To
Healthy Waters

From
Woods
Jasmin Moll – 3 Waters Engineer
Bidara Pathirage - Senior Associate Engineer

Reviewed
Pranil Wadan – Technical Director

W-REF: P24-646 Drury Centre – Stage 2
22 August 2025

Drury Metropolitan Centre Fast-track, Auckland Council Specialist Memo, Annexure 7 - Woods Response

1. Introduction

This memorandum has been prepared by Woods on behalf of Kiwi Property in response to recommendations and comments raised by Healthy Waters regarding the Fast-track application for Consolidated Stages 1 and 2 of the Drury Centre development (**Drury Centre Project**).

Stage 2 site covers approximately 24.27ha and is proposed to accommodate a mix of commercial, retail, accommodation, and community activities, supported by associated car parking and infrastructure. The consent also proposes to further subdivide Stage 1 super lots.

The purpose of the memo is to address Healthy Waters' recommendations/ comments and provide supporting information for the Drury Centre Project.

2. Documents

The following documents (Table 1) haven been submitted to support the Fast-track application for Stage 2 of the Drury Centre development, in relation to stormwater:

Table 1: Summary of documents

Report	Author	Version	Comment
Stormwater Assessment Report, Drury Centre, Stage 2'	Woods	Version 5, dated 22 August 2025	Submitted as part of this response to comments Updated in response to Councils two "section 67 requests" and the recommendations/ comments raised by Healthy Waters Annexure 7
		Version 4 (21 March 2025)	Submitted as part of Fast-Track application
Appendix D: *'Fitzgerald Stream Local Catchment Model, Stormwater Model Conversion and Update Report'*	Woods	Version 2, dated 18 February 2025	Submitted as part of Fast-Track application
'Response s67 further information memorandum recommended by Auckland Council'	B&A with input from Woods	24 July 2025	

'Response s67 further information recommended by Auckland Council Healthy Waters'	B&A with input from Woods	5 August 2025	

3. Recommendations/ Comments

Table 2 - Table 5 below:

- summarise comments received from Healthy Waters relating to flooding, erosion, stormwater management devices and Stage 1 stormwater management; and
- set out Woods' response to those comments (including any recommendations).

3.1. Flood Assessment

Table 2: Flood assessment

<table>
<tr><th>Healthy Waters Recommendation</th><th>Woods Response</th></tr>
<tr><td>The Applicant must provide a final copy of the hydraulic model prior to Engineering Plan Approval and prior to establishment of any impervious surfaces authorised by this consent.</td><td>Noted – however, the models have already been provided to Healthy Waters on 21/07/2025 and are not anticipated to change prior to Engineering Plan Approval submission. If necessary (e.g.: as a result of any significant changes), revised models will be provided prior to EPA submission.</td></tr>
<tr><td>The Applicant must provide the final proposed finished surface design that demonstrates no loss of storage volume within the Fitzgerald Stream 1% AEP floodplain.</td><td>While the proposed works will result in displacement of floodplain storage, this displacement does not generate any adverse effects within the Fitzgerald Stream 1% AEP floodplain. This was addressed in Stormwater Assessment Report, Drury Centre, Stage 2 Version 4.'. As such, while a final proposed finished surface design can be provided, it is not considered necessary that this demonstrate no loss of storage.</td></tr>
<tr><td>The Applicant must provide an updated Overland Flow Path Assessment to address the concerns outlined under Section 3.11. It is not considered appropriate to defer resolution of remaining concerns in this regard to Engineering Plan Approval stage as any design changes required to accommodate increased overland flows may trigger the need to vary the resource consent under Section 127 of the RMA.</td><td>The Overland flow path assessment dated 14/07/2025 was submitted as part of the Section 67 responses to Auckland Council.

The assessment incorporated the primary stormwater network as per the proposed design. The blockage assumption applies to the primary network are consistent with the requirements set out in Section 4.3.5.6 of Auckland Council's Stormwater Code of Practice (SWCoP) (Version 4, July 2025).

A 50% blockage was assumed for pipes DN > 600, and 100% blockage for pipes with DN ≤ 600.

It is therefore unclear why these assumptions have been considered inappropriate for the purpose of the assessment, and no detail has been provided as to Healthy Waters concerns with the 14/07/2025 response.

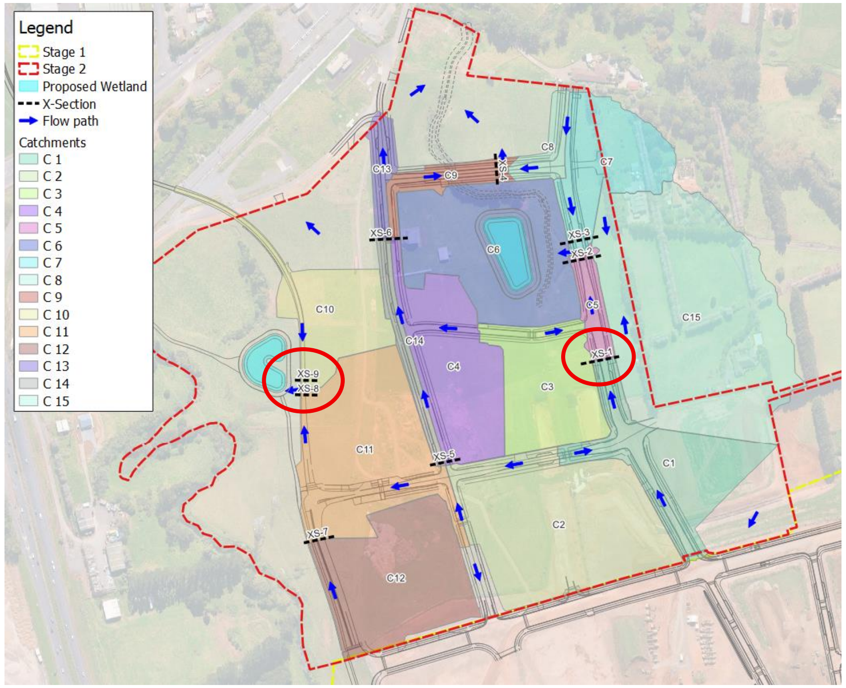
Despite this, further assessment was undertaken for Cross-sections 1, 8 and 9, assuming 100% blockage for all stormwater pipes (Noting this exceeds requirements of the stormwater code of practice). The results are summarised in the table below.

<table>
<tr><th>XS</th><th>Catchment Area (ha)</th><th>Peak flow rate (m^3/s)</th><th>Flow depth (m)</th><th>Average velocity (m/s)</th><th>Criteria (dxv) (m^2/s)</th><th>Max flow depth x Average velocity (dxv) (m^2/s)</th></tr>
<tr><td>XS-1</td><td>1.365</td><td>0.556</td><td>0.117</td><td>0.996</td><td>0.3</td><td>0.117</td></tr>
<tr><td>XS-8</td><td>3.847</td><td>1.574</td><td>0.271</td><td>1.324</td><td>0.4</td><td>0.359</td></tr>
</table></td></tr>
</table>

Healthy Waters Recommendation	Woods Response

XS-9	0.951	0.389	0.177	0.782	0.4	0.138

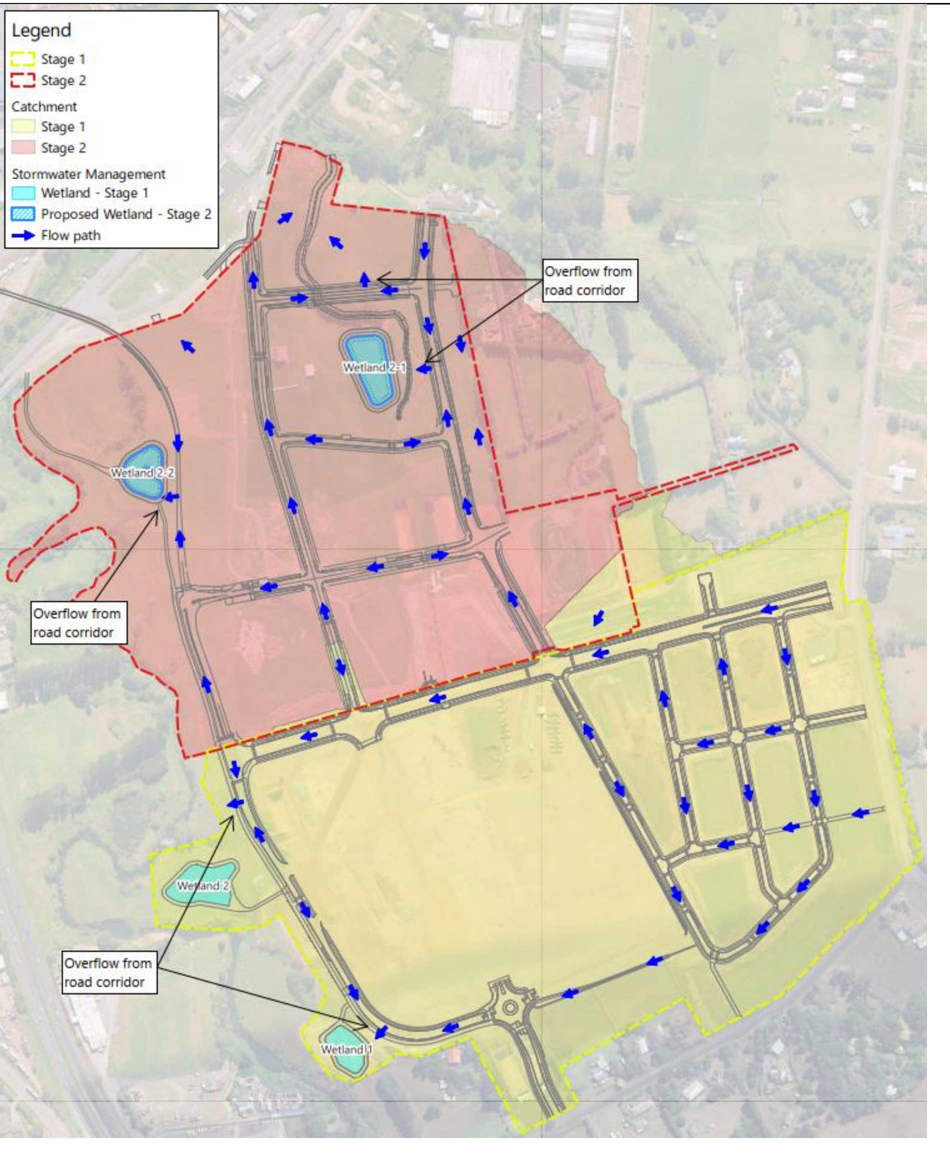
The location of the assessed cross sections is shown in the figure below.



XS1: The product of flow depth and average velocity is below the minimum threshold for both vehicular and pedestrian safety as outlined in the *Auckland Transport Traffic Design Manual* (AT TDM). The potential overland flow is fully contained within the proposed road reserve.

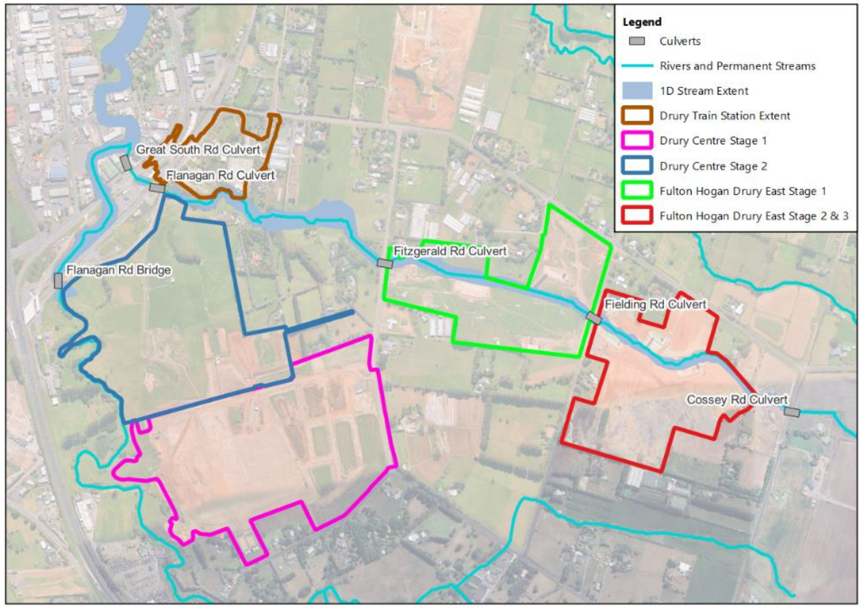
XS8 and XS9: The product of flow depth and average velocity does not exceed the threshold for people and vehicular safety (as there is no parking proposed at this location). Consistent with the previous assessment undertaken, the overland flow is not fully contained within the proposed road reserve (on the side of the reserve)), as this location is a low point where runoff discharges to the Stream and consistent with the design of the proposed road.

