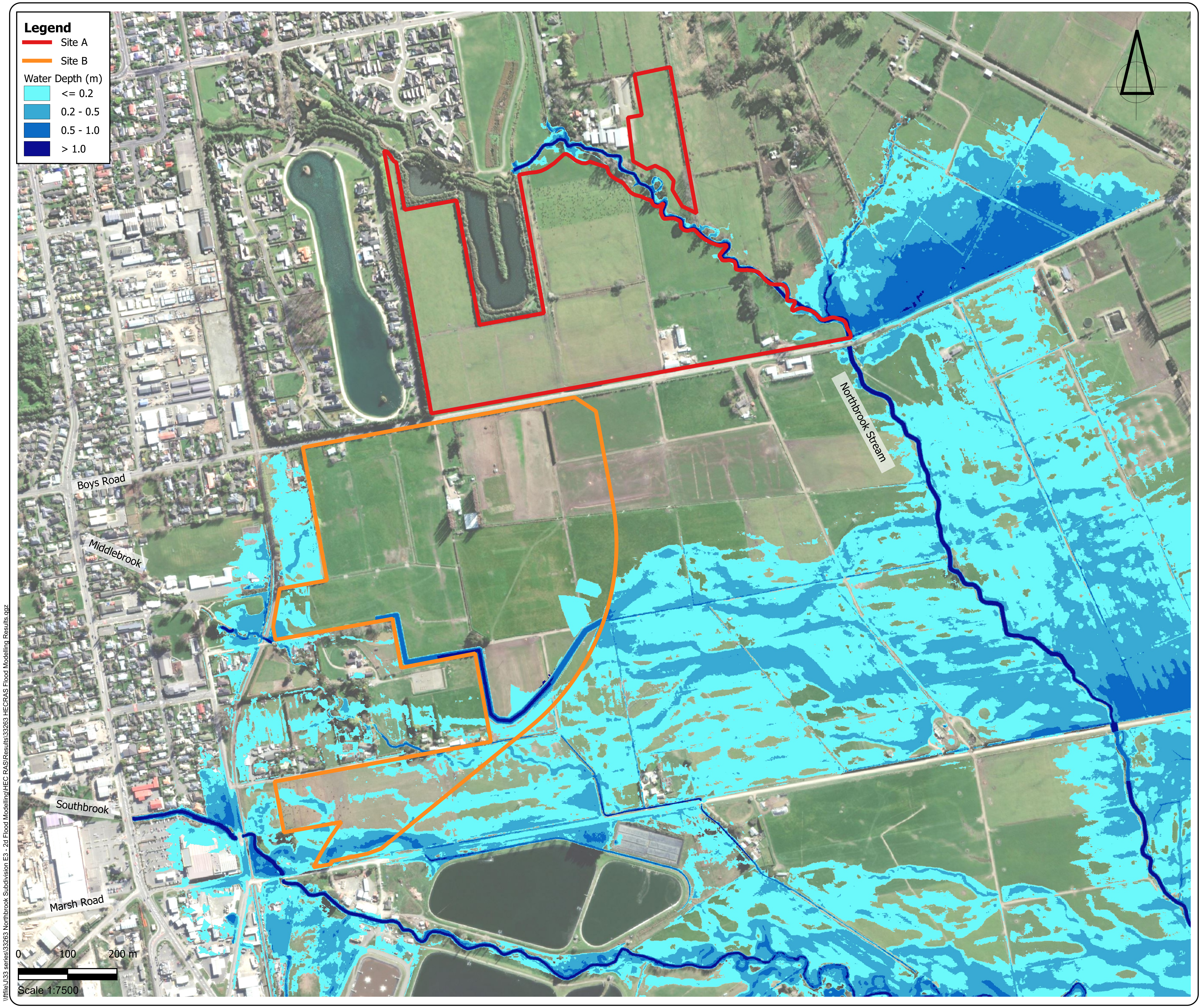
DRAWING No CH01508/FR/012 REVISION



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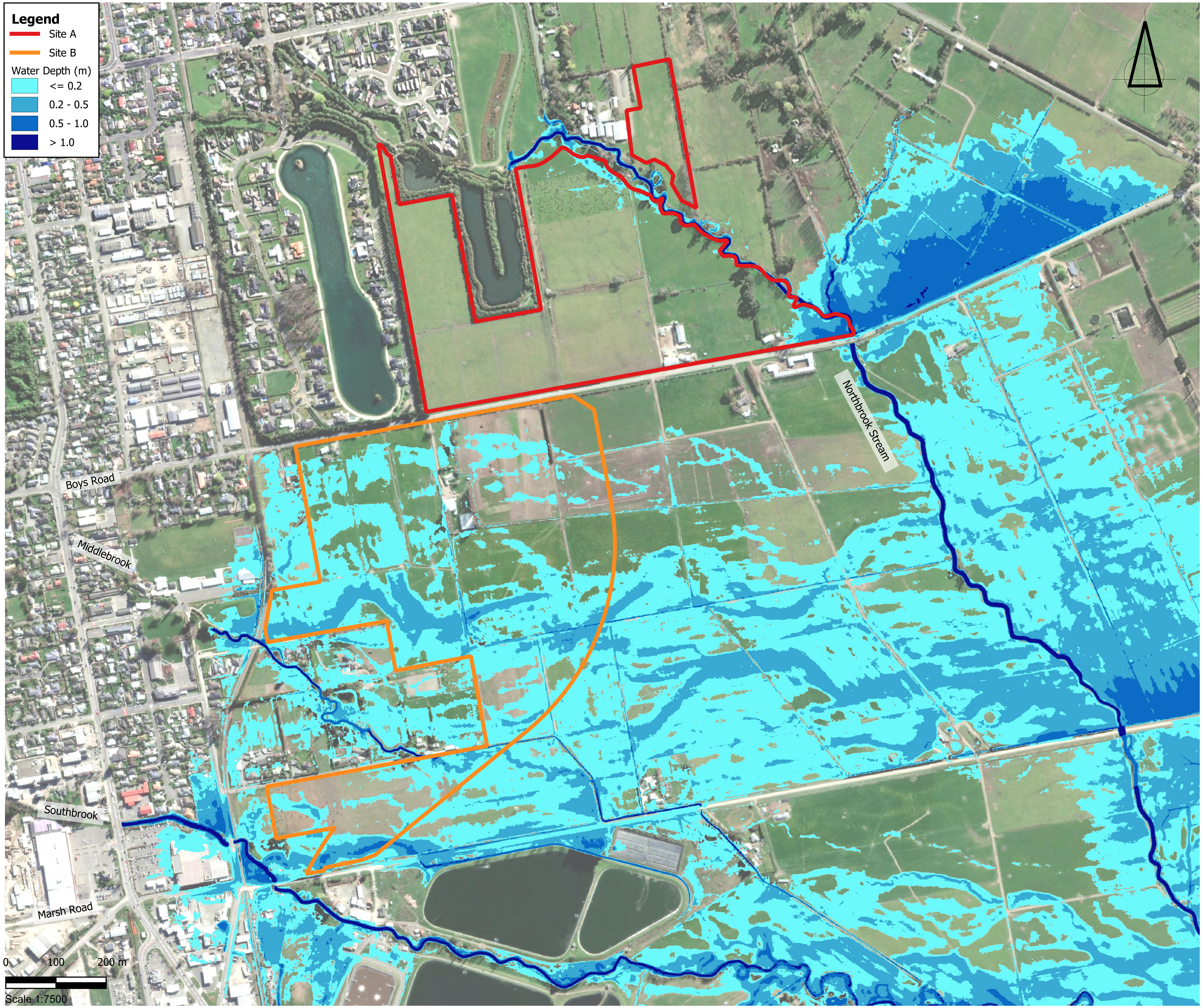

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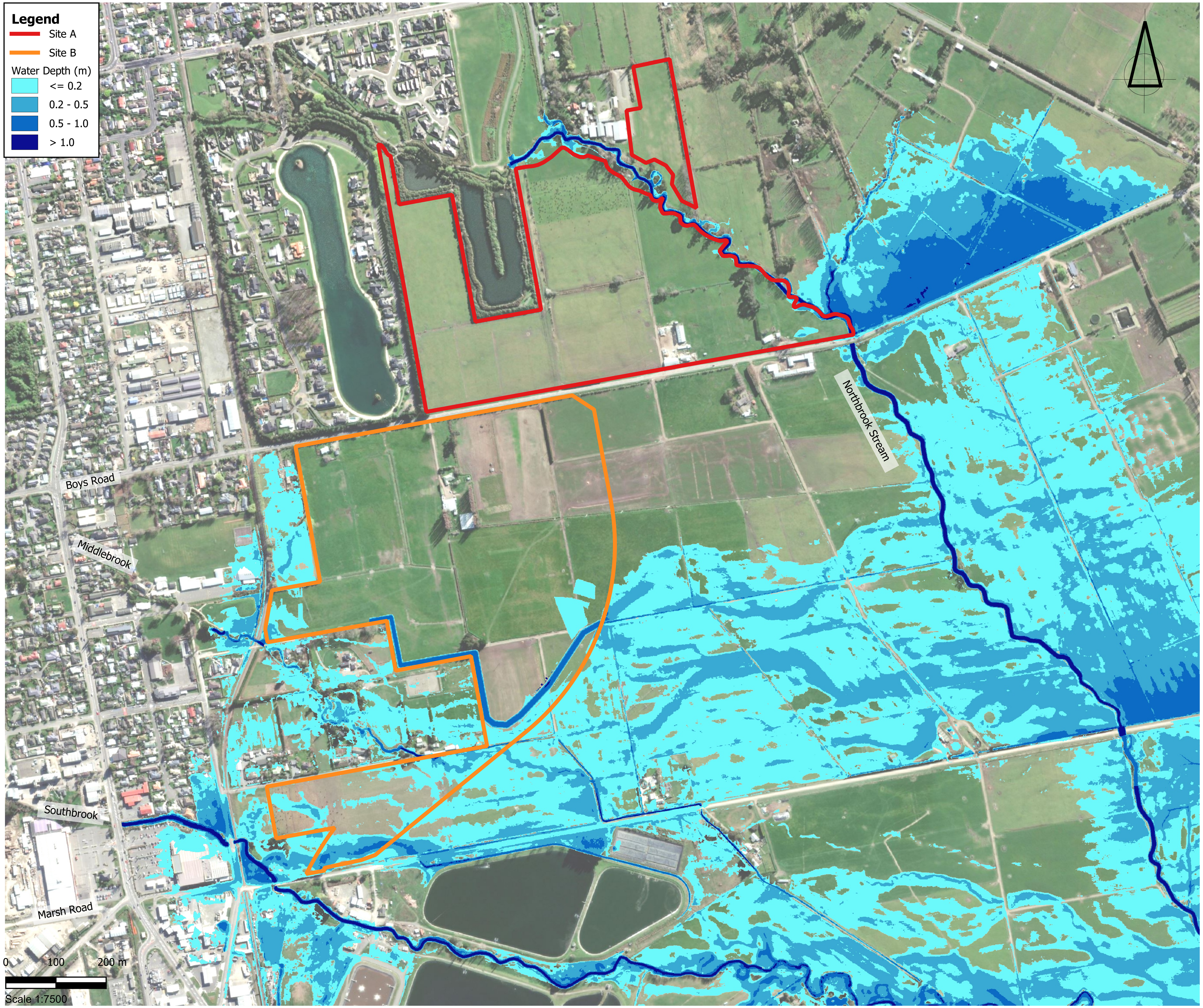
SCALE 1:7500 A3