Healthy Waters Recommendation	Woods Response
	As per the proposed design no overland flows originating from Stage 1 discharge towards Stage 2. This is illustrated in Figure below that shows the intended direction of overland flows within Stages 1 and 2.

Legend
Stage 1
Stage 2
Catchment
Stage 1
Stage 2
Stormwater Management
Wetland - Stage 1
Proposed Wetland - Stage 2
Flow path
Overflow from road corridor
Overflow from road corridor
Overflow from road corridor
Wetland 2-1
Wetland 2-2
Wetland 2
Wetland 1

Healthy Waters Recommendation	Woods Response
The Applicant must provide revised development layout for Lot 40 that provides a minimum of 20m of 'green space' offset from the Flanagan Road Culvert to any buildings or infrastructure (including access roads or driveways.	The building footprint within Lot 40 is located approximately 11m away from the edge of the top of Fitzgerald Stream. The building in Lot 40 is proposed to be developed with a minimum freeboard of 500mm above the 1% AEP + climate change allowance, with the appropriate flood level determined by the culvert(s) operational at the time of occupation. The flood level at this location, and any potential impacts to Lot 40, are directly influenced by the functioning of the Flanagan Road Culvert and any supplementary culvert. A condition is proposed to this effect. Any supplementary culvert is noted to provide additional flood relief under the same blockage assumptions as applied to Flanagan Road, thereby reducing flooding on the site. With respect to the request for a revised development layout providing a minimum 20m green space offset from the Flanagan Road Culvert, we don't believe this is required as safe development of Lot 40 can still be achieved through elevation of buildings to maintain the required freeboard. In addition, safe egress from the site has been considered, with access provided outside of flood-affected areas. Accordingly, consideration should be given to the combination of appropriate building elevation, provision of freeboard, and consideration of egress to ensure that Lot 40 can be developed in a manner that achieves the required level of flood resilience and safety.
The Applicant must assess the risk of flooding to proposed buildings and infrastructure adjacent to Fitzgerald stream from potential blockages of Flanagan Road culvert.	As described in response above, potential blockage of the Flanagan Road culvert has been considered, we have concluded that the building within Lot 40 can be safely located above the relevant flooding level at the time and a condition is proposed to this effect. The flood risk assessment has been carried out assuming only the Flanagan Road culvert is blocked. However, the Fitzgerald Tributary has multiple culverts located upstream of Flanagan Road as can be seen in figure 1 below. Any blockage assessment should consider blockage of all structures, upstream and downstream. Any blockages upstream would result in flood storage being provided upstream of the structure, resulting in lower flood levels around Flanagan Road culvert. Irrespective, this is to be dealt with at detail design stage (Building Consent). For the purposes of the assessment undertaken, the building has been elevated with allowances for displacement as discussed above.

Healthy Waters Recommendation	Woods Response
	 Figure 1 Fitzgerald Tributary has multiple culverts located upstream of Flanagan Road

3.2. Erosion Assessment

Table 3: Erosion assessment

Healthy Waters Recommendation	Woods Response
The Applicant must provide an updated erosion assessment demonstrating that the proposed development will not	A detailed stream erosion assessment has been undertaken (refer to Attachment A) for both the Hingaia Stream and Fitzgerald Stream at the locations specified. This assessment considered:

Healthy Waters Recommendation	Woods Response
increase the risk of erosion to existing Natural Wetland 2 and the Hingaia Stream (downstream of the discharge point associated with Wetland 2-2) and the overland flow path rock chute from Area 2. It is not considered appropriate to defer the update of the assessment to Engineering Plan Approval stage. Any design changes required to manage erosion may require a variation to the resource consent under Section 127 of the RMA. The Applicant must carry out a Geomorphic Risk Assessment of the Hingaia Stream, adjacent to the proposed development in order to understand long term erosion risk. The outputs of the Geomorphic Risk Assessment can be used to ensure that the proposed assets and structures adjacent to the stream are designed appropriately and will not be undermined by ongoing stream erosion. The Applicant must provide an erosion assessment of the Fitzgerald Stream to understand the potential migration of the stream overtime and demonstrate this will not undermine the proposed structures adjacent to the stream.	• A geomorphological site visit at both Hingaia and Fitzgerald Stream, adjacent to the development area • Ongoing stream erosion processes - a Geomorphological Change Detection (GCD) analysis • An Erosion Screening Tool (EST) assessment • The risk of stream erosion to structures adjacent to the streams – both existing (Natural Wetland 2) and proposed (Wetland 2-2 and Road 2) • Any future stormwater outlets **Hingaia Stream** In relation to the Hingaia Stream, the results of this assessment confirm that the proposed development will not increase the risk of erosion to Hingaia Stream as well as to Natural Wetland 2. This is attributed to the size of the proposed development (~ 24 ha or 0.44%) extent being minimal as compared to the overall Hingaia Stream catchment (~5493 ha). Additionally, based on the hydrograph information, the flows from the site discharge downstream to the Manukau Harbour before flows from the rest of catchment reach this portion of the Hingaia Stream therefore reducing the potential for erosion when peak flows are conveyed adjacent to the site. The assessment also concludes that the risk of erosion to proposed Wetland 2-2 is low as it located outside the floodplain and located above Natural Wetland 2. However, the GCD assessment has identified an erosion hot spot within the Hingaia Stream, adjacent to Wetland 2-2. Whilst the EST analysis we have undertaken demonstrates that there is no exacerbation of erosion potential to this area as a result of Drury Centre Stage 2, the stream may require further protection at this location to ensure future resilience of Wetland 2-2. The design of this is to be undertaken at detail design stage as part of EPA. **Rock chute** This was originally consented as part of a different consent. Modifications have been made with respect amendments to ensure maintenance and the rock chute/ green outfall. Overall the design of the rock chute, as previously consented, allows for 100-year flows (+climate change) and velocities and is to be further detailed accordingly as part of detail design (EPA stage). **Road 2** Road 2 and its location was previously consented to as part of a separate project. This has been noted on the plans but Road 2 was shown for completeness and to show how the development ties into this road. The questions relating to road 2 are therefore outside of the scope of this consent. **Fitzgerald Stream**

Healthy Waters Recommendation	Woods Response
	The assessment undertaken for the reach of Fitzgerald Stream (located adjacent to the development) concludes that it is generally stable with no erosion hotspots located within the area adjacent to the development. Therefore, any risk to structures is considered low and can be adequately managed through detailed design. **Conclusion** The assessment demonstrates that appropriate erosion management outcomes can be achieved at the Engineering Plan Approval stage. Any further refinement of design details will be undertaken within the framework established by this assessment.

3.3. Stormwater Management Devices

Table 4: Stormwater management

Healthy Waters Recommendation	Woods Response
The Applicant must either propose to vest Wetland 2-1 and Wetland 2-2 as public assets or confirm acceptance that any stormwater network upstream of the Stormwater Management Wetlands cannot be vested as public. If the Applicant prefers that the assets are vested as public, updated scheme plans must be provided indicating the Stormwater Management Wetlands (including maintenance access tracks) are located within '*Land in Lieu of Reserve – for Drainage Purposes*'.	Both Wetland 2-1 and Wetland 2-2 are proposed to remain in private ownership. In accordance with this approach, the stormwater network upstream of the devices discharging to these two stormwater management wetlands can also be made private, if required by Healthy Waters. The plans can be updated to reflect this. As such, there is no requirement to vest Wetland 2-1 or Wetland 2-2 as public assets, and no updates to the scheme plans are necessary in this regard.
The Applicant must provide updated scheme plans that showing the public Communal Raingarden 2-1 (including maintenance access tracks) located within	Scheme plan updated.

Healthy Waters Recommendation	Woods Response
a *'Land in Lieu of Reserve – for Drainage Purposes'*.	

3.4. Stage 1 – Superlot Stormwater Management

Table 5: Stage 1

Healthy Waters Recommendation	Woods Response
Conditions requiring that hydrology mitigation and water quality treatment are provided at-source on all individual private lots have been recommended within Appendix B. These requirements are to be secured via consent notices registered on the relevant titles.	Noted, this recommendation is addressed in the B&A response.

Attachment A

Stream Erosion Risk Assessment

Drury Centre Stage 2 - Fast Track Application

Auckland Council

Woods
Shakti Singh – 3 Waters Engineer
Danny Baucke – Environmental specialist
Boniface Kinnear – Senior Associate Engineer

Reviewers:
Bidara Pathirage – Senior Associate Engineer
Pranil Wadan – Technical Director

W-REF: P24-447 Drury Centre – Stage 2
21 August 2025

Stream Erosion Risk Assessment

Drury Centre Stage 2 - Fast Track Application

1. Introduction

Section 53(2) of the Fast-track Approvals Act 2024 enables the Expert Consenting Panel to invite written comments on the application from specified persons and groups.

This memorandum has been prepared in response to the technical specialist memorandums issued by Auckland Council as part of their assessment of the Drury Centre Stage 2 Fast-track Application. It specifically addresses the recommendations provided by Healthy Waters as outlined below:

- *The applicant must provide an updated erosion assessment demonstrating that the proposed development will not increase the risk of erosion to existing Natural Wetland 2 and Hingaia Stream (downstream of the discharge point associated with Wetland 2-2) and the overland flow path rock chute from Area 2. It is not considered appropriate to defer the update of the assessment to Engineering Approval stage. Any design changes required to manage erosion may require a variation to the resource consent under Section 127 of the RMA.*
- *The applicant must carry out a Geomorphic Risk Assessment of the Hingaia Stream adjacent to the proposed development in order to understand long term erosion risk. The outputs of the Geomorphic Risk Assessment can be used to ensure that the proposed assets and structures adjacent to the stream are designed appropriately and will not be undermined by ongoing stream erosion.*
- *The applicant must provide an erosion assessment of the Fitzgerald Stream to understand the potential migration of the stream overtime and demonstrate this will not undermine the proposed structures adjacent to the stream.*

Woods have undertaken a comprehensive evaluation of the Hingaia Stream and Fitzgerald stream to address the queries raised by Healthy Waters (as stated above). This included a site visit to visually assess any areas within the stream that are at risk of erosion. During the site visit, a drone was used to capture high-definition images of the streams where walkover was not possible. Furthermore, a Geomorphic Change Detection (GCD) analysis has been undertaken to assess the vertical change in elevations and identify patterns of erosion and deposition within the stream corridor. Appendix A of this memorandum contains the detailed observations.

An erosion assessment using Auckland Council Healthy Waters' Erosion Screening Tool (EST) has also been undertaken to evaluate the potential for erosion in streams for various storm events and to further identify the change in the erosion potential because of the development (if any).

2. Methodology

The assessment has been carried out individually for each stream (i.e. Hingaia Stream and Fitzgerald Stream).

Site visit

The site investigation informed of the existing vegetation cover, stream health and areas of exposure which are identified to be susceptible to erosion.

High-definition aerial imagery was captured and stored as digital information which is available upon request.

Geomorphic change detection (GCD)

The GCD analysis uses LiDAR 2024 and LiDAR 2016 to evaluate the lateral and vertical changes in the stream profile over the time-period of eight years. The results from the GCD analysis provided more information on the change in the stream profile that has occurred in the past with existing catchment characteristics.