DRAWING No CH01508/FR/014

REVISION



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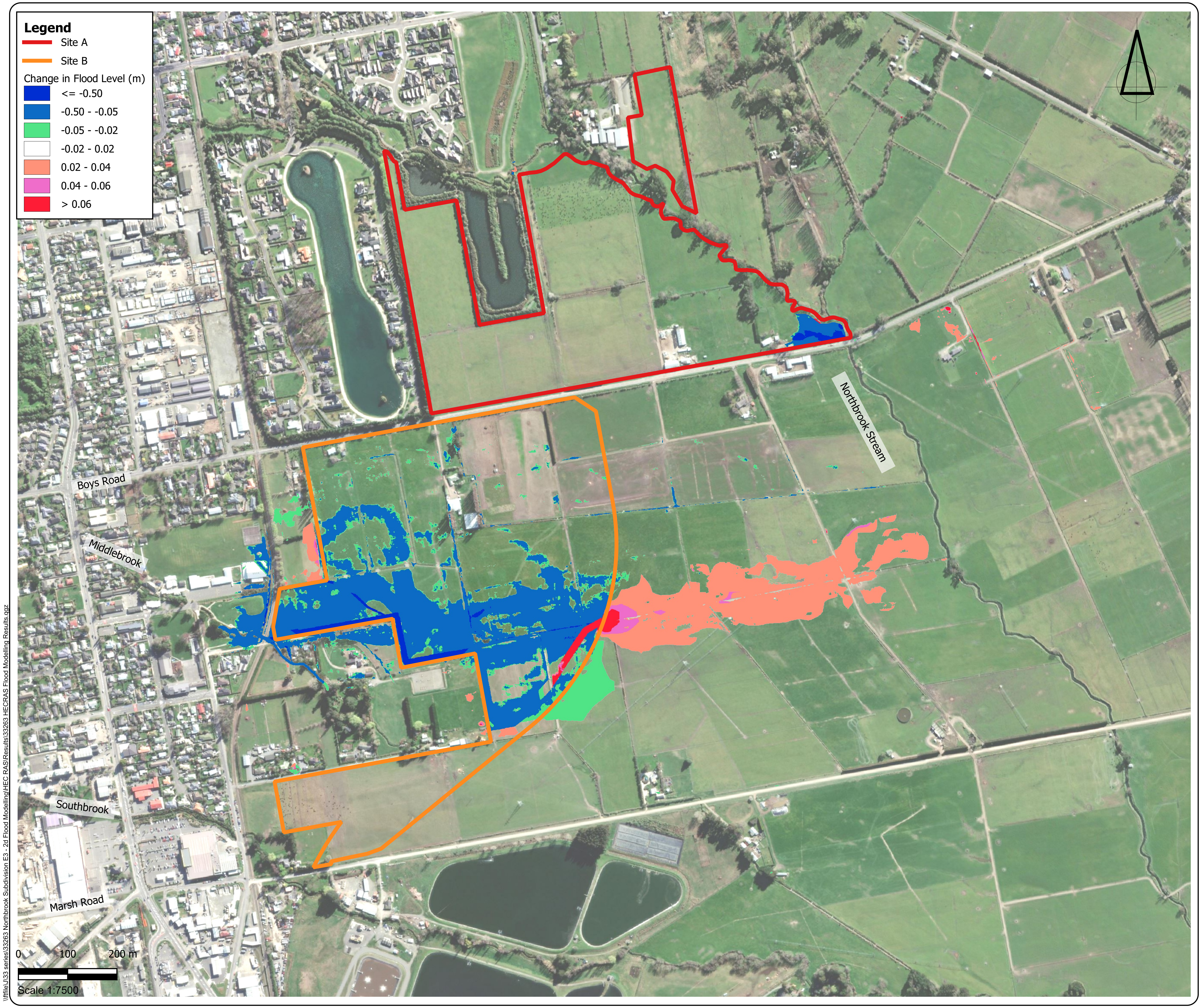

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DESIGNED	TB	30/01/2024		
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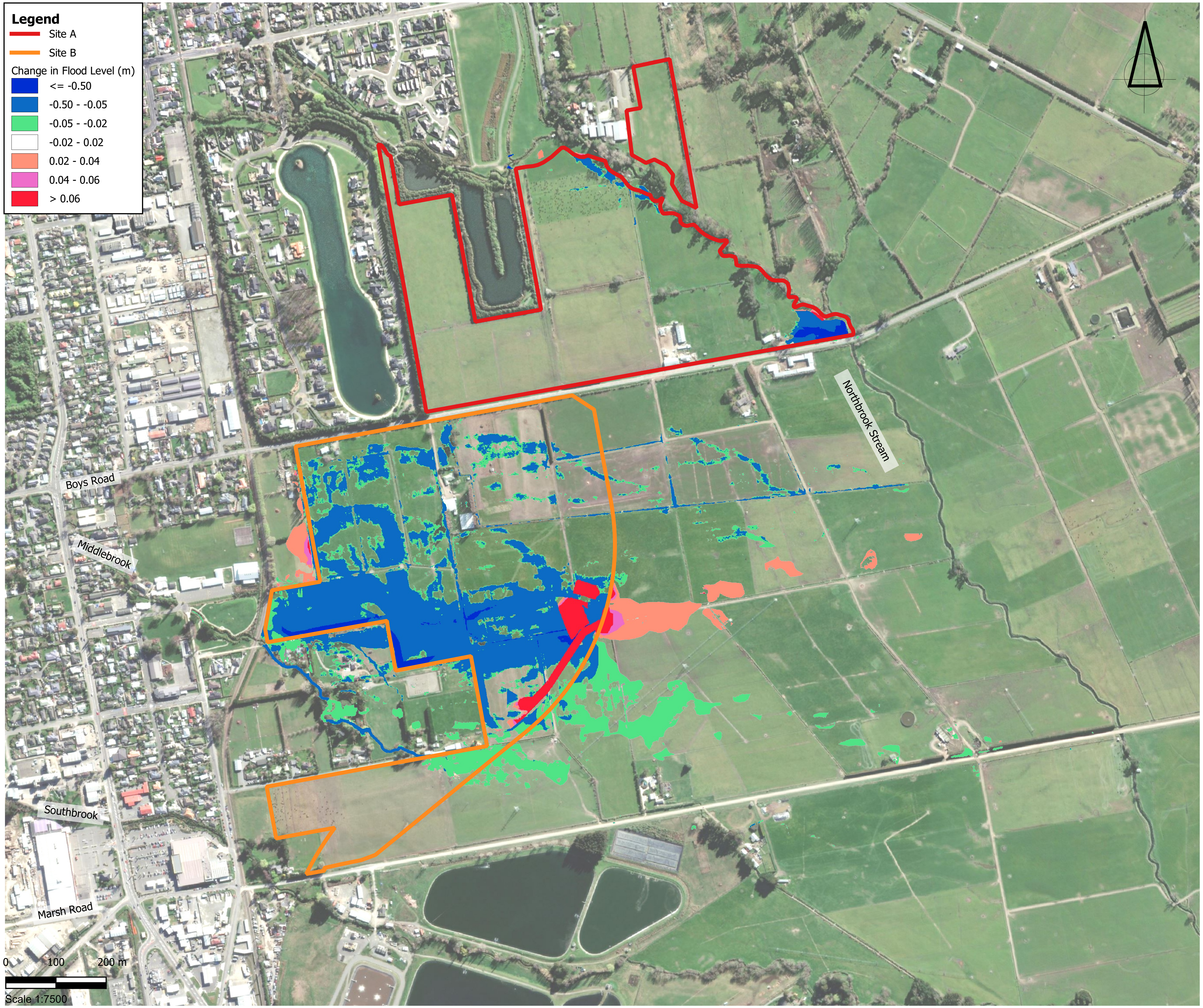

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SURVEYED			APPROVED	DATE
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PROJECT
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TITLE
200YR ARI - CHANGE IN FLOOD LEVELS PRE TO POST DEVELOPMENT - GIFKINS CULVERT BLOCKED

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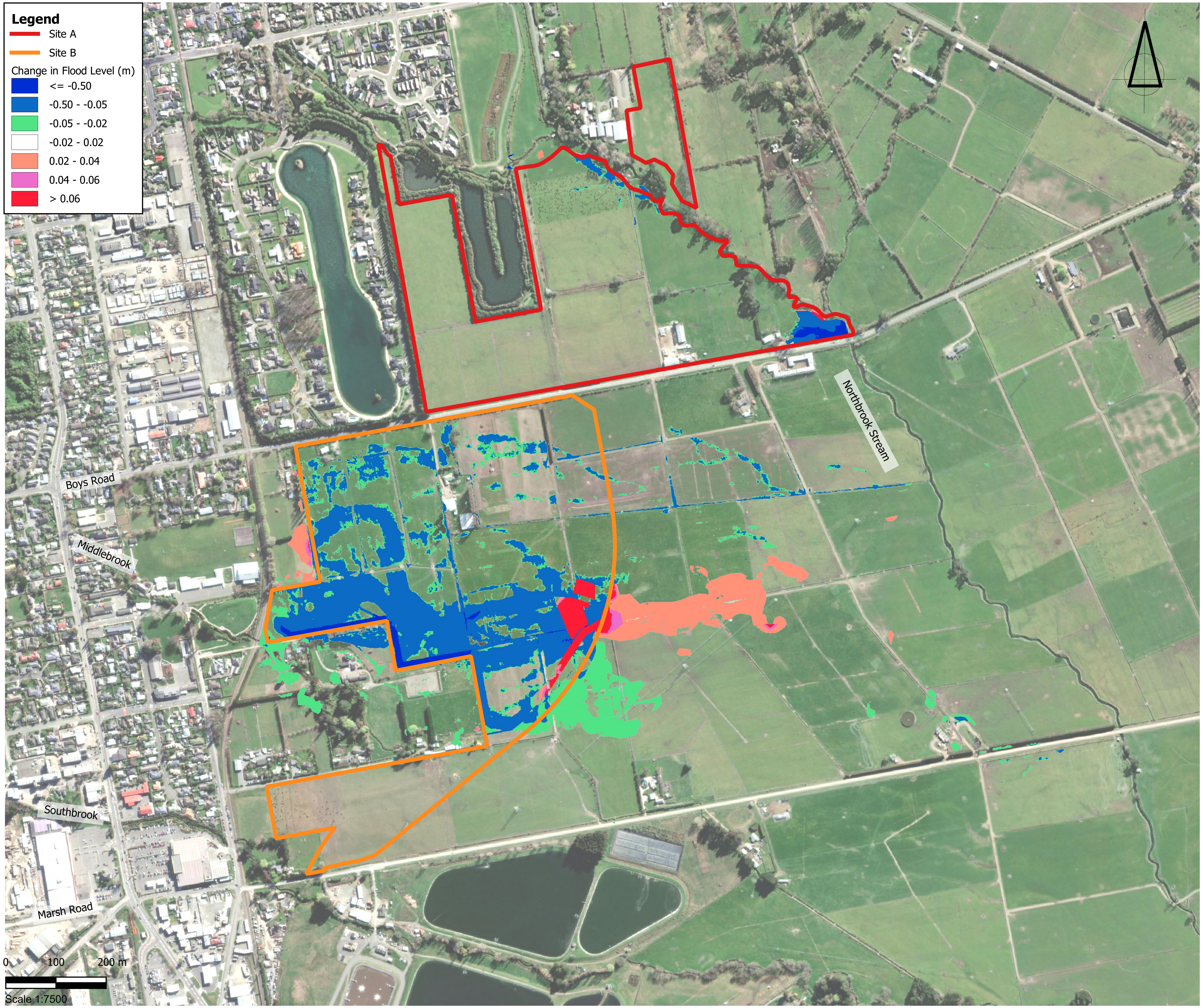