Stream erosion assessment

A stream erosion assessment has been carried out using Auckland Council's Healthy Waters EST tool. The assessment makes use of the *'Fitzgerald Stream Local Catchment (*refer to '*Drury Centre Stage 2 Stormwater Assessment Report'*, prepared by Woods, dated 21/08/2025, Version 5). Flow data for 2-, 10- and 100-year ARI storm events (with allowance for future temperature increase of 3.8°C by 2110) were extracted at specific locations for the '*Pre-development'* and '*Post-development with imperviousness addition of Fulton Hogan Stage 1'* (refer to *Drury Centre Stage 2 Stormwater Assessment Report*). It is noted that the flood models have been simulated for 18 hours and therefore, the EST contains exceedances for a total time duration of 18 hours.

The tool calculates bed shear stress and excess shear for each timestep based on the hydrological, cross sections inputs as well as critical shear stress. The critical shear stress is assumed to be 32.6 Pa for the site based on the findings in studies carried out by Cardno for Auckland Council (Table 2). This is supported by recommendations in Auckland Council Technical Report 038 / 2009 Erosion Parameters for Cohesive Sediment in Auckland Streams which suggests "using the median critical shear stress (approximately 33 Pa)" if specific parameters are not developed for a stream.

The calculated excess shear stress is analysed as per the four EST erosion risk profiles as developed by Auckland Council (included in Table 1).

Table 1: EST erosion risk profile

Threshold	Excess Shear	Description
Green	< 1.0	Indicates no erosion predicted to occur *(no erosion)*
Yellow	> 1.0 < 2.0	Indicates the potential for some erosion of the channel *(minimal erosion)*
Orange	> 2.0 < 10.0	Indicates the potential for channel to be mobile, *(active erosion)*
Red	> 10.0	Indicates potential rapid rates of erosion and incision of channel *(rapid erosion)*

Table 2: Critical shear stress in the bank materials at various locations around the Auckland region

All Cardno Data		Hoteo	Awaruku	Omaru	Oakley	Misc. Urban	Elliott et al. (2005)		
Percentile	τ_c	τ_c	τ_c	τ_c	τ_c	τ_c	τ_c	Avg	Median
99.99	403	404	164	218	64.2	336	72.3	237.4	218.4
99.9	395	398	163	218	63.9	334	72.1	234.9	218.4
99	324	335	158	218	61.4	312	70.1	211.2	217.8
95	208	158	134	215	50.5	262	62.1	155.6	157.8
90	138	121	117	168	39.7	237	57.6	125.7	121.2
85	113	109	109	147	34.8	194	57.1	109.0	109.1
80	85.3	72.0	95.4	128	30.9	155	55.9	89.0	85.3
75	**71.6**	**62.1**	**78.4**	**102**	**27.6**	**78.3**	**54.5**	**67.8**	**71.6**
70	61.3	54.5	76.6	97.6	22.9	76.9	53.3	63.3	61.3
65	52.4	45.2	72.3	90.2	19.8	65.3	47.5	56.1	52.4
60	41.4	29.7	63.3	64.6	19.4	51.7	36.9	43.9	41.4
55	32.0	24.7	54.4	57.2	19.3	40.5	36.1	37.8	36.1
50	**25.0**	**15.9**	**42.8**	**49.1**	**19.2**	**35.1**	**32.6**	**31.4**	**32.6**
45	19.4	13.5	33.8	36.1	16.9	30.7	26.4	25.3	26.4
40	13.8	10.2	30.1	25.0	15.2	21.9	24.5	20.1	21.9
35	10.4	8.6	21.2	21.7	14.2	8.3	22.1	15.2	14.2
30	7.8	6.6	15.3	19.9	10.9	4.4	22.0	12.4	10.9
25	**6.4**	**5.0**	**11.0**	**14.2**	**6.5**	**3.1**	**21.3**	**9.6**	**6.5**
20	4.4	3.1	8.4	10.3	6.4	3.1	19.7	7.9	6.4
15	2.8	1.5	6.3	7.0	5.7	2.8	16.8	6.1	5.7
10	1.0	0.61	4.2	4.2	3.5	1.5	13.7	4.1	3.5
5	0.34	0.17	2.4	2.6	2.1	0.46	9.1	2.5	2.1
1	0.06	0.05	0.78	0.67	1.2	0.22	5.3	1.2	0.7
0.1	0.04	0.04	0.42	0.22	1.0	0.18	4.4	0.9	0.2

3. Site observations

Detailed observations have been captured in Appendix A with the summary provided below.

Both Hingaia and Fitzgerald Streams are low-gradient, passively meandering systems within the same catchment, with varying degrees of floodplain connectivity and human modification. Hingaia Stream shows clear signs of vertical incision, leading to floodplain disconnection, deeper channel form, and patchy riparian cover, leaving some banks more vulnerable to erosion. Fitzgerald Stream retains greater connectivity and has a more continuous riparian corridor, although downstream reaches display some incision and confinement. Hydraulic diversity is present in both systems, with Fitzgerald Stream exhibiting more instream woody debris and localised knickpoints, while the Hingaia Stream's diversity is accompanied by more urban encroachment and infrastructure-related confinement.

4. Hingaia Stream

The following section includes the quantitative assessments undertaken for Hingaia Stream to evaluate the existing conditions of the stream and identify if the proposed development further exacerbates erosion potential in the future (if any).

It is noted that the findings of the analysis undertaken for Hingaia Stream are also applicable to the Natural Wetland 2 located on the banks of the Hingaia Stream.

4.1. Geomorphic change detection analysis

The GCD results (2016–2024) show alternating zones of erosion and deposition throughout the surveyed reach, with notable erosion hotspots (red) on outer meander bends (Figure 1). These areas align with bank slumping observed in the field, indicating ongoing bank retreat in cohesive clay banks due to helicoidal flow concentration. Adjacent to many of these erosion sites are aggradation zones (blue), likely representing recently failed bank material deposited at the channel toe. The position and proximity of these paired erosion/deposition features suggest limited reworking by the flow regime, with slumped material stored locally rather than transported downstream.

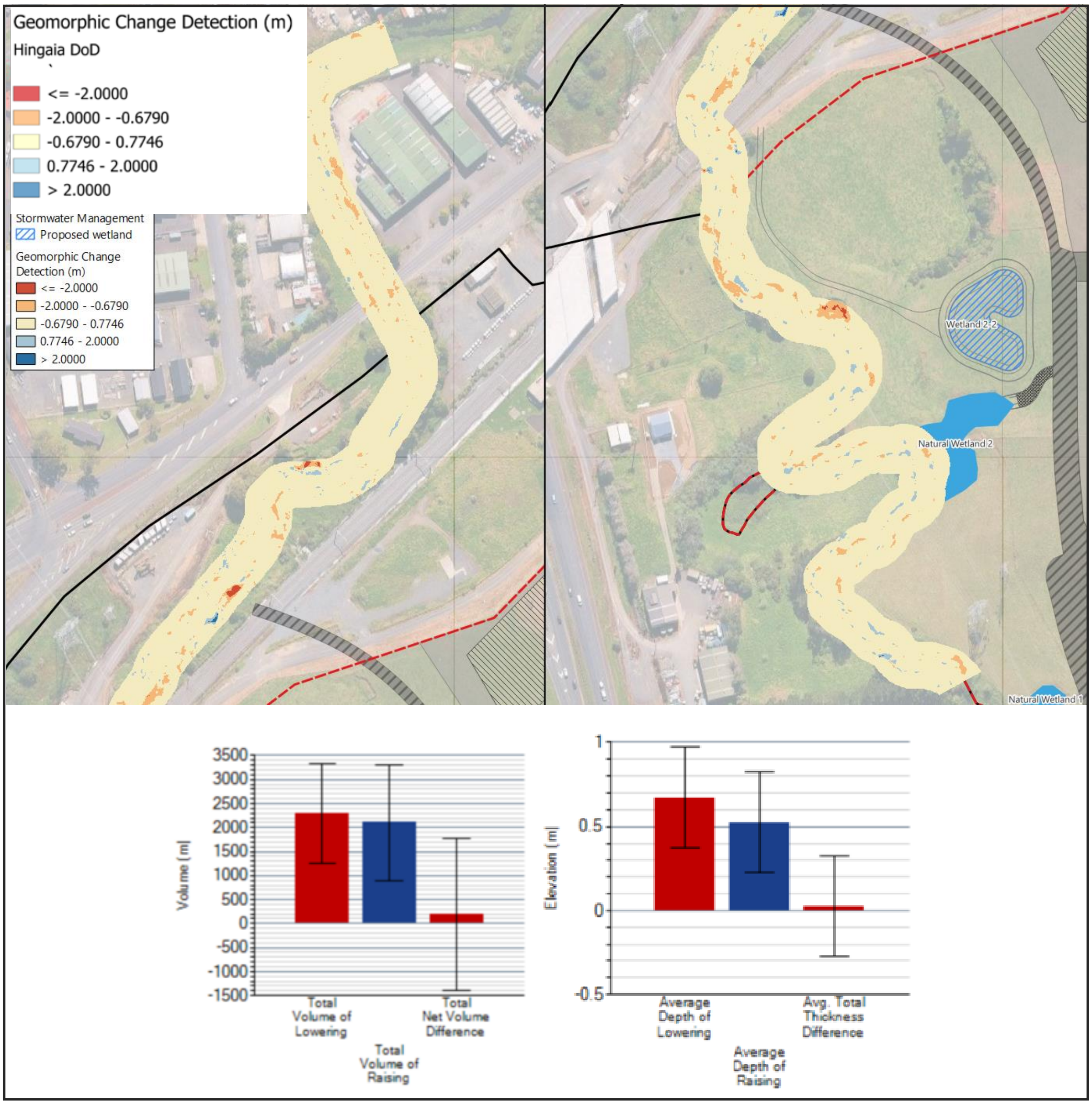


Figure 1: Geomorphic change detection of the Hingaia River. Top graph indicates the volumetric change (m^3) whereas the bottom graph indicates the average depth of lowering (m)

Inner meander bends display aggradation hotspots consistent with expected point-bar deposition zones. The distribution of red–blue pairs suggest a dynamic but balanced sediment regime, with erosion and deposition volumes of comparable magnitude (: net change: ~200 m³). This balance, combined with the lack of large-scale channel migration, points toward a "near" dynamic equilibrium condition.

It is important to note that high flow depths during both LiDAR capture dates limits the visibility of bed morphology, making it difficult to confirm whether the bed is actively incising or aggrading. However, the observed disconnection from the floodplain, lack of in-channel bars, and depth of the channel suggests some degree of historic incision. The dominant sediment source appears to be fine material, although occasional coarser clasts were observed in low-flow margins during field inspection (refer to Figure A1.1 Appendix A).

The minimum level of detection (LoD) used was 0.3 m, accounting for flow depth and survey uncertainty, ensuring that mapped changes exceed measurement error thresholds.

4.2. Erosion screening tool (EST)

To undertake this assessment, locations of interest were identified along Hingaia Stream. Three cross sections as shown on Figure 2 were drawn and corresponding flow hydrographs extracted from the flood model for multiple events (2-, 10- and 100-year ARI with climate change uplift factors of 3.8°C). Results from the EST for the study areas are presented in Table 3, Table 4, and Table 5. Model outputs available upon request however the extracted hydrographs are provided in Appendix B.

The extents of the post development flooding (100-year ARI with climate change) that the cross sections cover is given on Figure 3 below. Also shown on this figure are 2D velocity vectors along the stream.

Appendix C contains the EST results for all cross sections.