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SURVEYED			APPROVED	DATE
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TITLE
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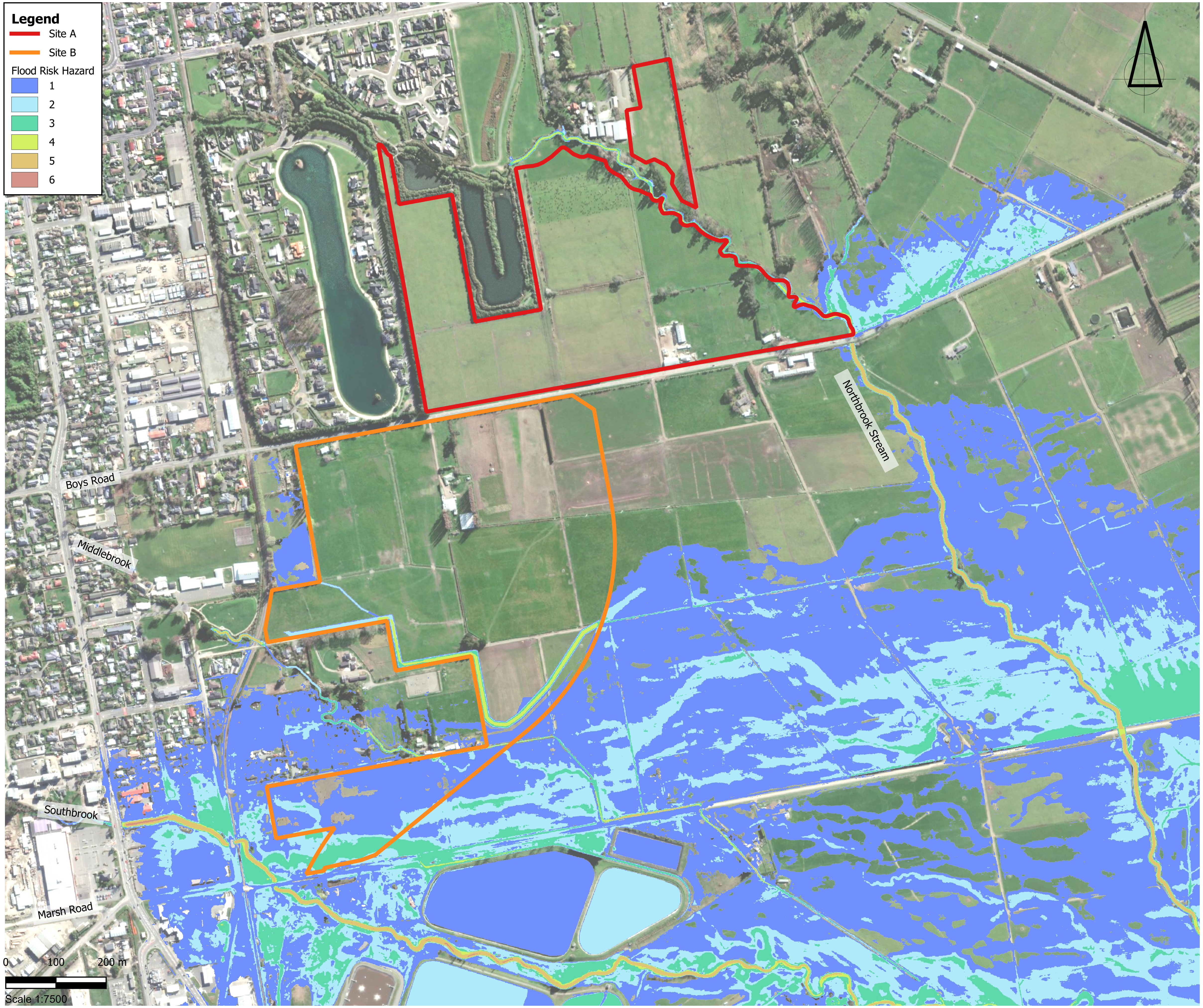

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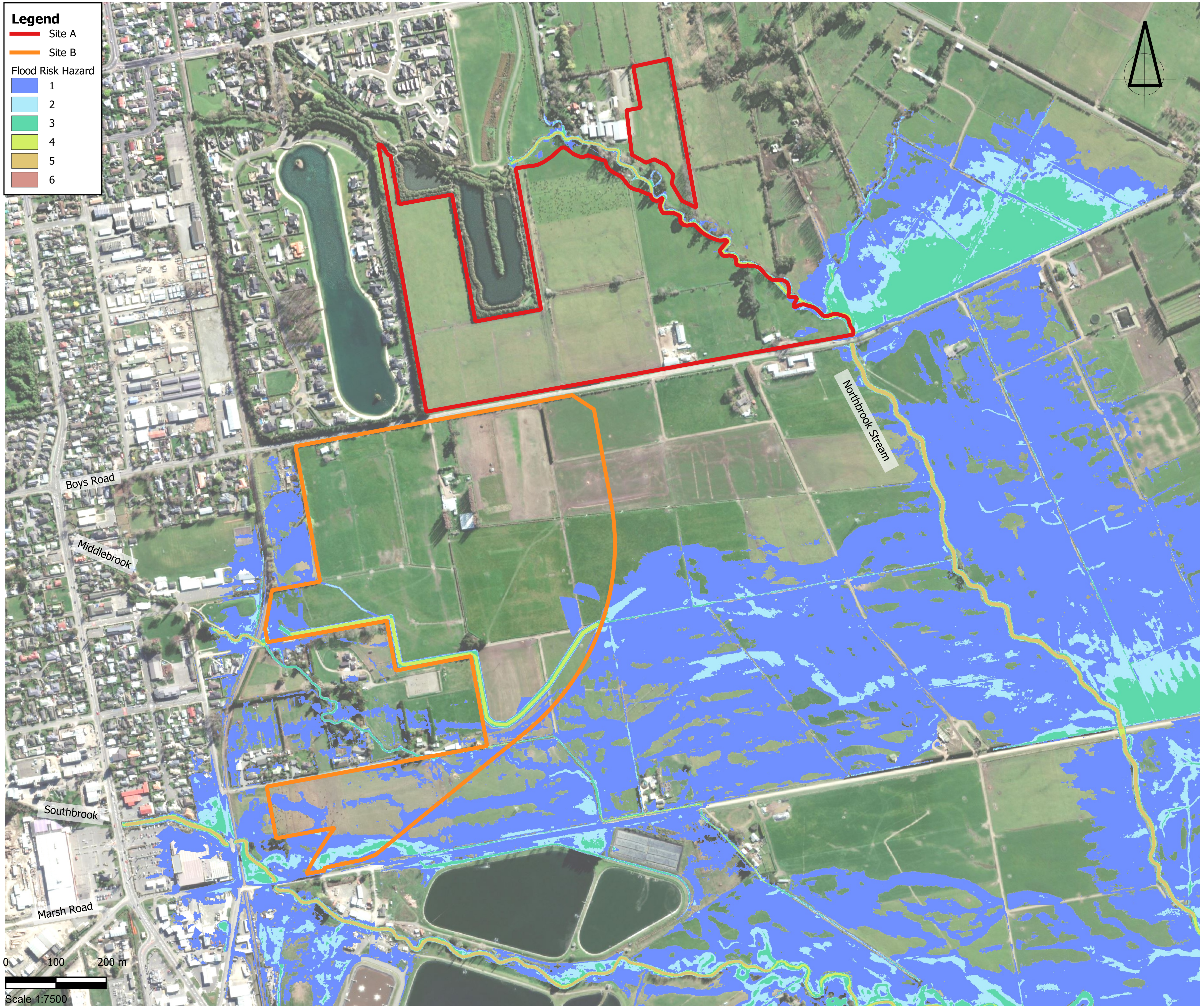

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SURVEYED			APPROVED	DATE
DESIGNED	TB	30/01/2024		
DRAWN	YG	30/01/2024		
CHECKED				

REVISION	CHANGES	CHECKED	DATE

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200YR ARI FLOOD RISK - GIFKINS ROAD CULVERT BLOCKED

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Appendix C

Input Data

Appendix C-1

Rainfall Hyterograph

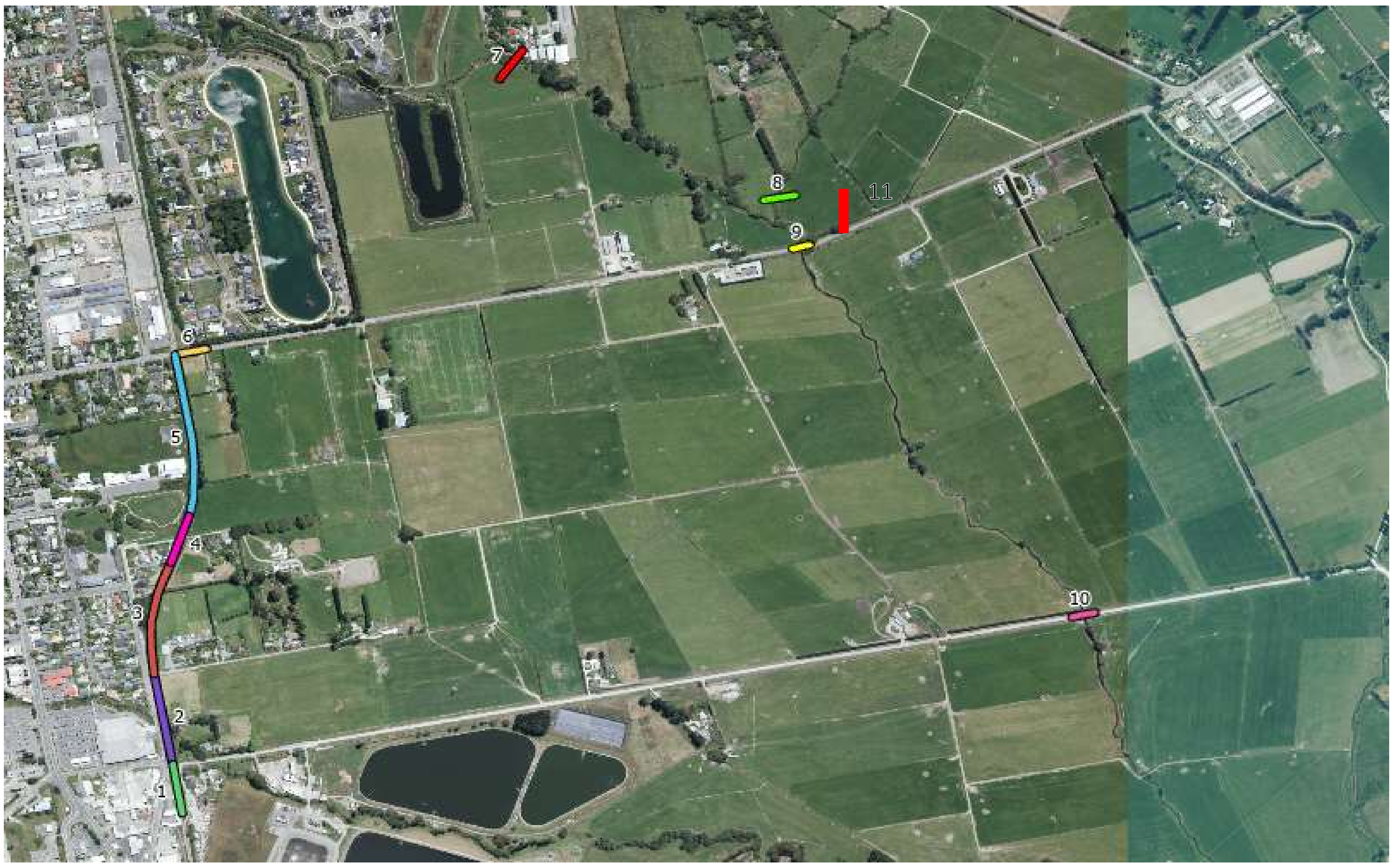
Site Hyterograph

Hyterograph provided by Waimakariri District Council

01/01/2000 0:00	0
01/01/2000 1:00	3.254749
01/01/2000 2:00	3.254749
01/01/2000 3:00	3.254749
01/01/2000 4:00	4.65102
01/01/2000 5:00	4.65102
01/01/2000 6:00	4.65102
01/01/2000 7:00	6.225452
01/01/2000 8:00	6.225452
01/01/2000 9:00	8.148881
01/01/2000 10:00	11.71087
01/01/2000 11:00	11.71087
01/01/2000 12:00	17.95561
01/01/2000 13:00	52.02544
01/01/2000 14:00	17.95561
01/01/2000 15:00	11.71087
01/01/2000 16:00	8.148881
01/01/2000 17:00	8.148881
01/01/2000 18:00	6.225452
01/01/2000 19:00	4.65102
01/01/2000 20:00	4.65102
01/01/2000 21:00	4.65102
01/01/2000 22:00	3.254749
01/01/2000 23:00	3.254749
02/01/2000 0:00	3.254749

Appendix C-2

Inflow Hydrographs



	1	2-1D	2-2D	2 Comb	3	4-1D	4-2D	4-Comb	5	6	7-1D	7-2D	7-Comb		8	9	10	11
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1/01/2000 0:05	0	0	0	0	0	0	0	0	0	0	0	0	0	1/01/2000 0:20:00	0	0	0	0
1/01/2000 0:10	0	0	0	0	0	0	0	0	0	0	0	0	0	1/01/2000 0:40:00	0	0	0	0
1/01/2000 0:15	0	0	0	0	0	0	0	0	0	0	0	0	0	1/01/2000 1:00:00	0	0	0	0
1/01/2000 0:20	0	0	0	0	0	0	0	0	0	0	0	0	0	1/01/2000 1:20:00	0	0	0	0
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1/01/2000 2:40	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.06	0	0.2	0
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1/01/2000 3:10	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.15	6.3	3.5	4
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1/01/2000 3:40	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	4.73	17	19	9
1/01/2000 3:45	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	4.51	17	19	9