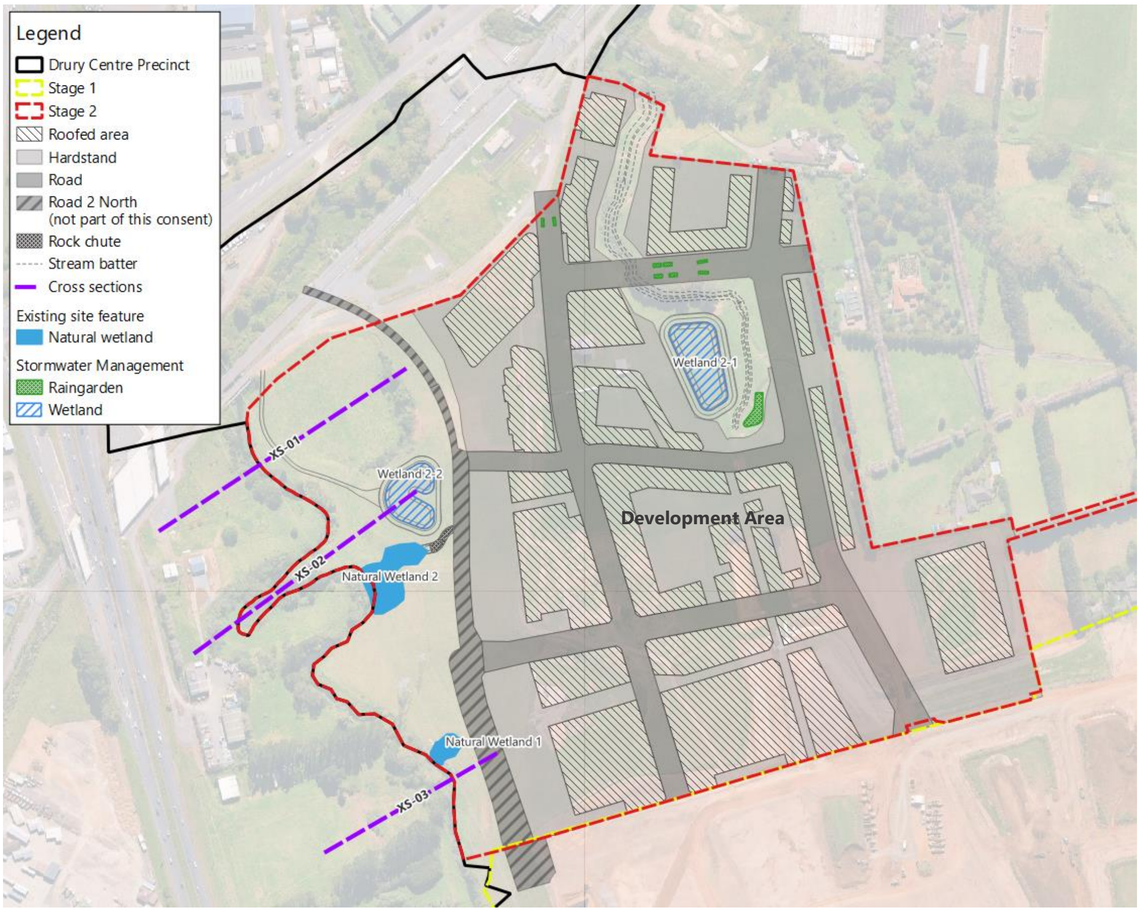


Figure 2: Hingaia Stream study area

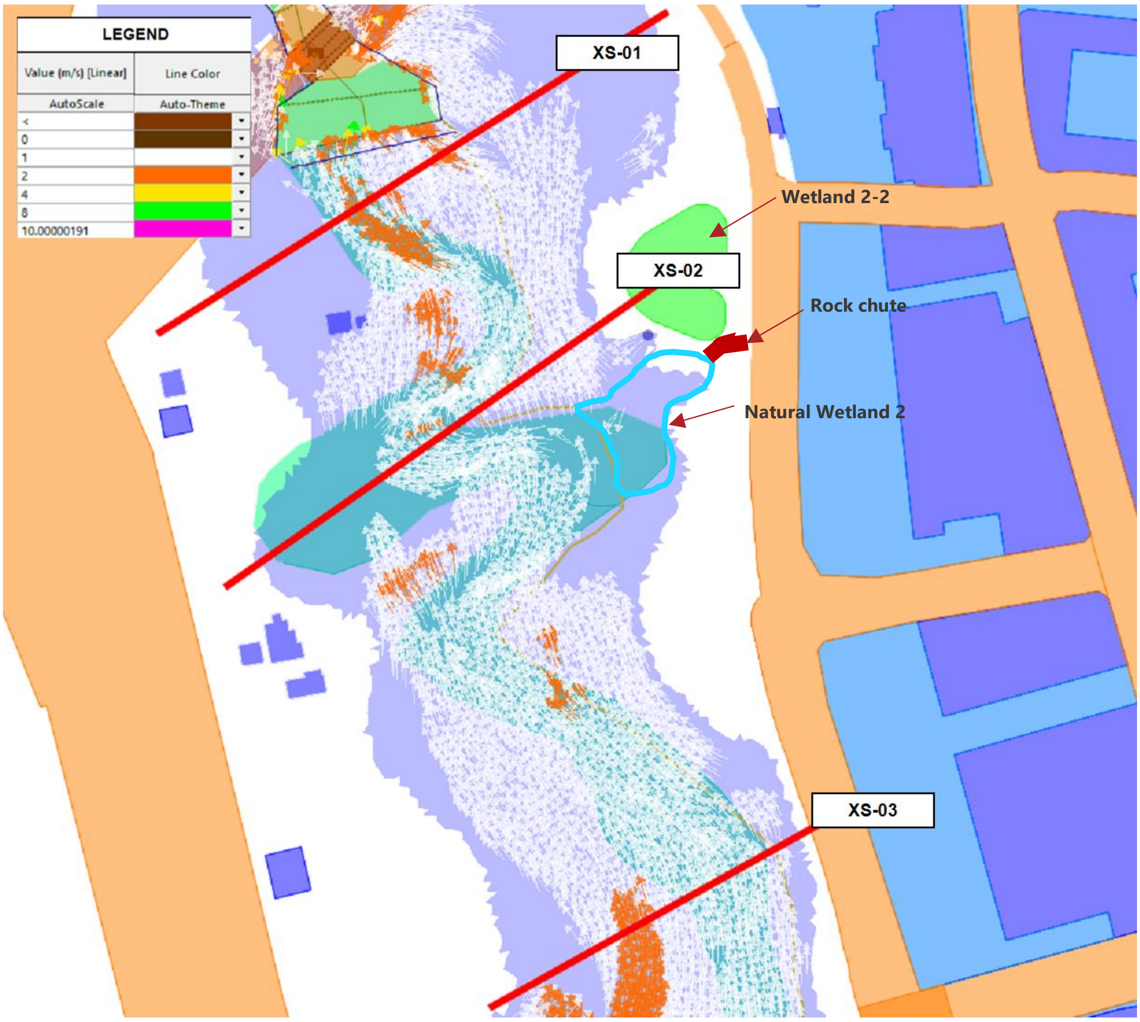


Figure 3: Flood extent and maximum velocity distribution at XS-01, XS02, and XS-03 for Post development model scenario (100-year ARI + 3.8°C)

Cross Section 1

Table 3: EST XS-01

XS - 01									
	Post development			**Pre-development**			**Change**		
	excess shear exceedance (%)			excess shear exceedance (%)			excess shear exceedance (%)		
	2-year	10-year	100-year	2-year	10-year	100-year	2-year	10-year	100-year
<1 (min)	44%	40%	34%	45%	41%	36%	-1%	-1%	-2%
>1 & <2 (min)	15%	6%	5%	9%	5%	3%	6%	2%	2%
>2 & <10 (min)	41%	54%	61%	45%	55%	61%	-5%	-1%	0%
>10 (min)	0%	0%	0%	0%	0%	0%	0%	0%	0%

At this cross section (Figure 4), located downstream of the development area, it has been observed that excess shear exceedance in the 'active erosion' band (orange) occurs more than a third of the time for the lower flood event (2-year ARI) but more than half the time for the larger events (10- and 100-year ARI).

The results, as shown on Table 3, further indicate that the post development scenario does not increase the exceedances i.e., the development does not exacerbate erosion within the stream. This is likely due to fact that overall contribution to the stream flow from the development site relative to the existing flows within Hingaia Stream is insignificant in a relatively wide floodplain (the development site is 0.44% of the overall Hingaia Stream Catchment).

There are no assets proposed at this location of the stream as part of the development thus no mitigation measures are recommended.

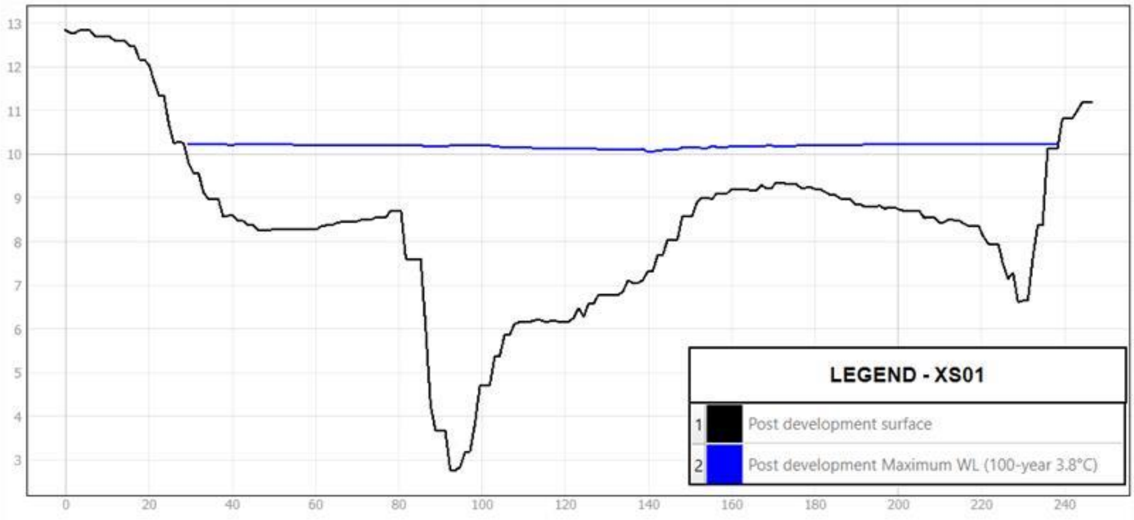


Figure 4: Cross section 1

Cross Section 2

Table 4: EST XS-02

XS - 02									
	Post development			**Pre-development**			**Change**		
	excess shear exceedance (%)			excess shear exceedance (%)			excess shear exceedance (%)		
	2-year	10-year	100-year	2-year	10-year	100-year	2-year	10-year	100-year
<1 (min)	44%	38%	32%	44%	40%	35%	-1%	-2%	-3%
>1 & <2 (min)	5%	4%	4%	4%	2%	1%	1%	2%	3%
>2 & <10 (min)	52%	58%	64%	52%	58%	64%	0%	0%	0%
>10 (min)	0%	0%	0%	0%	0%	0%	0%	0%	0%

At cross section 2 (extended up to the location of proposed Wetland 2-2 - Figure 5), a similar result to cross section 1 has been observed, with active erosion threshold occurring more than half the time for all events. However, there are no changes attributable to the proposed development.

It is noted that this part of the stream is sinuous with high likelihood of banks overtopping in larger events and short-circuiting of flows. It is however expected that the erosion potential will be concentrated at the bends of the middle of the stream corridor with minimal impact encroachment (Figure 3) to the proposed wetland i.e., the erosion risk to the wetland is insignificant.

With respect to Natural Wetland 2 which is located upstream of XS2, it is observed that it becomes inundated under the 100-year ARI event. The wetland is noted to receive flows via a rock chute from the proposed road and an overflow from Wetland 2-2. It is not expected that the flows from the rock chute (designed to convey 100-year flows) will exacerbate erosion of the wetland.

As part of the detailed design, specific hotspots will be identified in the vicinity of the cross section and targeted/appropriate measures put in place to minimise channel and bank scouring. Additional measures will also be provided at outlet devices in accordance with Auckland Council design guidelines.

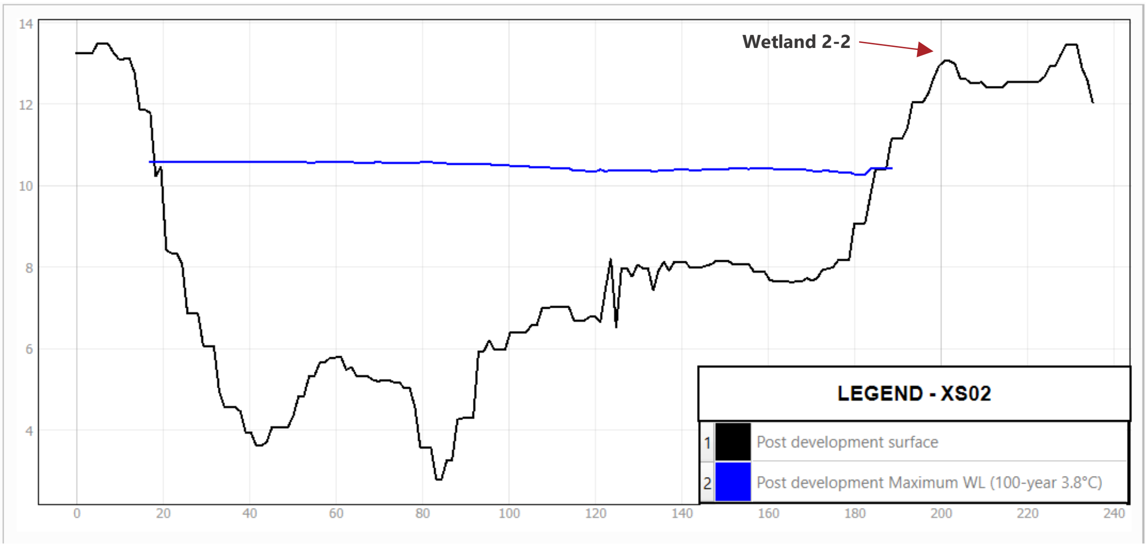


Figure 5: Cross section 2

Cross Section 3

Table 5: EST XS-03

XS - 03									
	Post development			**Pre-development**			**Change**		
	excess shear exceedance (%)			excess shear exceedance (%)			excess shear exceedance (%)		
	2-year	10-year	100-year	2-year	10-year	100-year	2-year	10-year	100-year
<1 (min)	42%	37%	31%	42%	38%	32%	0%	-1%	-1%
>1 & <2 (min)	0%	1%	1%	5%	3%	3%	-5%	-2%	-2%
>2 & <10 (min)	58%	55%	66%	54%	59%	65%	5%	-5%	1%
>10 (min)	0%	7%	2%	0%	0%	0%	0%	7%	2%

This cross section (Figure 6) has been extracted at a location where the stream is closest to the proposed development (next to Road 2) at the upstream end. The EST results indicates that under the existing situation the active erosion threshold occurs more than half the time.

In the post development scenario, rapid erosion is noted to occur for a small portion of the time. This is likely due to the landform being modified (retaining wall along east of the stream corridor). As part of the design for the retaining wall, a geotechnical investigation and design was undertaken, and it is not expected that the stream erosion will have a negative effect nor undermine the wall and by extension, Road 2. As previously mentioned, maximum 2D velocity outputs were extracted from the flood model for the post development (Figure 3) which showed that velocities greater than 2m/s (which are likely to initiate/exacerbate erosion) are prevalent on the western bank, across from the retaining wall located on the easter side. This reinforces the assumption that the likelihood of erosion causing failure of structures adjacent to the stream is low.

It is noted that Road 2 has previously been consented as part of a separate project. The road has been shown on the plans for completeness and to show how the development ties into this road. Any queries regarding Road 2 are therefore outside the scope of this response. This commentary is only provided as way of addressing the potential impact due to the interaction with the stream.

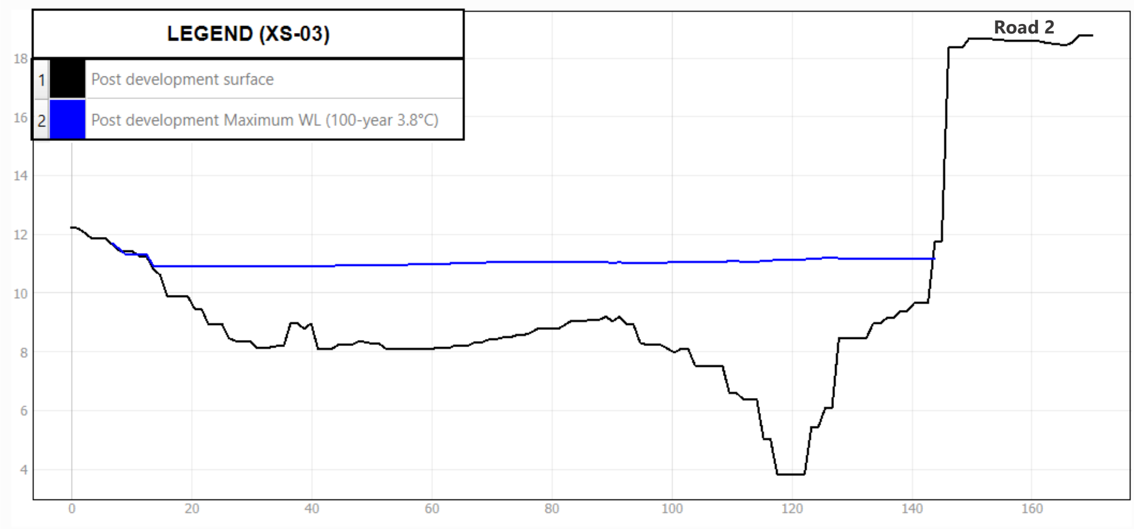


Figure 6: XS-03 cross section profile

5. Fitzgerald Stream

The Fitzgerald Stream GCD analysis (Figure 7) also covers the 2016–2024 period, with the same 0.3 m LoD applied. Compared to the Hingaia, Fitzgerald Stream has lower discharge and shallower flow, meaning more bed features are visible in the DEMs, though heavily vegetated reaches introduce some uncertainty. Apparent aggradation in some zones is likely influenced by vegetation growth or large woody debris (including felled trees), which may have infilled the channel in ways unrelated to sediment transport.

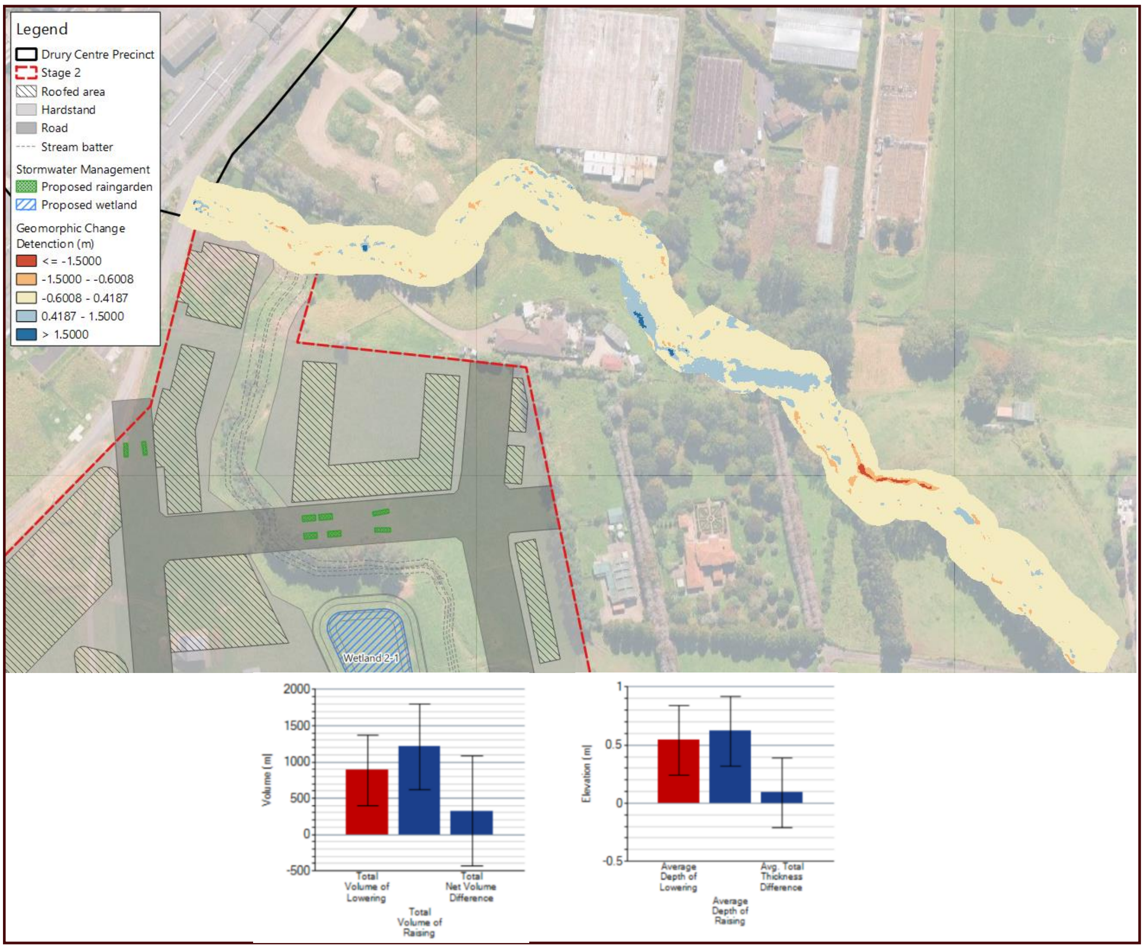


Figure 7. Geomorphic change detection of the Fitzgerlad stream and head water tributary. Top graph indicates the volumetric change (m3) whereas the bottom graph indicates the average depth of lowering (m)

The results from the GCD analysis indicate that:

- A single major erosion hotspot was detected in the upstream section, immediately downstream from the ephemeral headwater reach. This location corresponds to a steep, shear bank evident in the 2016 LiDAR data but was inaccessible during field surveys.
- The scale of change suggests substantial bank retreat and slumping over the survey period. Elsewhere in the reach, the channel exhibits a balanced pattern of sediment transport and deposition, with no large-scale instability evident. The primary aggradation zone is located at the confluence between the main branch and the upper, low-flow tributary.
- Overall, the reach appears stable, with isolated erosion driven by local bank geometry rather than systemic channel instability. Based on the evidence provided above and the site observations, no further analysis (i.e. EST tool) has been carried out for Fitzgerald Stream.

6. Conclusion

A detailed stream erosion assessment has been undertaken (refer to Appendix A for geomorphic site visit) for both the Hingaia Stream and Fitzgerald Stream at the locations specified. This assessment considered:

- A geomorphological site visit at both Hingaia and Fitzgerald Stream, adjacent to the development area
- Ongoing stream erosion processes - a Geomorphological Change Detection (GCD) analysis
- An Erosion Screening Tool (EST) assessment

- The risk of stream erosion to structures adjacent to the streams – both existing (Natural Wetland 2) and proposed (Wetland 2-2 and Road 2)
- Any future stormwater outlets

Hingaia Stream

In relation to the Hingaia Stream, the results of this assessment confirm that the proposed development will not increase the risk of erosion to Hingaia Stream as well as to Natural Wetland 2. This is attributed to the size of the proposed development (~ 24 ha or 0.44%) extent being minimal as compared to the overall Hingaia Stream catchment (~5493 ha). Additionally, based on the hydrograph information, the flows from the site discharge downstream to the Manukau Harbour before flows from the rest of catchment reach this portion of the Hingaia Stream therefore reducing the potential for erosion when peak flows are conveyed adjacent to the site.

The assessment also concludes that the risk of erosion to proposed Wetland 2-2 is low as it located outside the floodplain and located above Natural Wetland 2. However, the GCD assessment has identified an erosion hot spot within the Hingaia Stream, adjacent to Wetland 2-2. Whilst the EST analysis we have undertaken demonstrates that there is no exacerbation of erosion potential to this area as a result of Drury Centre Stage 2, the stream may require further protection at this location to ensure future resilience of Wetland 2-2. The design of this is to be undertaken at detail design stage as part of EPA.