1/01/2000 3:50	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	4.22	16	18	9
1/01/2000 3:55	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	3.83	15	18	8
1/01/2000 4:00	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	3.44	14	17	8
1/01/2000 4:05	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	2.94	13	16	8
1/01/2000 4:10	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	2.52	12	15	7
1/01/2000 4:15	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	2.28	11	14	7
1/01/2000 4:20	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	2.05	11	13	7
1/01/2000 4:25	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.87	11	13	7
1/01/2000 4:30	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.68	11	12	7
1/01/2000 4:35	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.54	10	12	7
1/01/2000 4:40	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.37	10	11	7
1/01/2000 4:45	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.19	9.6	11	7
1/01/2000 4:50	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	1.09	9.3	10	7
1/01/2000 4:55	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.99	8.9	9.9	7
1/01/2000 5:00	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.94	8.6	9.4	7
1/01/2000 5:05	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.88	8.3	9	7
1/01/2000 5:10	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.79	8	8.5	6
1/01/2000 5:15	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.76	7.7	8.1	6
1/01/2000 5:20	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.67	7.4	7.8	6
1/01/2000 5:25	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.63	7.2	7.4	6
1/01/2000 5:30	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.54	6.9	7	6
1/01/2000 5:35	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.46	6.6	6.7	6
1/01/2000 5:40	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.37	6.3	6.3	5
1/01/2000 5:45	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.31	6	6	5
1/01/2000 5:50	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.3	5.7	5.7	5
1/01/2000 5:55	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0.26	5.5	5.4	5
1/01/2000 6:00	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 0:00:00	0.25	5.3	5.1	5
1/01/2000 6:05	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 0:20:00	0.21	5.1	4.9	5
1/01/2000 6:10	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 0:40:00	0.18	4.8	4.6	4
1/01/2000 6:15	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 1:00:00	0.15	4.5	4.4	4
1/01/2000 6:20	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 1:20:00	0.13	4.2	4.1	4
1/01/2000 6:25	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 1:40:00	0.11	4	3.8	4
1/01/2000 6:30	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 2:00:00	0.08	3.7	3.5	3
1/01/2000 6:35	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 2:20:00	0.04	3.4	3.3	3
1/01/2000 6:40	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 2:40:00	0.01	3.1	3.1	3
1/01/2000 6:45	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 3:00:00	0	2.9	2.9	3
1/01/2000 6:50	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 3:20:00	0	2.7	2.7	3
1/01/2000 6:55	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 3:40:00	0	2.6	2.5	3
1/01/2000 7:00	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 4:00:00	0	2.4	2.3	2
1/01/2000 7:05	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 4:20:00	0	2.3	2.1	2
1/01/2000 7:10	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 4:40:00	0	2.2	2	2
1/01/2000 7:15	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 5:00:00	0	2.1	1.9	2
1/01/2000 7:20	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 5:20:00	0	2	1.7	2
1/01/2000 7:25	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 5:40:00	0	1.9	1.7	2
1/01/2000 7:30	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 6:00:00	0	1.8	1.6	2
1/01/2000 7:35	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 6:20:00	0	1.7	1.5	2
1/01/2000 7:40	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 6:40:00	0	1.6	1.4	2
1/01/2000 7:45	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 7:00:00	0	1.5	1.3	1
1/01/2000 7:50	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 7:20:00	0	1.4	1.2	1
1/01/2000 7:55	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 7:40:00	0	1.4	1.1	1
1/01/2000 8:00	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 8:00:00	0	1.3	1	1
1/01/2000 8:05	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 8:20:00	0	1.3	1	1
1/01/2000 8:10	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 8:40:00	0	1.2	0.9	1
1/01/2000 8:15	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 9:00:00	0	1.2	0.9	1
1/01/2000 8:20	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 9:20:00	0	1.1	0.8	1
1/01/2000 8:25	0	0	0	0	0	0	0	0	0	0	0	0	0	2/01/2000 9:40:00	0	1.1	0.8	1
1/01/2000 8:30	0	0	0	0	0	0	0	0	0	0	0	0	0	###############	0	1	0.8	1
1/01/2000 8:35	0	0.01	0	0.011056	0	0	0	0	0	0	0	0	0	###############	0	1	0.8	1
1/01/2000 8:40	0	0.02	0	0.019912	0	0	0	0	0	0	0	0	0	###############	0	1	0.8	1
1/01/2000 8:45	0	0.03	0	0.02649	0	0	0	0	0	0	0	0	0	###############	0	0.9	0.7	1
1/01/2000 8:50	0	0.03	0	0.030591	0	0	0	0	0	0	0	0	0	###############	0	0.9	0.7	1
1/01/2000 8:55	0	0.03	0	0.033267	0	0	0	0	0	0	0	0	0	###############	0	0.8	0.7	1
1/01/2000 9:00	0	0.04	0	0.03511	0	0	0	0	0	0	0	0	0	###############	0	0.8	0.6	1
1/01/2000 9:05	0	0.04	0	0.036486	0	0	0	0	0	0	0	0	0	###############	0	0.7	0.6	1
1/01/2000 9:10	0	0.04	0	0.03745	0	0	0	0	0	0	0	0	0	###############	0	0.7	0.6	1
1/01/2000 9:15	0	0.04	0	0.038149	0	0	0	0	0	0	0	0	0	###############	0	0.7	0.6	1
1/01/2000 9:20	0	0.04	0	0.038677	0	0	0	0	0	0	0	0	0	###############	0	0.7	0.6	1
1/01/2000 9:25	0	0.04	0	0.039084	0	0	0	0	0	0	0	0	0	###############	0	0.7	0.5	1
1/01/2000 9:30	0	0.04	0	0.039406	0	0	0	0	0	0	0	0	0	###############	0	0.5	0.5	1
1/01/2000 9:35	0	0.04	0	0.039669	0	0	0	0	0	0	0	0	0	###############	0	0.5	0.5	0
1/01/2000 9:40	0	0.04	0	0.039882	0	0	0	0	0	0	0	0	0	###############	0	0.5	0.5	0
1/01/2000 9:45	0	0.04	0	0.040054	0	0	0	0	0	0	0	0	0	###############	0	0.4	0.5	0
1/01/2000 9:50	0	0.04	0	0.040358	0	0	0	0	0	0	0	0	0	###############	0	0.4	0.4	0
1/01/2000 9:55	0	0.04	0	0.040764	0	0	0	0	0	0	0	0	0	###############	0	0.4	0.4	0

1/01/2000 10:00	0	0.04	0	0.041212	0	0	0	0	0	0	0	0	0	################	0	0.3	0.4	0
1/01/2000 10:05	0	0.04	0	0.041672	0	0	0	0	0	0	0	0	0	################	0	0.3	0.4	0
1/01/2000 10:10	0	0.04	0	0.042167	0	0	0	0	0	0	0	0	0	################	0	0.3	0.4	0
1/01/2000 10:15	0	0.04	0	0.042705	0	0	0	0	0	0	0	0	0	################	0	0.3	0.4	0
1/01/2000 10:20	0	0.04	0	0.043269	0	0	0	0	0	0	0.01	0	0.014324	################	0	0.2	0.3	0
1/01/2000 10:25	0	0.05	0	0.047967	0	0.01	0	0.01058	0	0	0.02	0	0.024449	################	0	0.2	0.3	0
1/01/2000 10:30	0	0.07	0	0.065665	0	0.01	0	0.01201	0	0	0.05	0	0.048197	################	0	0.2	0.3	0
1/01/2000 10:35	0	0.08	0	0.078781	0	0.02	0	0.01779	0	0	0.05	0	0.05428	################	0	0.2	0.3	0
1/01/2000 10:40	0	0.08	0	0.079005	0	0.02	0	0.01978	0	0	0.05	0	0.048813	################	0	0.1	0.3	0
1/01/2000 10:45	0	0.08	0	0.079361	0	0.02	0	0.01855	0	0	0.05	0	0.04723	################	0	0.1	0.3	0
1/01/2000 10:50	0	0.08	0	0.084267	0	0.02	0	0.01961	0	0	0.05	0	0.053394	################	0	0.1	0.3	0
1/01/2000 10:55	0	0.09	0	0.093236	0	0.02	0	0.0232	0	0	0.06	0	0.05902	################	0	0.1	0.2	0
1/01/2000 11:00	0	0.1	0	0.104701	0	0.03	0	0.02828	0	0	0.06	0	0.063722	################	0	0.1	0.2	0
1/01/2000 11:05	0	0.12	0	0.11744	0	0.04	0	0.03576	0	0	0.07	0	0.069916	################	0	0.1	0.2	0
1/01/2000 11:10	0	0.13	0	0.128503	0	0.04	0	0.04275	0	0	0.08	0	0.076949	################	0	0.1	0.2	0
1/01/2000 11:15	0	0.14	0	0.13731	0	0.05	0	0.05098	0	0	0.09	0	0.085288	################	0	0.1	0.2	0
1/01/2000 11:20	0	0.15	0	0.149342	0	0.06	0	0.0626	0	0	0.09	0	0.093714	################	0	0	0.2	0
1/01/2000 11:25	0	0.16	0	0.161134	0	0.08	0	0.07587	0	0	0.11	0	0.108493	################	0	0	0.2	0
1/01/2000 11:30	0	0.19	0	0.192679	0	0.09	0	0.09006	0	0	0.13	0	0.130634	################	0	0	0.2	0
1/01/2000 11:35	0	0.24	0	0.240658	0	0.11	0	0.10733	0	0	0.14	0	0.144996	################	0	0	0.2	0
1/01/2000 11:40	0	0.27	0	0.267933	0	0.13	0	0.12917	0	0	0.15	0	0.154163	################	0	0	0.2	0
1/01/2000 11:45	0	0.28	0	0.284877	0	0.16	0	0.1568	0	0	0.16	0	0.1614	################	0	0	0.2	0
1/01/2000 11:50	0	0.31	0	0.306223	0	0.19	0	0.18921	0	0	0.17	0	0.169212	################	0	0	0.1	0
1/01/2000 11:55	0	0.34	0	0.342722	0	0.23	0	0.22752	0	0	0.18	0	0.183079	################	0	0	0.1	0
1/01/2000 12:00	0	0.39	0	0.392236	0	0.27	0	0.27073	0	0	0.21	0	0.208548	3/01/2000 0:00:00	0	0	0.1	0
1/01/2000 12:05	0	0.45	0	0.447412	0	0.32	0	0.32082	0	0	0.25	0	0.249797	3/01/2000 0:20:00	0	0	0.1	0
1/01/2000 12:10	0	0.51	0	0.511198	0	0.38	0	0.37877	0	0	0.3	0	0.299394	3/01/2000 0:40:00	0	0	0.1	0
1/01/2000 12:15	0	0.6	0	0.603986	0	0.45	0	0.4473	0	0	0.37	0	0.367179	3/01/2000 1:00:00	0	0	0.1	0
1/01/2000 12:20	0	0.68	0	0.684719	0	0.52	0	0.52066	0	0	0.46	0	0.46096	3/01/2000 1:20:00	0	0	0.1	0
1/01/2000 12:25	0	0.76	0	0.758274	0	0.61	0	0.60776	0	0	0.57	0.017	0.584741	3/01/2000 1:40:00	0	0	0.1	0
1/01/2000 12:30	0	0.85	0	0.847356	0	0.71	0	0.71358	0	0	0.82	0.024	0.841223	3/01/2000 2:00:00	0	0	0.1	0
1/01/2000 12:35	0	0.95	0	0.953914	0	0.84	0	0.83911	0	0	1.11	0.014	1.124367					
1/01/2000 12:40	0	1.07	0	1.072765	0	0.98	0	0.98273	0	0	1.42	0.016	1.440593					
1/01/2000 12:45	0	1.17	0	1.173414	0	1.14	0	1.14362	0	0	1.86	0.017	1.876708					
1/01/2000 12:50	0	1.29	0	1.289372	0	1.33	0	1.33444	0	0	2.4	0.017	2.415717					
1/01/2000 12:55	0	1.41	0	1.406893	0	1.58	0	1.57875	0	0	2.97	0.022	2.990751					
1/01/2000 13:00	0	1.62	0	1.62328	0	1.84	0	1.83657	0	0	3.5	0.018	3.517185					
1/01/2000 13:05	0	1.86	0	1.859132	0	2.11	0	2.11077	0	0	4.05	0.018	4.070152					
1/01/2000 13:10	0	2.08	0	2.075596	0	2.44	0	2.43636	0	0	4.57	0.019	4.586898					
1/01/2000 13:15	0	2.4	0.04	2.436374	0	2.88	0	2.87559	0	0	4.99	0.035	5.028163					
1/01/2000 13:20	0	2.77	0	2.770085	0.1	3.42	0	3.41808	0	0	5.35	0.016	5.361578					
1/01/2000 13:25	0	3.06	0.06	3.118893	0.1	4	0	4.0028	0	0	5.6	0.018	5.619099					
1/01/2000 13:30	0	3.3	0.07	3.362708	0.1	4.79	0.01	4.79997	0	0	5.76	0.016	5.775976					
1/01/2000 13:35	0	3.48	0.08	3.558631	0.1	5.68	0.05	5.72479	0	0	5.92	0.02	5.943748					
1/01/2000 13:40	0	3.65	0.08	3.730932	0.2	6.4	0.29	6.68518	0.1	0	6.04	0.016	6.054837					
1/01/2000 13:45	0	3.82	0.08	3.897077	0.2	6.88	0.53	7.41221	0.2	0	6.09	0.012	6.098879					
1/01/2000 13:50	0	4.03	0.08	4.114502	0.2	7.14	0.83	7.97756	0.3	0.1	6.1	0.014	6.119333					
1/01/2000 13:55	0	4.34	0.09	4.430112	0.2	7.31	0.93	8.24163	0.4	0.1	6.13	0.011	6.136604					
1/01/2000 14:00	0	4.82	0.1	4.914489	0.2	7.43	1.01	8.43888	0.6	0	6.17	0	6.167753					
1/01/2000 14:05	0	5.39	0.13	5.519078	0.3	7.51	1.16	8.6617	0.7	0.1	6.26	0	6.263553					
1/01/2000 14:10	0	5.95	0.18	6.129135	0.3	7.56	1.45	9.01869	0.8	0.1	6.38	0	6.377439					
1/01/2000 14:15	0	6.48	0.23	6.715778	0.3	7.61	1.68	9.28461	1	0.3	6.54	0	6.542688					
1/01/2000 14:20	0.0116	6.99	0.33	7.314654	0.3	7.65	1.58	9.22802	0.9	0.1	6.71	0	6.705884					
1/01/2000 14:25	0.0592	7.49	0.45	7.937255	0.3	7.67	1.54	9.20851	1.1	0.2	6.89	0	6.89052					
1/01/2000 14:30	0.1647	7.96	0.78	8.737552	0.3	7.69	1.75	9.44143	1.1	0.1	7.06	0	7.056504					
1/01/2000 14:35	0.4262	8.37	1.4	9.772801	0.3	7.69	1.76	9.45364	1.2	0.3	7.23	0	7.227631					
1/01/2000 14:40	1.1724	8.65	1.85	10.49645	0.3	7.7	1.75	9.44644	1.2	0	7.34	0	7.336322					
1/01/2000 14:45	1.9433	8.78	2.62	11.40086	0.3	7.7	1.89	9.59293	1.4	0.2	7.44	0	7.439068					
1/01/2000 14:50	2.6471	8.84	2.83	11.67146	0.3	7.7	1.73	9.43849	1.2	0.2	7.59	0.013	7.603022					
1/01/2000 14:55	3.1495	8.91	3.4	12.31374	0.3	7.7	1.81	9.51169	1.4	0.2	7.86	0.064	7.922983					
1/01/2000 15:00	3.4252	8.98	3.46	12.4408	0.3	7.69	1.92	9.61088	1.2	0.2	8.28	0.175	8.456851					
1/01/2000 15:05	3.7154	9.04	3.95	12.9924	0.3	7.68	1.74	9.41681	1.2	0.4	8.6	0.281	8.878907					
1/01/2000 15:10	3.8702	9.09	4.19	13.2853	0.3	7.66	1.72	9.37725	1.3	0.2	8.77	0.334	9.10628					
1/01/2000 15:15	4.0812	9.14	4.52	13.66812	0.3	7.64	1.74	9.38323	1.1	0.1	8.84	0.353	9.19471					
1/01/2000 15:20	4.224	9.19	4.34	13.52825	0.3	7.63	1.54	9.16991	1.1	0.3	8.84	0.348	9.189637					
1/01/2000 15:25	4.1754	9.23	4.6	13.82705	0.3	7.61	1.81	9.41615	1	0.3	8.8	0.335	9.133814					
1/01/2000 15:30	4.416	9.25	4.99	14.24615	0.3	7.58	1.54	9.11392	1.1	0.2	8.72	0.314	9.036576					
1/01/2000 15:35	4.4666	9.27	5.02	14.28718	0.2	7.55	1.4	8.94753	1	0.2	8.62	0.276	8.900527					
1/01/2000 15:40	4.4233	9.28	5.22	14.50511	0.3	7.52	1.59	9.1134	1.1	0.2	8.5	0.237	8.735474					
1/01/2000 15:45	4.5505	9.29	5.21	14.50543	0.3	7.49	1.43	8.92262	0.9	0.1	8.36	0.193	8.550078					
1/01/2000 15:50	4.4841	9.3	5.03	14.3273	0.2	7.46	1.25	8.71718	1.1	0.2	8.21	0.149	8.361256					
1/01/2000 15:55	4.488	9.3	5	14.29679	0.2	7.43	1.17	8.60443	0.8	0.2	8.06	0.116	8.175508					
1/01/2000 16:00	4.5872	9.3	5.28	14.57894	0.2	7.4	1.14	8.54468	0.9	0.4	7.89	0.08	7.970265					
1/01/2000 16:05	4.5503	9.29	5.06	14.35581	0.2	7.37	1.11	8.48226	0.8	0.2	7.74	0.046	7.781548					

1/01/2000 16:10	4.5509	9.29	4.97	14.26336	0.2	7.34	1.16	8.50143	0.6	0.2	7.58	0.017	7.595561
1/01/2000 16:15	4.4762	9.29	5.18	14.46345	0.2	7.31	1.06	8.36936	0.6	0.1	7.41	0	7.407059
1/01/2000 16:20	4.5466	9.28	4.82	14.10486	0.2	7.28	0.98	8.25958	0.5	0.2	7.2	0	7.203649
1/01/2000 16:25	4.5602	9.28	5.13	14.40174	0.2	7.25	0.82	8.06393	0.5	0.1	6.99	0	6.993628
1/01/2000 16:30	4.5671	9.27	4.86	14.13145	0.2	7.21	0.9	8.11221	0.5	0	6.82	0	6.820254
1/01/2000 16:35	4.6695	9.26	4.99	14.25619	0.2	7.18	0.74	7.91667	0.4	0.1	6.66	0	6.6613
1/01/2000 16:40	4.6421	9.26	4.98	14.23874	0.2	7.14	0.92	8.05733	0.4	0.1	6.51	0	6.509564
1/01/2000 16:45	4.5558	9.25	4.92	14.17647	0.2	7.1	0.74	7.8373	0.4	0.1	6.36	0	6.364352
1/01/2000 16:50	4.5844	9.25	5.03	14.27589	0.2	7.06	0.71	7.77171	0.3	0.1	6.23	0	6.225781
1/01/2000 16:55	4.4561	9.24	4.92	14.15595	0.2	7.02	0.65	7.66667	0.3	0	6.1	0	6.097871
1/01/2000 17:00	4.4067	9.23	4.97	14.19804	0.2	6.97	0.54	7.51234	0.3	0	5.99	0	5.986779
1/01/2000 17:05	4.4028	9.22	4.87	14.08777	0.2	6.92	0.57	7.4918	0.2	0.1	5.9	0	5.897525
1/01/2000 17:10	4.2589	9.21	4.52	13.7323	0.2	6.87	0.6	7.47314	0.2	0	5.81	0	5.806319
1/01/2000 17:15	4.191	9.2	4.73	13.93329	0.2	6.82	0.43	7.2528	0.2	0	5.71	0	5.710154
1/01/2000 17:20	4.0733	9.19	4.51	13.69239	0.2	6.76	0.4	7.15968	0.2	0	5.62	0	5.617821
1/01/2000 17:25	3.9084	9.17	4.52	13.68897	0.2	6.71	0.37	7.07866	0.1	0	5.53	0	5.526404
1/01/2000 17:30	3.7983	9.15	4.01	13.16005	0.2	6.65	0.38	7.03484	0.1	0	5.44	0	5.437793
1/01/2000 17:35	3.8037	9.13	4.08	13.20845	0.1	6.59	0.31	6.89957	0.1	0	5.34	0	5.344841
1/01/2000 17:40	3.6034	9.11	4.18	13.28661	0.1	6.52	0.32	6.84527	0.1	0	5.25	0	5.25056
1/01/2000 17:45	3.4754	9.09	3.82	12.90945	0.1	6.45	0.26	6.71591	0.1	0	5.15	0	5.148559
1/01/2000 17:50	3.3283	9.07	3.63	12.7002	0.1	6.38	0.23	6.61154	0.1	0	5.03	0	5.028938
1/01/2000 17:55	3.3203	9.05	3.72	12.76882	0.1	6.31	0.22	6.52175	0.1	0	4.94	0	4.938951
1/01/2000 18:00	3.1358	9.03	3.43	12.45769	0.1	6.23	0.23	6.45475	0	0	4.84	0	4.836566
1/01/2000 18:05	2.9643	9	3.55	12.55445	0.1	6.15	0.17	6.32192	0	0	4.77	0	4.765088
1/01/2000 18:10	2.8448	8.98	3.47	12.45721	0.1	6.07	0.18	6.25029	0	0	4.71	0	4.705658
1/01/2000 18:15	2.6926	8.96	2.96	11.92993	0.1	5.99	0.13	6.1189	0	0	4.65	0	4.645782
1/01/2000 18:20	2.5664	8.95	3.09	12.03385	0.1	5.91	0.13	6.04681	0	0	4.58	0	4.579349
1/01/2000 18:25	2.4832	8.92	2.79	11.7108	0.1	5.82	0.1	5.91545	0	0	4.51	0	4.512159
1/01/2000 18:30	2.3145	8.9	3.03	11.93197	0.1	5.73	0.1	5.83431	0	0	4.44	0	4.438632
1/01/2000 18:35	2.1916	8.88	2.61	11.4839	0.1	5.65	0.06	5.71825	0	0	4.37	0	4.366082
1/01/2000 18:40	2.0943	8.85	2.44	11.29296	0.1	5.56	0.05	5.61307	0	0	4.3	0	4.299571
1/01/2000 18:45	1.9758	8.82	2.59	11.4061	0.1	5.46	0.07	5.52768	0	0	4.25	0	4.247226
1/01/2000 18:50	1.8416	8.79	2.54	11.32889	0.1	5.36	0.03	5.39111	0	0	4.19	0	4.192558
1/01/2000 18:55	1.763	8.76	2.3	11.06235	0.1	5.25	0.03	5.28238	0	0	4.13	0	4.132291
1/01/2000 19:00	1.6594	8.73	2.29	11.01969	0.1	5.15	0.02	5.17473	0	0	4.08	0	4.075747
1/01/2000 19:05	1.5758	8.7	2.15	10.84219	0.1	5.05	0.02	5.06449	0	0	4.02	0	4.023267
1/01/2000 19:10	1.4755	8.66	2.09	10.75395	0.1	4.93	0.01	4.94471	0	0	3.95	0	3.950297
1/01/2000 19:15	1.4168	8.63	1.89	10.51976	0.1	4.83	0.03	4.85822	0	0	3.88	0	3.875521
1/01/2000 19:20	1.3733	8.59	1.88	10.46441	0.1	4.74	0	4.736	0	0	3.8	0	3.800726
1/01/2000 19:25	1.2556	8.55	1.78	10.32918	0.1	4.63	0	4.63065	0	0	3.74	0	3.738585
1/01/2000 19:30	1.2109	8.51	1.6	10.10496	0.1	4.52	0	4.52467	0	0	3.67	0	3.674075
1/01/2000 19:35	1.1406	8.47	1.56	10.02539	0.1	4.42	0	4.41966	0	0	3.6	0	3.601364
1/01/2000 19:40	1.0843	8.43	1.37	9.803421	0.1	4.32	0	4.31665	0	0	3.53	0	3.529672
1/01/2000 19:45	1.0259	8.38	1.37	9.751223	0.1	4.22	0	4.21778	0	0	3.47	0	3.471078
1/01/2000 19:50	0.9682	8.33	1.33	9.660411	0.1	4.13	0	4.12795	0	0	3.43	0	3.431211
1/01/2000 19:55	0.8904	8.27	1.17	9.440133	0.1	4.04	0	4.04101	0	0	3.4	0	3.395937
1/01/2000 20:00	0.843	8.21	1.11	9.321049	0.1	3.95	0	3.94534	0	0	3.35	0	3.349631
1/01/2000 20:05	0.7957	8.16	1.05	9.210183	0.1	3.87	0	3.87129	0	0	3.3	0	3.298869
1/01/2000 20:10	0.7336	8.11	0.97	9.077226	0	3.78	0	3.77534	0	0	3.25	0	3.248579
1/01/2000 20:15	0.6742	8.07	0.93	8.995718	0	3.68	0	3.67624	0	0	3.2	0	3.198048
1/01/2000 20:20	0.6239	8.02	0.87	8.893456	0	3.6	0	3.60281	0	0	3.15	0	3.151243
1/01/2000 20:25	0.5711	7.97	0.87	8.833509	0	3.53	0	3.52845	0	0	3.11	0	3.113016
1/01/2000 20:30	0.5255	7.91	0.78	8.69472	0	3.45	0	3.45498	0	0	3.08	0	3.079338
1/01/2000 20:35	0.4688	7.86	0.76	8.616349	0	3.38	0	3.38018	0	0	3.05	0	3.046906
1/01/2000 20:40	0.4366	7.8	0.72	8.519983	0	3.31	0	3.30636	0	0	3.02	0	3.015879
1/01/2000 20:45	0.399	7.74	0.67	8.414149	0	3.23	0	3.23378	0	0	2.98	0	2.984055
1/01/2000 20:50	0.3743	7.68	0.64	8.325794	0	3.16	0	3.16482	0	0	2.95	0	2.950546
1/01/2000 20:55	0.3234	7.61	0.66	8.269672	0	3.1	0	3.09782	0	0	2.91	0	2.91497
1/01/2000 21:00	0.3082	7.55	0.63	8.175178	0	3.03	0	3.03488	0	0	2.88	0	2.876502
1/01/2000 21:05	0.2697	7.48	0.56	8.037259	0	2.98	0	2.97988	0	0	2.84	0	2.841602
1/01/2000 21:10	0.2284	7.41	0.5	7.905844	0	2.92	0	2.9231	0	0	2.81	0	2.809603
1/01/2000 21:15	0.2114	7.33	0.48	7.812984	0	2.87	0	2.86504	0	0	2.78	0	2.775157
1/01/2000 21:20	0.1823	7.25	0.47	7.720618	0	2.81	0	2.81382	0	0	2.74	0	2.736234
1/01/2000 21:25	0.1755	7.17	0.49	7.659779	0	2.77	0	2.76542	0	0	2.7	0	2.697322
1/01/2000 21:30	0.1456	7.09	0.45	7.539196	0	2.71	0	2.71158	0	0	2.66	0	2.657298
1/01/2000 21:35	0.1301	7	0.44	7.443535	0	2.66	0	2.66426	0	0	2.61	0	2.612634
1/01/2000 21:40	0.1203	6.92	0.41	7.32962	0	2.62	0	2.61547	0	0	2.57	0	2.571107
1/01/2000 21:45	0.1052	6.83	0.43	7.253543	0	2.57	0	2.57279	0	0	2.53	0	2.529368
1/01/2000 21:50	0.0889	6.74	0.39	7.127725	0	2.53	0	2.5292	0	0	2.49	0	2.485183
1/01/2000 21:55	0.0781	6.65	0.37	7.023124	0	2.49	0	2.49084	0	0	2.44	0	2.442902
1/01/2000 22:00	0.0567	6.56	0.37	6.933251	0	2.45	0	2.4537	0	0	2.4	0	2.400678
1/01/2000 22:05	0.0616	6.48	0.36	6.832476	0	2.41	0	2.41371	0	0	2.36	0	2.358426
1/01/2000 22:10	0.0459	6.4	0.36	6.759582	0	2.38	0	2.37508	0	0	2.32	0	2.320791
1/01/2000 22:15	0.0432	6.32	0.33	6.649782	0	2.34	0	2.33621	0	0	2.28	0	2.276426