Rock chute

This was originally consented as part of a different consent. Modifications have been made with respect amendments to ensure maintenance and the rock chute/ green outfall. Overall, the design of the rock chute, as previously consented, allows for 100-year flows (+climate change) and velocities and is to be further detailed accordingly as part of detail design (EPA stage).

Road 2

Road 2 and its location was previously consented to as part of a separate project. This has been noted on the plans but Road 2 was shown for completeness and to show how the development ties into this road. The questions relating to road 2 are therefore outside of the scope of this consent.

Fitzgerald Stream

The assessment undertaken for the reach of Fitzgerald Stream (located adjacent to the development) concludes that it is generally stable with no erosion hotspots located within the area adjacent to the development. Therefore, any risk to structures is considered low and can be adequately managed through detailed design.

Conclusion

The assessment demonstrates that appropriate erosion management outcomes can be achieved at the Engineering Plan Approval stage. Any further refinement of design details will be undertaken within the framework established by this assessment.

Appendix A – Site observations

Hingaia Stream

The assessed reach of the Hingaia Stream is a passively meandering channel with two pronounced bends within the area of interest. The active channel is approximately 7 m wide at baseflow and is comparatively deep and narrow, with the banks rising ~5 m (extracted from DEM) from the water surface to the disconnected floodplain surface (Figure A1.1). This floodplain disconnection suggests ongoing vertical incision, likely reducing the frequency of overbank flows and limiting floodplain sediment exchange.

Figure A1.1: Image denotes disconnection from river

The stream is generally laterally unconfined, although one bank shows partial confinement from nearby development. Bank materials are predominantly cohesive clay (Figure A1.2), producing steep, near-vertical profiles. While clay banks resist gradual erosion, undercutting and mass failure are evident (Figure A1.3), particularly along outer bends where flow is directed into the bank. Scarps and slumping were noted in several locations (Figure A1.4).

Figure A1.2: Exposed banks indicating clay substrate

Figure A1.3: Examples of slumping along the Hingaia

Figure A1.4: Examples of bank scarps/scarring

Bed material in low-flow areas comprises mixed volcanic and greywacke clasts (10–70 mm), with limited gravel and cobble deposits (Figure A1.5). These coarse materials do not appear to be part of a well-established, stable bedform. It is unclear whether they represent recent deposition or are the result of fines being washed away, exposing the underlying coarser substrate. Sediment storage within meander bends is moderate and vegetated (Figure A1.6), suggesting low bedload mobility under current flow conditions. Flow observations indicated steady transport of fine suspended sediment.

Figure A1.5: Observed mixed coarse bedload sediment

Figure A1.6: Observed long term sediment stores. Vegetated point bar (left) and evidence of deposition in adjacent former slump fill feature (right)

The reach displays good hydraulic diversity, with riffles, runs, glides, and pools present (Figure A1.7). No knickpoints were observed, and the longitudinal profile appears stable. Signs of past high flows, including bent riparian vegetation (Figure A1.8), indicate occasional flood events capable of mobilising sediment and altering banks.

Figure A1.7: One of many riffle/run sequences within the Hingaia

Figure A1.8: Noted debris lines and bent vegetation denoting peak flow

The riparian corridor is patchy and discontinuous, with some exposed banks lacking vegetative cover (Figure A1.9). In these areas, erosion risk is increased. Downstream, infrastructure such as bridges and built-up areas encroaches upon the riparian margin (Figure A1.10), further constraining the channel and influencing local hydraulics. Woody debris and vegetated patches within the channel provide some local habitat complexity and small-scale sediment trapping (Figure A1.11).

Figure A1.9: Bank Strengthening tree. One of a few areas with vegetation coverage

Figure A1.10: Flanagan Bridge at the lower extent of the reach

Figure A1.11: Examples of woody debris within the Hingaia, note that the right image displays imbedded wood not boulders

Fitzgerald Stream

Fitzgerald Stream is approximately a third of the size of the Hingaia (width ratio), with a passively meandering planform and a generally unconfined setting. Some local confinement occurs where urban works encroach along one bank. The channel is narrow, with a width-to-depth ratio favouring width and retains floodplain connectivity in most areas (Figure A1.12). Bank material is predominantly cohesive clay, as indicated by exposed vertical faces along outer bends (Figure A1.13). These banks are resistant to gradual erosion but prone to undercutting and slumping when flows are concentrated against them.


Figure A1.12: Downstream orientation, example of the Fitzgerald make up and connection to its floodplain


Figure A1.13: Exposed banks revealing cohesive clay substrate

The bed surface is primarily muddy and silty (Figure A1.14) and presume suspended sediment is the dominant mode of transport. No significant coarse-grained sediment deposits or gravel bars were identified, suggesting a low bedload supply and transport regime. This fine-textured sediment environment aligns with the low-gradient setting and catchment context.

Figure A1.14: Upstream (left) and downstream (right) denoting the muddy bed surface. Woody debris was consistently featured throughout the Fitzgerald

Riparian vegetation is mostly continuous, with wide, well-vegetated margins along many sections and only sporadic gaps. Anthropogenic armouring both instream and along the banks is present in certain locations (Figure A1.15), likely for erosion control. Hydraulic diversity includes riffles, runs, and pools, along with several small knickpoints (Figure A1.16). Evidence of bank scour is concentrated on outer bends. Woody debris, including large, felled trees across the channel, contributes to habitat complexity and local sediment retention (Figure A1.17).

Figure A1.15: Examples of anthropomorphic armouring both in stream and banks

Figure A1.16: Hydraulic features were present throughout the observed section of the Fitzgerald

Figure A1.17: Riparian corridor was dense for large sections of the Fitzgerald with felled trees being a common feature too

Downstream, floodplain connectivity becomes increasingly asymmetric, particularly near a private bridge crossing where the channel narrows (Figure A1.18), banks steepen, and historic incision has left one bank well-connected to its floodplain while the other is disconnected, creating small "pocket" floodplains within an urban/suburban setting. Upstream headwaters display ephemeral characteristics (Figure A1.19), with surface flow initiating further downstream.

Figure A1.18: Lower extent of the Fitzgerald, downstream of a private bridge. example of incision process and some disconnection from its floodplain

Figure A1.19: Head water of a tributary that connects with the main Fitzgerald branch downstream

Comparative Summary between Hingaia & Fitzgerald Stream

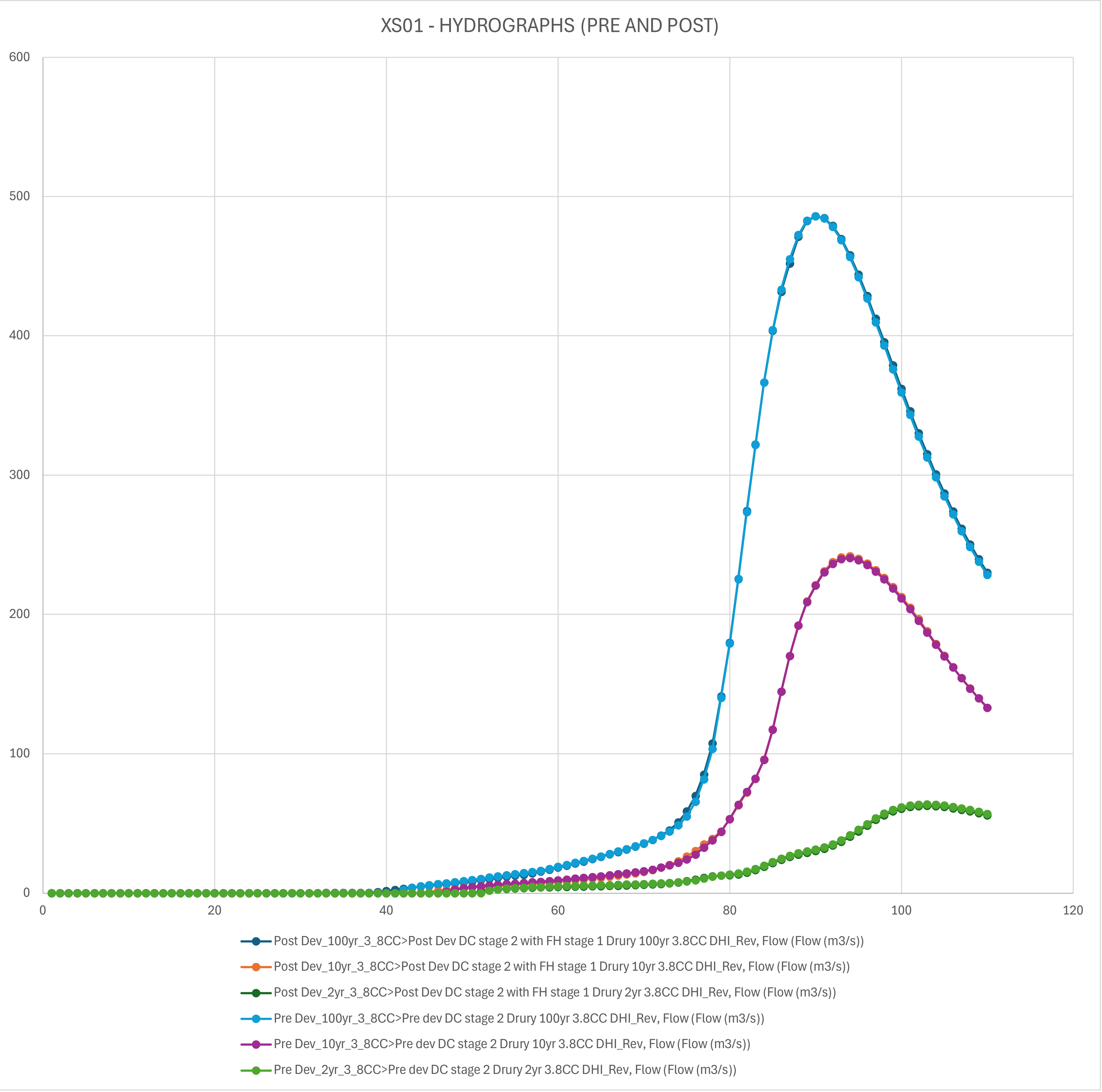
Both Hingaia and Fitzgerald Streams are low-gradient, passively meandering systems within the same catchment, with varying degrees of floodplain connectivity and human modification. Hingaia Stream shows clear signs of vertical incision, leading to floodplain disconnection, deeper channel form, and patchy riparian cover, leaving some banks more vulnerable to erosion. Fitzgerald Stream retains greater connectivity and has a more continuous riparian corridor, although downstream reaches display some incision and confinement. Hydraulic diversity is present in both systems, with Fitzgerald exhibiting more instream woody debris and localised knickpoints, while the Hingaia's diversity is accompanied by more urban encroachment and infrastructure-related confinement

Conclusion

The geomorphic assessments of Hingaia and Fitzgerald Streams indicate that while both channels exhibit active geomorphic processes, the nature and magnitude of risk differ. Along Hingaia Stream, ongoing bank erosion and sediment transport may potentially present long-term risks to adjacent assets however, this will be minimised through safety in design where appropriate measures will be integrated into the development as a whole. In contrast, Fitzgerald Stream is relatively stable, with cohesive banks and low risk of planform migration, meaning the likelihood of undermining adjacent structures is minimal. These findings should inform asset placement and design to ensure resilience against future channel change.

Appendix B – Hydrographs

Time	Dev_100yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 100yr 3.8CC DHI_Rev, Flow Flows (m3/	Dev_10yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 10yr 3.8CC DHI_Rev, Flow (Flow Flows (m3/	Dev_2yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 2yr 3.8CC DHI_Rev, Flow (Flow Flows (m3/	Dev_100yr_3_8CC>Pre dev DC stage 2 Drury 100yr 3.8CC DHI_Rev, Flow (Flow (m3/s)) Flows (m3/	Pre Dev_10yr_3_8CC>Pre dev DC stage 2 Drury 10yr 3.8CC DHI_Rev, Flow (Flow (m3/s)) Flows (m3/	Pre Dev_2yr_3_8CC>Pre dev DC stage 2 Drury 2yr 3.8CC DHI_Rev, Flow (Flow (m3/s)) Flows (m3/s
0:00:00	0	0	0	0	0	0
0:10:00	0	0	0	0	0	0
0:20:00	0	0	0	0	0	0
0:30:00	0	0	0	0	0	0
0:40:00	0	0	0	0	0	0
0:50:00	0	0	0	0	0	0
1:00:00	0	0	0	0	0	0
1:10:00	0	0	0	0	0	0
1:20:00	0	0	0	0	0	0
1:30:00	0	0	0	0	0	0
1:40:00	0	0	0	0	0	0
1:50:00	0	0	0	0	0	0
2:00:00	0	0	0	0	0	0
2:10:00	0	0	0	0	0	0
2:20:00	0	0	0	0	0	0
2:30:00	0	0	0	0	0	0
2:40:00	0	0	0	0	0	0
2:50:00	0	0	0	0	0	0
3:00:00	0	0	0	0	0	0
3:10:00	0	0	0	0	0	0
3:20:00	0	0	0	0	0	0
3:30:00	0	0	0	0	0	0
3:40:00	0	0	0	0	0	0
3:50:00	0	0	0	0	0	0
4:00:00	0	0	0	0	0	0
4:10:00	0	0	0	0	0	0
4:20:00	0	0	0	0	0	0
4:30:00	0	0	0	0	0	0
4:40:00	0	0	0	0	0	0
4:50:00	0	0	0	0	0	0
5:00:00	0	0	0	0	0	0
5:10:00	0.03	0	0	0	0	0
5:20:00	0.07	0	0	0	0	0
5:30:00	0.1	0	0	0	0	0
5:40:00	0.11	0	0	0	0	0
5:50:00	0.12	0	0	0	0	0



6:00:00	0.16	0	0	0	0	0
6:10:00	0.56	0	0	0	0	0
6:20:00	1.45	0	0	0	0	0
6:30:00	2.35	0	0	0	0	0
6:40:00	3.12	0	0	2.25	0	0
6:50:00	3.89	0	0	3.78	0	0
7:00:00	4.6	0	0	4.95	0	0
7:10:00	5.24	0.53	0	5.8	0	0
7:20:00	5.82	1.55	0	6.48	0	0
7:30:00	6.4	2.38	0	7.07	0.99	0
7:40:00	7	2.97	0	7.8	2.45	0
7:50:00	7.68	3.52	0	8.53	3.49	0
8:00:00	8.43	4.04	0	9.4	4.3	0
8:10:00	9.24	4.47	1.28	10.27	4.98	0
8:20:00	10.07	4.89	2.14	11.13	5.54	1.75
8:30:00	10.87	5.26	2.7	11.97	6.02	2.59
8:40:00	11.64	5.63	3.03	12.8	6.44	3.19
8:50:00	12.4	6.01	3.35	13.54	6.8	3.61
9:00:00	13.19	6.42	3.65	14.26	7.25	3.96
9:10:00	14.17	6.83	3.85	15.04	7.69	4.24
9:20:00	15.41	7.26	4.01	16.05	8.14	4.48
9:30:00	16.81	7.72	4.16	17.34	8.63	4.69
9:40:00	18.26	8.2	4.3	18.8	9.19	4.87
9:50:00	19.7	8.72	4.43	20.25	9.75	5.04
10:00:00	21.14	9.25	4.55	21.68	10.31	5.2
10:10:00	22.66	9.81	4.67	23.15	10.87	5.34
10:20:00	24.28	10.42	4.78	24.7	11.45	5.47
10:30:00	26.02	11.08	4.91	26.35	12.09	5.61
10:40:00	27.77	11.79	5.06	28.09	12.8	5.76
10:50:00	29.49	12.51	5.22	29.84	13.49	5.92
11:00:00	31.26	13.23	5.4	31.61	14.16	6.08
11:10:00	33.23	14.09	5.61	33.51	14.82	6.25
11:20:00	35.51	15.18	5.85	35.65	15.61	6.43
11:30:00	38.17	16.58	6.12	38.16	16.77	6.66
11:40:00	41.24	18.25	6.47	40.96	18.24	6.96
11:50:00	45.07	20.19	6.93	44.18	19.88	7.3
12:00:00	50.66	22.76	7.58	48.52	21.71	7.73
12:10:00	58.6	26.11	8.55	54.98	24.05	8.28
12:20:00	69.69	30.25	9.68	65.42	27.51	9.09
12:30:00	85.12	34.89	10.9	81.64	32.6	10.33
12:40:00	107.35	38.97	11.96	103.43	37.82	11.67
12:50:00	141.15	44.29	12.52	140.12	44.01	12.66
13:00:00	179.75	52.89	12.83	179.16	53.17	13.34
13:10:00	225.54	62.88	13.35	225.17	63.48	14.1
13:20:00	274.23	72.18	14.52	273.35	72.68	15.32
13:30:00	321.89	81.96	16.48	321.71	82.12	17.27
13:40:00	366.46	95.9	18.91	366.6	95.51	19.73
13:50:00	403.65	117.54	21.53	404.1	117.28	22.3

14:00:00	431.64	144.51	23.97	433.25	144.56	24.75
14:10:00	452.02	170.14	26	455.01	170.12	26.83
14:20:00	471.08	192.14	27.61	472.33	191.99	28.52
14:30:00	482.46	209.41	28.97	482.74	208.82	29.95
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14:50:00	484.54	231.13	31.9	484.33	230.33	32.9
15:00:00	478.93	237.56	34.05	478.13	236.17	35.06
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15:20:00	457.95	241.75	40.37	456.61	240.52	41.45
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16:00:00	395.6	226.2	55.88	393.14	225.17	57.05
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16:20:00	361.99	212.58	60.44	359.35	211.47	61.48
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17:00:00	300.73	178.95	62.32	298.46	178.32	63.38
17:10:00	286.91	170.41	61.71	284.8	169.98	62.78
17:20:00	273.89	162.13	60.84	271.82	161.99	61.92
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17:40:00	250.32	146.86	58.58	248.36	146.81	59.66
17:50:00	239.73	139.77	57.25	237.92	139.75	58.32
18:00:00	229.92	132.97	55.84	228.27	133.03	56.9

Time	Post Dev_10yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 10yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Post Dev_2yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 2yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Pre Dev_100yr_3_8CC> Pre dev DC stage 2 Drury 100yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Pre Dev_10yr_3_8CC>Pre dev DC stage 2 Drury 10yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Pre Dev_2yr_3_8CC>Pre dev DC stage 2 Drury 2yr 3.8CC DHI_Rev, Flow (Flow (m3/s))
	Flows (m3/	Flows (m3/	Flows (m3/	Flows (m3/s)	
0:00:00	0.00	0.00	0.00	0.00	0.00
0:10:00	0.00	0.00	0.00	0.00	0.00
0:20:00	0.00	0.00	0.00	0.00	0.00
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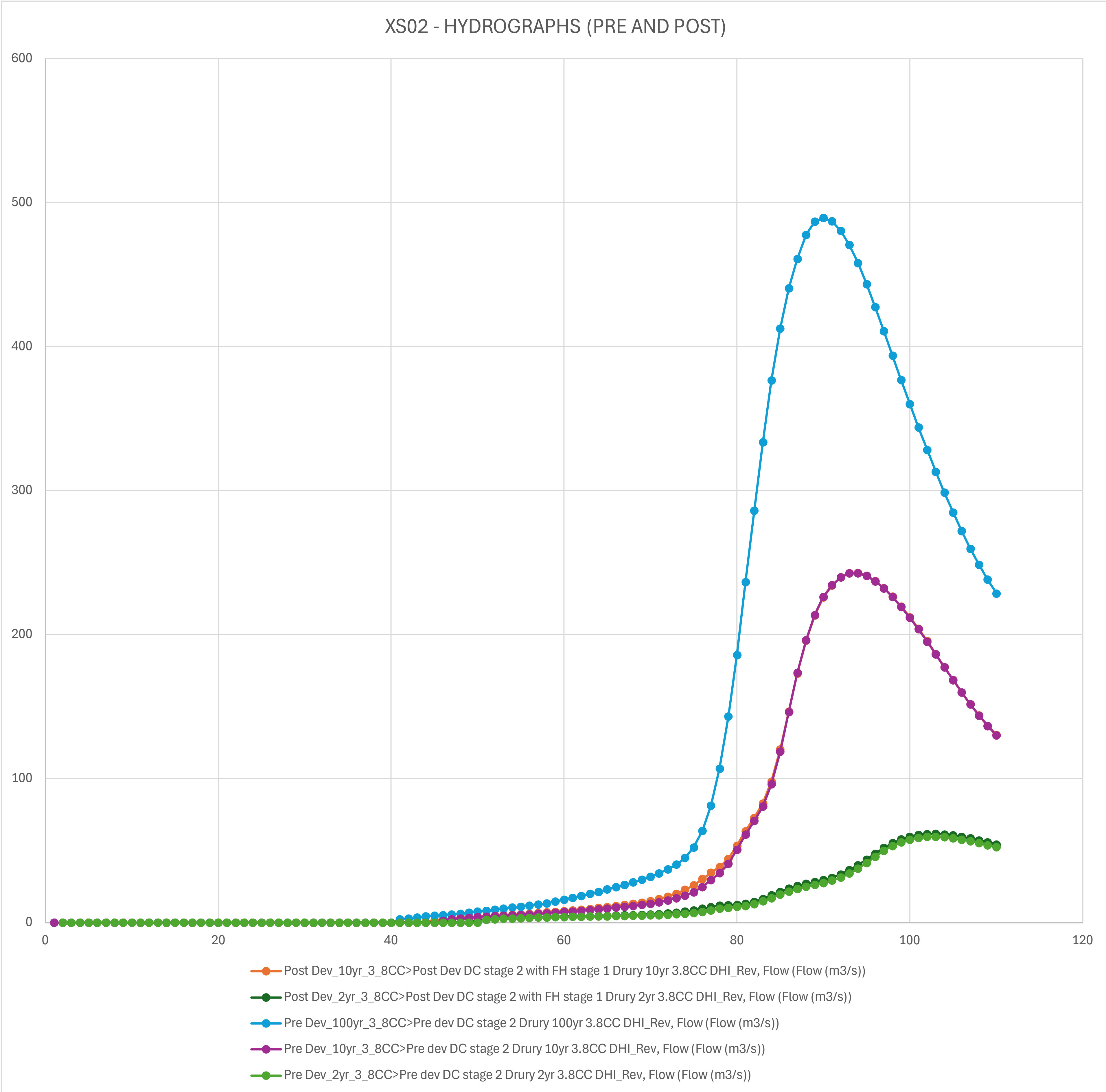
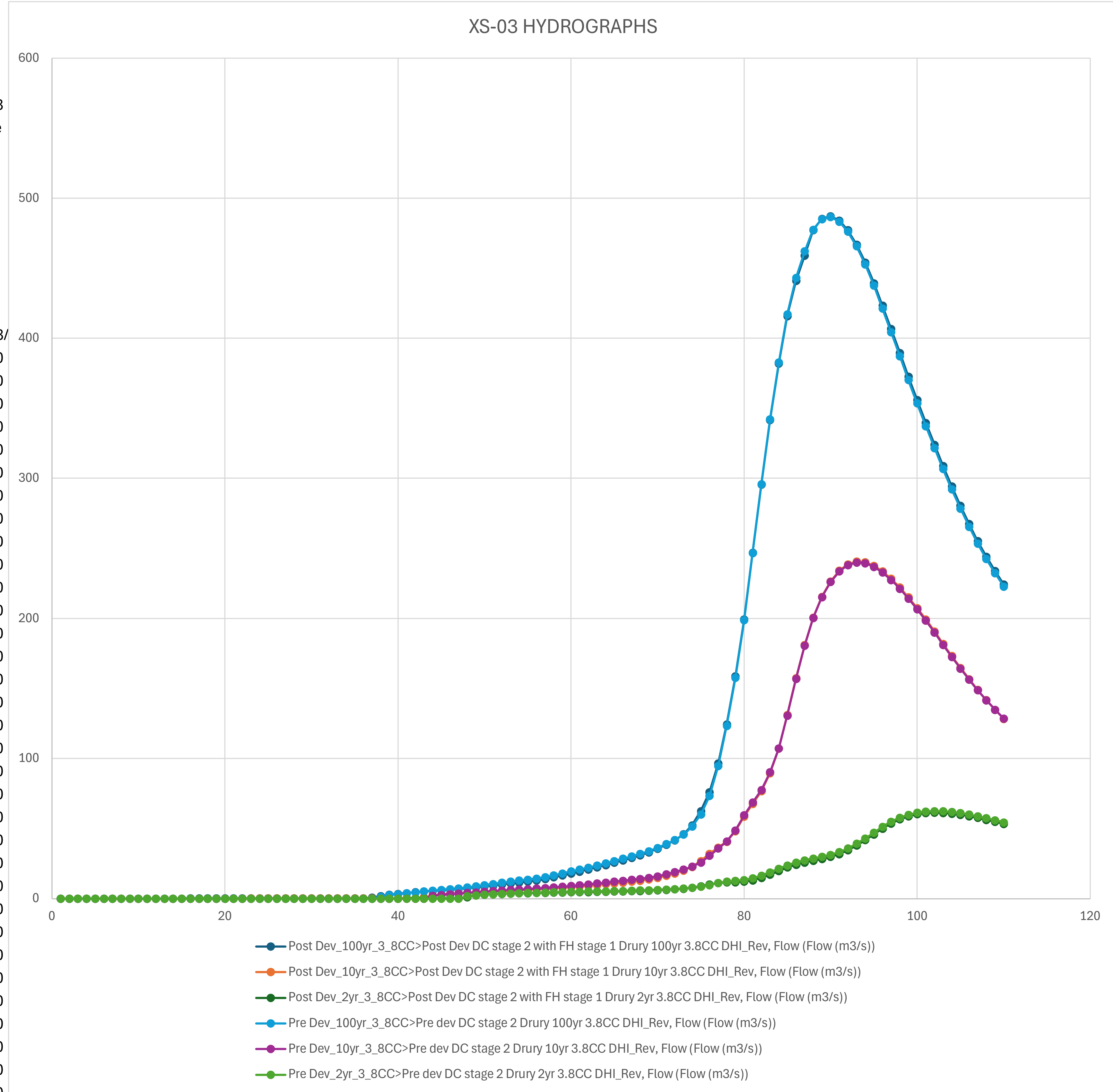
3:30:00	0.01	0.00	0.00	0.00	0.00
3:40:00	0.01	0.00	0.00	0.00	0.00
3:50:00	0.01	0.00	0.00	0.00	0.00
4:00:00	0.01	0.00	0.00	0.00	0.00
4:10:00	0.01	0.00	0.00	0.00	0.00
4:20:00	0.01	0.00	0.00	0.00	0.00
4:30:00	0.01	0.00	0.00	0.00	0.00
4:40:00	0.01	0.00	0.00	0.00	0.00
4:50:00	0.01	0.00	0.00	0.00	0.00
5:00:00	0.01	0.00	0.00	0.00	0.00
5:10:00	0.01	0.00	0.00	0.00	0.00
5:20:00	0.01	0.00	0.00	0.00	0.00