1/01/2000 22:20	0.0411	6.24	0.32	6.55905	0	2.3	0	2.2994	0	0	2.23	0	2.227092
1/01/2000 22:25	0.0371	6.16	0.31	6.469196	0	2.26	0	2.26204	0	0	2.17	0	2.168711
1/01/2000 22:30	0.0331	6.08	0.3	6.375186	0	2.23	0	2.22888	0	0	2.11	0	2.10661
1/01/2000 22:35	0.0301	6	0.29	6.289319	0	2.19	0	2.19264	0	0	2.04	0	2.041926
1/01/2000 22:40	0.0277	5.91	0.28	6.195288	0	2.15	0	2.15429	0	0	1.97	0	1.972449
1/01/2000 22:45	0.0205	5.84	0.27	6.112264	0	2.12	0	2.11872	0	0	1.89	0	1.893375
1/01/2000 22:50	0.0189	5.77	0.26	6.026026	0	2.08	0	2.08011	0	0	1.8	0	1.799259
1/01/2000 22:55	0.0163	5.7	0.26	5.956083	0	2.05	0	2.04834	0	0	1.69	0	1.691538
1/01/2000 23:00	0.0156	5.63	0.24	5.871945	0	2.02	0	2.01747	0	0	1.58	0	1.576101
1/01/2000 23:05	0.0136	5.56	0.24	5.790902	0	1.99	0	1.98742	0	0	1.46	0	1.464302
1/01/2000 23:10	0.0112	5.48	0.23	5.706959	0	1.96	0	1.9601	0	0	1.37	0	1.367781
1/01/2000 23:15	0.0101	5.4	0.22	5.619983	0	1.92	0	1.92438	0	0	1.29	0	1.287144
1/01/2000 23:20	0	5.32	0.21	5.535588	0	1.89	0	1.88827	0	0	1.21	0	1.213262
1/01/2000 23:25	0	5.25	0.21	5.455215	0	1.85	0	1.84966	0	0	1.15	0	1.15094
1/01/2000 23:30	0	5.18	0.21	5.392631	0	1.81	0	1.81052	0	0	1.1	0	1.102293
1/01/2000 23:35	0	5.11	0.2	5.310014	0	1.77	0	1.76868	0	0	1.06	0	1.062638
1/01/2000 23:40	0	5.06	0.19	5.246685	0	1.72	0	1.72468	0	0	1.03	0	1.028305
1/01/2000 23:45	0	5.01	0.19	5.198992	0	1.68	0	1.68336	0	0	1	0	0.997627
1/01/2000 23:50	0	4.96	0.18	5.144655	0	1.64	0	1.64396	0	0	0.97	0	0.972309
1/01/2000 23:55	0	4.91	0.18	5.086265	0	1.61	0	1.60695	0	0	0.95	0	0.949913
2/01/2000 0:00	0	4.86	0.17	5.035557	0	1.57	0	1.56984	0	0	0.93	0	0.927219
2/01/2000 0:05	0	4.81	0.18	4.98989	0	1.53	0	1.53351	0	0	0.91	0	0.906177
2/01/2000 0:10	0	4.75	0.17	4.917766	0	1.5	0	1.49686	0	0	0.89	0	0.887226
2/01/2000 0:15	0	4.68	0.16	4.840842	0	1.46	0	1.46455	0	0	0.87	0	0.871765
2/01/2000 0:20	0	4.61	0.15	4.759408	0	1.43	0	1.4336	0	0	0.86	0	0.858006
2/01/2000 0:25	0	4.54	0.15	4.692872	0	1.4	0	1.40213	0	0	0.84	0	0.843152
2/01/2000 0:30	0	4.48	0.15	4.626134	0	1.37	0	1.37074	0	0	0.83	0	0.827681
2/01/2000 0:35	0	4.42	0.14	4.55878	0	1.34	0	1.33984	0	0	0.81	0	0.809732
2/01/2000 0:40	0	4.35	0.14	4.491274	0	1.31	0	1.30939	0	0	0.79	0	0.787062
2/01/2000 0:45	0	4.29	0.13	4.425439	0	1.28	0	1.27932	0	0	0.76	0	0.761336
2/01/2000 0:50	0	4.23	0.13	4.36116	0	1.25	0	1.24992	0	0	0.73	0	0.734897
2/01/2000 0:55	0	4.17	0.12	4.29766	0	1.22	0	1.21998	0	0	0.71	0	0.707713
2/01/2000 1:00	0	4.12	0.12	4.235359	0	1.19	0	1.1904	0	0	0.68	0	0.677989
2/01/2000 1:05	0	4.06	0.12	4.175173	0	1.16	0	1.16009	0	0	0.65	0	0.64779
2/01/2000 1:10	0	4	0.11	4.113953	0	1.13	0	1.12928	0	0	0.62	0	0.617608
2/01/2000 1:15	0	3.95	0.11	4.051537	0	1.1	0	1.09917	0	0	0.59	0	0.587505
2/01/2000 1:20	0	3.89	0.1	3.990367	0	1.07	0	1.06905	0	0	0.56	0	0.557619
2/01/2000 1:25	0	3.83	0.1	3.931209	0	1.04	0	1.03719	0	0	0.53	0	0.527919
2/01/2000 1:30	0	3.78	0.09	3.871756	0	1	0	1.00316	0	0	0.5	0	0.499058
2/01/2000 1:35	0	3.73	0.09	3.816575	0	0.97	0	0.96692	0	0	0.47	0	0.471819
2/01/2000 1:40	0	3.68	0.09	3.765043	0	0.93	0	0.92975	0	0	0.45	0	0.446541
2/01/2000 1:45	0	3.63	0.08	3.716038	0	0.89	0	0.89211	0	0	0.42	0	0.423557
2/01/2000 1:50	0	3.59	0.08	3.667339	0	0.86	0	0.8574	0	0	0.4	0	0.403006
2/01/2000 1:55	0	3.54	0.08	3.621411	0	0.82	0	0.82405	0	0	0.39	0	0.385616
2/01/2000 2:00	0	3.5	0.08	3.573351	0	0.79	0	0.79294	0	0	0.37	0	0.370422
2/01/2000 2:05	0	3.45	0.07	3.527996	0	0.76	0	0.76358	0	0	0.36	0	0.356836
2/01/2000 2:10	0	3.41	0.07	3.478681	0	0.73	0	0.73475	0	0	0.35	0	0.345335
2/01/2000 2:15	0	3.37	0.07	3.43486	0	0.71	0	0.70585	0	0	0.34	0	0.335149
2/01/2000 2:20	0	3.33	0.06	3.390328	0	0.68	0	0.67782	0	0	0.33	0	0.325847
2/01/2000 2:25	0	3.28	0.06	3.348723	0	0.65	0	0.65063	0	0	0.32	0	0.317109
2/01/2000 2:30	0	3.24	0.03	3.274998	0	0.63	0	0.62565	0	0	0.31	0	0.308595
2/01/2000 2:35	0	3.19	0.05	3.248339	0	0.6	0	0.60189	0	0	0.3	0	0.300367
2/01/2000 2:40	0	3.14	0.03	3.173906	0	0.58	0	0.57864	0	0	0.29	0	0.292566
2/01/2000 2:45	0	3.09	0.05	3.144608	0	0.56	0	0.55637	0	0	0.29	0	0.285186
2/01/2000 2:50	0	3.04	0.03	3.070366	0	0.54	0	0.53526	0	0	0.28	0	0.278298
2/01/2000 2:55	0	2.99	0.02	3.009191	0	0.52	0	0.51561	0	0	0.27	0	0.270862
2/01/2000 3:00	0	2.94	0.02	2.962124	0	0.5	0	0.49748	0	0	0.26	0	0.262863
2/01/2000 3:05	0	2.89	0	2.888625	0	0.48	0	0.48093	0	0	0.25	0	0.252452
2/01/2000 3:10	0	2.84	0.04	2.88267	0	0.47	0	0.46514	0	0	0.24	0	0.2415
2/01/2000 3:15	0	2.8	0	2.798547	0	0.45	0	0.44901	0	0	0.23	0	0.233651
2/01/2000 3:20	0	2.76	0	2.762381	0	0.43	0	0.43455	0	0	0.23	0	0.226997
2/01/2000 3:25	0	2.73	0.02	2.747373	0	0.42	0	0.42241	0	0	0.22	0	0.220813
2/01/2000 3:30	0	2.7	0.02	2.721397	0	0.41	0	0.41171	0	0	0.22	0	0.215443
2/01/2000 3:35	0	2.67	0.02	2.689452	0	0.4	0	0.40286	0	0	0.21	0	0.210663
2/01/2000 3:40	0	2.64	0.02	2.659239	0	0.39	0	0.39489	0	0	0.21	0	0.206306
2/01/2000 3:45	0	2.62	0.02	2.636931	0	0.39	0	0.38678	0	0	0.2	0	0.202358
2/01/2000 3:50	0	2.6	0	2.603162	0	0.38	0	0.37867	0	0	0.2	0	0.1988
2/01/2000 3:55	0	2.58	0	2.584694	0	0.37	0	0.37089	0	0	0.2	0	0.195549
2/01/2000 4:00	0	2.56	0	2.563234	0	0.36	0	0.36365	0	0	0.19	0	0.192552
2/01/2000 4:05	0	2.54	0	2.5396	0	0.36	0	0.35707	0	0	0.19	0	0.188701
2/01/2000 4:10	0	2.52	0.01	2.529786	0	0.35	0	0.35095	0	0	0.19	0	0.186853
2/01/2000 4:15	0	2.49	0.01	2.499163	0	0.35	0	0.34523	0	0	0.18	0	0.184855
2/01/2000 4:20	0	2.46	0.01	2.466807	0	0.34	0	0.34008	0	0	0.18	0	0.182734
2/01/2000 4:25	0	2.42	0	2.422957	0	0.33	0	0.33477	0	0	0.18	0	0.180675

2/01/2000 4:30	0	2.39	0	2.391209	0	0.33	0	0.33015	0	0	0.18	0	0.178688
2/01/2000 4:35	0	2.36	0	2.360928	0	0.33	0	0.32656	0	0	0.18	0	0.176759
2/01/2000 4:40	0	2.33	0	2.328794	0	0.32	0	0.32305	0	0	0.17	0	0.174868
2/01/2000 4:45	0	2.29	0	2.294729	0	0.32	0	0.31954	0	0	0.17	0	0.173008
2/01/2000 4:50	0	2.26	0	2.263417	0	0.32	0	0.31591	0	0	0.17	0	0.171175
2/01/2000 4:55	0	2.24	0	2.237208	0	0.31	0	0.31194	0	0	0.17	0	0.169369
2/01/2000 5:00	0	2.21	0	2.210228	0	0.31	0	0.30744	0	0	0.17	0	0.167582
2/01/2000 5:05	0	2.18	0	2.182486	0	0.3	0	0.30243	0	0	0.17	0	0.165815
2/01/2000 5:10	0	2.15	0	2.154536	0	0.3	0	0.29709	0	0	0.16	0	0.164062
2/01/2000 5:15	0	2.13	0	2.128895	0	0.29	0	0.29149	0	0	0.16	0	0.162311
2/01/2000 5:20	0	2.1	0	2.102968	0	0.29	0	0.28595	0	0	0.16	0	0.160587
2/01/2000 5:25	0	2.07	0	2.074403	0	0.28	0	0.28054	0	0	0.16	0	0.158881
2/01/2000 5:30	0	2.05	0.01	2.057699	0	0.28	0	0.27518	0	0	0.16	0	0.157186
2/01/2000 5:35	0	2.02	0	2.016954	0	0.27	0	0.27008	0	0	0.16	0	0.155496
2/01/2000 5:40	0	1.99	0	1.988478	0	0.27	0	0.26544	0	0	0.15	0	0.153818
2/01/2000 5:45	0	1.96	0	1.958598	0	0.26	0	0.26134	0	0	0.15	0	0.152136
2/01/2000 5:50	0	1.93	0	1.929549	0	0.26	0	0.25778	0	0	0.15	0	0.150395
2/01/2000 5:55	0	1.9	0	1.900419	0	0.25	0	0.2547	0	0	0.15	0	0.148982
2/01/2000 6:00	0	1.87	0	1.873586	0	0.25	0	0.2518	0	0	0.15	0	0.148124
2/01/2000 6:05	0	1.85	0	1.848554	0	0.25	0	0.24877	0	0	0.15	0	0.147533
2/01/2000 6:10	0	1.82	0	1.824781	0	0.25	0	0.24556	0	0	0.15	0	0.147037
2/01/2000 6:15	0	1.8	0	1.802539	0	0.24	0	0.2423	0	0	0.15	0	0.14658
2/01/2000 6:20	0	1.78	0	1.780791	0	0.24	0	0.23924	0	0	0.15	0	0.146144
2/01/2000 6:25	0	1.76	0	1.758912	0	0.24	0	0.23646	0	0	0.15	0	0.14572
2/01/2000 6:30	0	1.74	0	1.736257	0	0.23	0	0.23393	0	0	0.15	0	0.145304
2/01/2000 6:35	0	1.71	0	1.712502	0	0.23	0	0.23176	0	0	0.14	0	0.144895
2/01/2000 6:40	0	1.69	0	1.686894	0	0.23	0	0.22985	0	0	0.14	0	0.144492
2/01/2000 6:45	0	1.66	0	1.660395	0	0.23	0	0.22817	0	0	0.14	0	0.144094
2/01/2000 6:50	0	1.63	0	1.6338	0	0.23	0	0.22667	0	0	0.14	0	0.143701
2/01/2000 6:55	0	1.61	0	1.605323	0	0.23	0	0.22521	0	0	0.14	0	0.143312
2/01/2000 7:00	0	1.57	0	1.574785	0	0.22	0	0.22388	0	0	0.14	0	0.142927
2/01/2000 7:05	0	1.54	0	1.543315	0	0.22	0	0.22267	0	0	0.14	0	0.142546
2/01/2000 7:10	0	1.51	0	1.508498	0	0.22	0	0.22153	0	0	0.14	0	0.142165
2/01/2000 7:15	0	1.47	0	1.469608	0	0.22	0	0.22044	0	0	0.14	0	0.141777
2/01/2000 7:20	0	1.43	0	1.434065	0	0.22	0	0.21944	0	0	0.14	0	0.141378
2/01/2000 7:25	0	1.4	0	1.404769	0	0.22	0	0.21851	0	0	0.14	0	0.140962
2/01/2000 7:30	0	1.37	0	1.373751	0	0.22	0	0.21765	0	0	0.14	0	0.14053
2/01/2000 7:35	0	1.35	0	1.354742	0	0.22	0	0.21683	0	0	0.14	0	0.14008
2/01/2000 7:40	0	1.3	0	1.303471	0	0.22	0	0.21605	0	0	0.14	0	0.139612
2/01/2000 7:45	0	1.23	0	1.22694	0	0.22	0	0.21529	0	0	0.14	0	0.139124
2/01/2000 7:50	0	1.17	0	1.169753	0	0.21	0	0.21453	0	0	0.14	0	0.138619
2/01/2000 7:55	0	1.12	0	1.122594	0	0.21	0	0.21378	0	0	0.14	0	0.138092

Appendix C-3

Time Of Concentration Calculation

Catchment Area Summary

	Predevelopment		Postdevelopment	
	North	South	North	South
Impervious	0	0	151013	190100
Pervious	232327	292461	81314	102361

Assumed imperviousness 65%

Existing North - Catchment Properties

Catchment characteristics

	Soil Group	Area (ha)	
Grassed area	C	23.2	(Pasture good condition)
Impervious area	D	0	(Pasture good condition)
Total Area		23.2	

Time of concentration

Sheet and shallow concentrated flow

Length of flow	180	m
Slope	0.2	%
Mannings n	0.05	
Time	37.67	Minutes

Open channel flow 1

Slope	0.005	m/m
Mannings n	0.03	
Channel base width	1	m
Channel height	1	m
Channel side slope 1:	2	
Hydraulic radius	0.548	
Velocity	1.50	m/s
Length	976	m
Time	10.81	Minutes

Open channel flow 2

Slope	0.00	m/m
Mannings n	0.03	
Channel base width	2	m
Channel height	1	m
Channel side slope	1	
Hydraulic radius	0.621	
Velocity	0.00	m/s
Length	0	m
Time	0.00	Minutes

Pipe flow

Gradient	0.00	m/m
Diameter	800	m
Velocity	4	m/s
Length	0	m
Time	0	Minutes

Total time of concetration

Time	48.49	Minutes
Lag time	0.54	Hours

Catchment time of concentration check

Length	1156	m
Height difference	4.82	m
Time	36.71	Minutes

Existing South - Catchment Properties

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Catchment characteristics

	Soil Group	Area (ha)	
Grassed area	C	29.2	(Pasture good condition)
Impervious area	D	0.0	(Pasture good condition)
Total Area		29.2	

Time of concentration

Sheet and shallow concentrated flow

Length of flow	160	m
Slope	0.6	%
Mannings n	0.05	
Time	29.75	Minutes

Open channel flow 1

Slope	0.004	m/m
Mannings n	0.03	
Channel base width	1	m
Channel height	1	m
Channel side slope 1:	2	
Hydraulic radius	0.548	
Velocity	1.40	m/s
Length	758	m
Time	8.99	Minutes

Open channel flow 2

Slope	0.00	m/m
Mannings n	0.03	
Channel base width	2	m
Channel height	1	m
Channel side slope	1	
Hydraulic radius	0.621	
Velocity	0.00	m/s
Length	0	m
Time	0.00	Minutes

Pipe flow

Gradient	0.00	m/m
Diameter	800	m
Velocity	4	m/s
Length	0	m
Time	0	Minutes

Total time of concetration

Time	38.74	Minutes
Lag time	0.43	Hours

Catchment time of concentration check

Length	918	m
Height difference	3.93	m
Time	30.43	Minutes

Proposed North - Catchment Properties

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Over 50 Years

Catchment characteristics

	Soil Group	Area (ha)	
Grassed area	C	8.1	(Pasture good condition)
Impervious area	D	15.1	(Pasture good condition)
Total Area		23.2	

Time of concentration

Sheet and shallow concentrated flow

Length of flow	50	m
Slope	0.2	%
Mannings n	0.05	
Time	26.23	Minutes

Open channel flow 1

Slope	0.003	m/m
Mannings n	0.02	
Channel base width	3	m
Channel height	0.6	m
Channel side slope 1:	2	
Hydraulic radius	0.443	
Velocity	1.57	m/s
Length	350	m
Time	3.72	Minutes

Open channel flow 2

Slope	0.002	m/m
Mannings n	0.03	
Channel base width	2	m
Channel height	1	m
Channel side slope	2	
Hydraulic radius	0.618	
Velocity	1.13	m/s
Length	770	m
Time	11.36	Minutes

Pipe flow

Gradient	0.00	m/m
Diameter	800	m
Velocity	4	m/s
Length	0	m
Time	0	Minutes

Total time of concetration

Time	41.31	Minutes
Lag time	0.46	Hours

Catchment time of concentration check

Length	1170	m
Height difference	2.78	m
Time	46.01	Minutes

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Proposed South - Catchment Properties

Catchment characteristics

	Soil Group	Area (ha)	
Grassed area	C	10.2	(Pasture good condition)
Impervious area	D	19.0	(Pasture good condition)
Total Area		29.2	

Time of concentration

Sheet and shallow concentrated flow

Length of flow	50	m
Slope	0.5	%
Mannings n	0.05	
Time	21.06	Minutes

Open channel flow 1

Slope	0.006	m/m
Mannings n	0.02	
Channel base width	0.7	m
Channel height	0.6	m
Channel side slope 1:	2	
Hydraulic radius	0.337	
Velocity	1.88	m/s
Length	250	m
Time	2.22	Minutes

Open channel flow 2

Slope	0.00	m/m
Mannings n	0.03	
Channel base width	2	m
Channel height	1	m
Channel side slope	2	
Hydraulic radius	0.618	
Velocity	1.36	m/s
Length	560	m
Time	6.86	Minutes

Pipe flow

Gradient	0.00	m/m
Diameter	800	m
Velocity	4	m/s
Length	0	m
Time	0	Minutes

Total time of concetration

Time	30.14	Minutes
Lag time	0.33	Hours

Catchment time of concentration check

Length	860	m
Height difference	3.51	m
Time	29.47	Minutes

Appendix C-4

Site Discharge Hydrograph

Flow Discharge: Block A

	Predevelopment		Postdevelopment		Final Post development flow
Time	50yr flow	200yr flow	50yr flow	200yr flow	200-0.5* (50yr post + 50yr pre)
0:15:00	0	0	0	0	0.0000
0:30:00	0	0	0	0	0.0000
0:45:00	0	0	0	0	0.0000
1:00:00	0	0	0	0.01	0.0100
1:15:00	0	0.01	0.01	0.03	0.0250
1:30:00	0	0.02	0.03	0.06	0.0450
1:45:00	0	0.03	0.04	0.08	0.0600
2:00:00	0	0.03	0.06	0.1	0.0700
2:15:00	0	0.04	0.08	0.11	0.0700
2:30:00	0	0.05	0.09	0.12	0.0750
2:45:00	0	0.05	0.09	0.13	0.0850
3:00:00	0	0.06	0.1	0.14	0.0900
3:15:00	0	0.06	0.11	0.15	0.0950
3:30:00	0	0.06	0.11	0.15	0.0950
3:45:00	0.01	0.07	0.11	0.16	0.1100
4:00:00	0.01	0.07	0.12	0.19	0.1350
4:15:00	0.01	0.09	0.13	0.21	0.1500
4:30:00	0.01	0.1	0.14	0.22	0.1550
4:45:00	0.02	0.11	0.15	0.24	0.1750
5:00:00	0.02	0.12	0.16	0.24	0.1700
5:15:00	0.03	0.13	0.17	0.25	0.1800
5:30:00	0.03	0.14	0.17	0.25	0.1800
5:45:00	0.04	0.15	0.17	0.26	0.1950
6:00:00	0.04	0.16	0.18	0.26	0.1900
6:15:00	0.05	0.16	0.18	0.26	0.1950
6:30:00	0.05	0.17	0.18	0.26	0.1950
6:45:00	0.06	0.17	0.18	0.26	0.2000
7:00:00	0.06	0.18	0.19	0.3	0.2350
7:15:00	0.07	0.2	0.21	0.32	0.2500
7:30:00	0.08	0.22	0.23	0.33	0.2550
7:45:00	0.09	0.24	0.24	0.34	0.2650
8:00:00	0.1	0.25	0.25	0.35	0.2750
8:15:00	0.11	0.26	0.26	0.36	0.2850
8:30:00	0.12	0.27	0.26	0.36	0.2900
8:45:00	0.13	0.27	0.27	0.36	0.2900
9:00:00	0.14	0.28	0.27	0.41	0.3450
9:15:00	0.15	0.31	0.3	0.44	0.3650
9:30:00	0.16	0.34	0.32	0.46	0.3800
9:45:00	0.18	0.36	0.33	0.47	0.3950
10:00:00	0.19	0.37	0.34	0.57	0.4950
10:15:00	0.22	0.44	0.41	0.63	0.5350
10:30:00	0.25	0.49	0.45	0.67	0.5700
10:45:00	0.28	0.52	0.48	0.69	0.5900
11:00:00	0.3	0.55	0.5	0.7	0.6000
11:15:00	0.32	0.58	0.52	0.71	0.6100

11:30:00	0.34	0.59	0.52	0.71	0.6200
11:45:00	0.36	0.61	0.53	0.71	0.6250
12:00:00	0.38	0.62	0.53	0.91	0.8350
12:15:00	0.43	0.75	0.66	1.01	0.8950
12:30:00	0.49	0.83	0.74	1.07	0.9450
12:45:00	0.53	0.89	0.79	1.09	0.9600
13:00:00	0.57	0.93	0.82	2.39	2.2650
13:15:00	0.89	1.74	1.61	2.99	2.6300
13:30:00	1.19	2.24	2.04	3.2	2.7750
13:45:00	1.45	2.57	2.25	3.28	2.8800
14:00:00	1.66	2.79	2.35	1.91	1.5650
14:15:00	1.46	2.05	1.53	1.46	1.4250
14:30:00	1.31	1.71	1.21	1.27	1.3200
14:45:00	1.2	1.51	1.05	1.19	1.2650
15:00:00	1.12	1.39	0.97	0.95	1.0250
15:15:00	0.99	1.17	0.79	0.84	0.9400
15:30:00	0.89	1.04	0.69	0.78	0.8800
15:45:00	0.81	0.95	0.64	0.75	0.8350
16:00:00	0.75	0.88	0.61	0.63	0.7000
16:15:00	0.67	0.77	0.51	0.57	0.6500
16:30:00	0.61	0.69	0.46	0.53	0.6050
16:45:00	0.56	0.64	0.43	0.52	0.5850
17:00:00	0.51	0.6	0.41	0.5	0.5500
17:15:00	0.48	0.57	0.39	0.5	0.5450
17:30:00	0.45	0.54	0.38	0.49	0.5250
17:45:00	0.43	0.52	0.38	0.49	0.5150
18:00:00	0.41	0.51	0.37	0.44	0.4600
18:15:00	0.38	0.47	0.34	0.41	0.4300
18:30:00	0.36	0.44	0.32	0.39	0.4100
18:45:00	0.34	0.41	0.31	0.38	0.3950
19:00:00	0.32	0.4	0.3	0.34	0.3500
19:15:00	0.29	0.36	0.27	0.31	0.3200
19:30:00	0.27	0.33	0.25	0.29	0.3000
19:45:00	0.26	0.31	0.23	0.28	0.2950
20:00:00	0.24	0.3	0.22	0.28	0.2900
20:15:00	0.23	0.29	0.22	0.27	0.2750
20:30:00	0.21	0.28	0.21	0.27	0.2700
20:45:00	0.2	0.27	0.21	0.27	0.2650
21:00:00	0.19	0.26	0.2	0.26	0.2550
21:15:00	0.19	0.25	0.2	0.26	0.2550
21:30:00	0.18	0.25	0.2	0.26	0.2500
21:45:00	0.17	0.24	0.2	0.26	0.2450
22:00:00	0.17	0.24	0.2	0.23	0.2150
22:15:00	0.16	0.22	0.18	0.21	0.2000
22:30:00	0.15	0.2	0.17	0.2	0.1900
22:45:00	0.14	0.19	0.16	0.19	0.1800
23:00:00	0.13	0.18	0.16	0.19	0.1750
23:15:00	0.13	0.18	0.15	0.18	0.1700
23:30:00	0.12	0.17	0.15	0.18	0.1650
23:45:00	0.12	0.16	0.15	0.18	0.1650
0:00:00	0.11	0.16	0.15	0.2	0.1800

Flow Discharge: Block B

	Predevelopment		Postdevelopment		Final Post development flow
Time	50yr flow	200yr flow	50yr flow	200yr flow	200-0.5* (50yr post + 50yr pre)
0:15:00	0	0	0	0	0.0000
0:30:00	0	0	0	0	0.0000
0:45:00	0	0	0	0	0.0000
1:00:00	0	0	0	0	0.0000
1:15:00	0	0	0.01	0.01	0.0050
1:30:00	0	0	0.02	0.03	0.0200
1:45:00	0	0	0.04	0.05	0.0300
2:00:00	0	0	0.06	0.07	0.0400
2:15:00	0	0	0.07	0.09	0.0550
2:30:00	0	0	0.09	0.11	0.0650
2:45:00	0	0	0.1	0.13	0.0800
3:00:00	0	0.01	0.11	0.15	0.0950
3:15:00	0	0.01	0.12	0.16	0.1000
3:30:00	0.01	0.01	0.13	0.17	0.1100
3:45:00	0.01	0.01	0.14	0.18	0.1150
4:00:00	0.01	0.02	0.14	0.18	0.1150
4:15:00	0.02	0.02	0.16	0.21	0.1400
4:30:00	0.02	0.03	0.18	0.24	0.1600
4:45:00	0.03	0.04	0.19	0.26	0.1800
5:00:00	0.04	0.05	0.2	0.28	0.2000
5:15:00	0.04	0.06	0.21	0.29	0.2050
5:30:00	0.05	0.07	0.21	0.3	0.2200
5:45:00	0.06	0.07	0.22	0.31	0.2300
6:00:00	0.06	0.08	0.22	0.31	0.2300
6:15:00	0.07	0.09	0.23	0.32	0.2400
6:30:00	0.08	0.1	0.23	0.32	0.2450
6:45:00	0.08	0.11	0.23	0.32	0.2450
7:00:00	0.09	0.12	0.24	0.32	0.2450
7:15:00	0.1	0.13	0.26	0.36	0.2800
7:30:00	0.12	0.15	0.29	0.39	0.3050
7:45:00	0.13	0.16	0.3	0.41	0.3250
8:00:00	0.15	0.18	0.32	0.42	0.3350
8:15:00	0.16	0.19	0.32	0.43	0.3500
8:30:00	0.17	0.21	0.33	0.44	0.3600
8:45:00	0.18	0.22	0.34	0.44	0.3600
9:00:00	0.19	0.23	0.34	0.45	0.3750
9:15:00	0.21	0.26	0.37	0.5	0.4200
9:30:00	0.23	0.28	0.39	0.53	0.4500
9:45:00	0.24	0.3	0.41	0.56	0.4750
10:00:00	0.26	0.32	0.42	0.58	0.5000
10:15:00	0.3	0.37	0.5	0.68	0.5800
10:30:00	0.34	0.41	0.56	0.76	0.6500
10:45:00	0.38	0.45	0.6	0.81	0.7000
11:00:00	0.41	0.49	0.63	0.84	0.7300
11:15:00	0.44	0.53	0.65	0.86	0.7550

11:30:00	0.46	0.56	0.66	0.88	0.7800
11:45:00	0.48	0.59	0.67	0.89	0.7950
12:00:00	0.5	0.61	0.67	0.89	0.8050
12:15:00	0.58	0.7	0.82	1.09	0.9700
12:30:00	0.65	0.78	0.91	1.22	1.0900
12:45:00	0.71	0.85	0.98	1.3	1.1650
13:00:00	0.77	0.91	1.02	1.34	1.2150
13:15:00	1.22	1.38	1.91	2.69	2.3450
13:30:00	1.64	1.83	2.48	3.48	3.0600
13:45:00	1.98	2.25	2.79	3.86	3.4550
14:00:00	2.25	2.6	2.94	4.04	3.6950
14:15:00	1.92	2.35	2.01	2.62	2.5750
14:30:00	1.68	2.16	1.59	2.02	2.0650
14:45:00	1.52	2	1.37	1.74	1.8150
15:00:00	1.39	1.88	1.25	1.59	1.6600
15:15:00	1.21	1.69	1.03	1.3	1.3900
15:30:00	1.08	1.54	0.9	1.14	1.2300
15:45:00	0.98	1.43	0.82	1.04	1.1200
16:00:00	0.9	1.33	0.77	0.99	1.0550
16:15:00	0.8	1.2	0.66	0.85	0.9200
16:30:00	0.72	1.1	0.59	0.76	0.8250
16:45:00	0.65	1.02	0.55	0.71	0.7600
17:00:00	0.6	0.95	0.52	0.68	0.7200
17:15:00	0.56	0.89	0.5	0.66	0.6900
17:30:00	0.53	0.84	0.49	0.64	0.6600
17:45:00	0.5	0.8	0.48	0.63	0.6400
18:00:00	0.48	0.76	0.47	0.63	0.6350
18:15:00	0.45	0.71	0.44	0.57	0.5750
18:30:00	0.42	0.67	0.41	0.53	0.5350
18:45:00	0.4	0.63	0.4	0.51	0.5100
19:00:00	0.38	0.6	0.38	0.49	0.4900
19:15:00	0.34	0.56	0.34	0.44	0.4400
19:30:00	0.32	0.53	0.32	0.41	0.4100
19:45:00	0.3	0.49	0.3	0.39	0.3900
20:00:00	0.28	0.47	0.28	0.37	0.3700
20:15:00	0.26	0.44	0.27	0.36	0.3550
20:30:00	0.25	0.42	0.27	0.35	0.3400
20:45:00	0.24	0.4	0.26	0.35	0.3400
21:00:00	0.23	0.39	0.26	0.34	0.3250
21:15:00	0.22	0.37	0.25	0.34	0.3250
21:30:00	0.21	0.36	0.25	0.34	0.3200
21:45:00	0.2	0.35	0.25	0.33	0.3050
22:00:00	0.2	0.34	0.25	0.33	0.3050
22:15:00	0.19	0.32	0.23	0.3	0.2800
22:30:00	0.17	0.3	0.22	0.28	0.2550
22:45:00	0.16	0.29	0.21	0.26	0.2350
23:00:00	0.16	0.27	0.2	0.25	0.2300
23:15:00	0.15	0.26	0.2	0.24	0.2150
23:30:00	0.14	0.25	0.19	0.24	0.2150
23:45:00	0.14	0.24	0.19	0.23	0.2050
0:00:00	0.13	0.23	0.18	0.23	0.2050