5:30:00	0.02	0.00	0.00	0.00	0.00
5:40:00	0.02	0.00	0.00	0.00	0.00
5:50:00	0.02	0.00	0.00	0.00	0.00
6:00:00	0.02	0.00	0.00	0.00	0.00
6:10:00	0.03	0.00	0.00	0.00	0.00
6:20:00	0.04	0.01	0.00	0.00	0.00
6:30:00	0.04	0.02	2.28	0.00	0.00
6:40:00	0.06	0.02	2.91	0.00	0.00
6:50:00	0.14	0.01	3.49	0.00	0.00
7:00:00	0.43	0.01	4.23	0.00	0.00
7:10:00	1.42	0.01	4.75	0.00	0.00
7:20:00	2.16	0.01	5.20	1.33	0.00
7:30:00	2.80	0.01	5.69	2.28	0.00
7:40:00	3.20	0.01	6.21	2.80	0.00
7:50:00	3.66	0.01	6.84	3.18	0.00
8:00:00	4.03	1.42	7.55	3.71	0.00
8:10:00	4.43	2.05	8.30	4.13	1.96
8:20:00	4.79	2.55	9.04	4.48	2.30
8:30:00	5.12	2.94	9.76	4.81	2.70
8:40:00	5.47	3.07	10.45	5.09	2.90
8:50:00	5.83	3.38	11.10	5.39	3.16
9:00:00	6.22	3.57	11.72	5.72	3.34
9:10:00	6.63	3.73	12.44	6.06	3.51
9:20:00	7.07	3.86	13.40	6.42	3.65
9:30:00	7.52	4.01	14.60	6.84	3.79
9:40:00	7.99	4.13	15.91	7.29	3.91
9:50:00	8.48	4.24	17.23	7.76	4.01
10:00:00	9.00	4.35	18.55	8.24	4.12
10:10:00	9.56	4.46	19.91	8.73	4.22
10:20:00	10.17	4.57	21.38	9.25	4.31
10:30:00	10.83	4.70	22.97	9.82	4.41
10:40:00	11.53	4.84	24.59	10.43	4.52
10:50:00	12.23	5.00	26.23	11.03	4.64
11:00:00	12.96	5.18	27.91	11.61	4.76
11:10:00	13.81	5.39	29.73	12.19	4.89
11:20:00	14.95	5.62	31.78	12.96	5.02
11:30:00	16.40	5.92	34.17	14.08	5.23
11:40:00	18.07	6.29	36.88	15.44	5.47
11:50:00	20.04	6.81	40.18	16.96	5.75
12:00:00	22.72	7.58	44.92	18.73	6.10
12:10:00	25.92	8.49	52.15	21.07	6.59
12:20:00	30.18	9.66	63.77	24.67	7.37
12:30:00	34.65	10.82	81.30	29.57	8.51
12:40:00	38.60	11.72	106.94	34.37	9.62
12:50:00	44.26	12.12	142.99	40.72	10.34
13:00:00	53.42	12.42	185.88	50.59	10.90
13:10:00	63.51	13.06	236.33	61.06	11.65
13:20:00	72.78	14.43	286.02	70.61	12.89

13:30:00	82.72	16.50	333.45	80.61	14.76
13:40:00	97.88	18.89	376.43	95.96	17.02
13:50:00	120.13	21.37	412.47	118.67	19.39
14:00:00	146.56	23.59	440.32	146.21	21.59
14:10:00	172.92	25.42	460.80	173.33	23.45
14:20:00	195.66	26.88	477.46	196.13	24.95
14:30:00	213.17	28.15	486.59	213.55	26.24
14:40:00	225.84	29.49	489.21	226.13	27.55
14:50:00	234.03	31.18	486.81	234.21	29.13
15:00:00	239.78	33.43	480.31	239.71	31.28
15:10:00	242.61	36.36	470.56	242.45	34.06
15:20:00	242.74	39.85	458.01	242.68	37.47
15:30:00	240.78	43.66	443.32	240.65	41.38
15:40:00	237.17	47.80	427.39	236.98	45.68
15:50:00	232.27	51.81	410.57	232.02	49.82
16:00:00	226.24	55.16	393.65	226.03	53.23
16:10:00	219.54	57.73	376.76	219.21	55.78
16:20:00	212.07	59.64	360.00	211.69	57.59
16:30:00	204.01	60.90	343.75	203.67	58.89
16:40:00	195.41	61.50	328.14	195.12	59.52
16:50:00	186.41	61.56	313.06	186.19	59.60
17:00:00	177.35	61.20	298.57	177.18	59.25
17:10:00	168.43	60.50	284.73	168.41	58.56
17:20:00	159.77	59.57	271.73	159.85	57.62
17:30:00	151.63	58.43	259.60	151.56	56.48
17:40:00	143.87	57.13	248.41	143.74	55.19
17:50:00	136.72	55.74	238.12	136.52	53.78
18:00:00	130.27	54.28	228.47	129.90	52.29

	Post Dev_100yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 100yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Post Dev_10yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 10yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Post Dev_2yr_3_8CC>Post Dev DC stage 2 with FH stage 1 Drury 2yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Pre Dev_100yr_3_8CC>Pre dev DC stage 2 Drury 100yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Pre Dev_10yr_3_8CC>Pre dev DC stage 2 Drury 10yr 3.8CC DHI_Rev, Flow (Flow (m3/s))	Pre Dev_2yr_3_8CC>Pre dev DC stage 2 Drury 2yr 3.8CC DHI_Rev, Flow (Flow (m3/s))
Time	Flows (m3/	Flows (m3/	Flows (m3/	Flows (m3/	Flows (m3/	Flows (m3/
0:00:00	0	0	0	0	0	0
0:10:00	0	0	0	0	0	0
0:20:00	0	0	0	0	0	0
0:30:00	0	0	0	0	0	0
0:40:00	0	0	0	0	0	0
0:50:00	0	0	0	0	0	0
1:00:00	0	0	0	0	0	0
1:10:00	0	0	0	0	0	0
1:20:00	0	0	0	0	0	0
1:30:00	0	0	0	0	0	0
1:40:00	0	0	0	0	0	0
1:50:00	0	0	0	0	0	0
2:00:00	0	0	0	0	0	0
2:10:00	0.01	0	0	0	0	0
2:20:00	0.03	0	0	0	0	0
2:30:00	0.03	0	0	0	0	0
2:40:00	0.03	0	0	0	0	0
2:50:00	0.07	0	0	0	0	0
3:00:00	0.1	0	0	0	0	0
3:10:00	0.11	0	0	0	0	0
3:20:00	0.11	0.01	0	0	0	0
3:30:00	0.12	0.02	0	0	0	0
3:40:00	0.12	0.02	0	0	0	0
3:50:00	0.12	0.02	0	0	0	0
4:00:00	0.12	0.02	0	0	0	0
4:10:00	0.12	0.02	0	0	0	0
4:20:00	0.12	0.05	0	0	0	0
4:30:00	0.13	0.06	0	0	0	0
4:40:00	0.13	0.06	0	0	0	0
4:50:00	0.13	0.07	0	0	0	0
5:00:00	0.13	0.07	0	0	0	0
5:10:00	0.13	0.07	0	0	0	0
5:20:00	0.13	0.07	0	0	0	0



5:30:00	0.13	0.07	0	0	0	0
5:40:00	0.13	0.07	0	0	0	0
5:50:00	0.61	0.07	0	0	0	0
6:00:00	1.81	0.07	0	1.21	0	0
6:10:00	2.67	0.08	0	2.42	0	0
6:20:00	3.32	0.12	0	3.09	0	0
6:30:00	3.89	0.15	0.02	3.75	0	0
6:40:00	4.48	0.17	0.02	4.38	0	0
6:50:00	4.98	0.81	0.02	5.02	0	0
7:00:00	5.4	2.1	0.02	5.6	1.91	0
7:10:00	5.82	2.81	0.03	6.14	2.59	0
7:20:00	6.27	3.29	0.06	6.66	3.05	0
7:30:00	6.79	3.68	0.07	7.23	3.53	0
7:40:00	7.38	4.04	1.05	7.9	3.96	1.65
7:50:00	8.01	4.41	2.24	8.69	4.41	2.28
8:00:00	8.69	4.72	2.78	9.52	4.86	2.66
8:10:00	9.38	5.01	3.11	10.41	5.28	3.05
8:20:00	10.07	5.29	3.36	11.26	5.67	3.34
8:30:00	10.73	5.59	3.56	12.07	6.03	3.57
8:40:00	11.37	5.91	3.73	12.81	6.36	3.77
8:50:00	12.02	6.25	3.88	13.49	6.7	3.97
9:00:00	12.82	6.6	4.01	14.22	7.07	4.15
9:10:00	13.88	6.97	4.15	15.17	7.48	4.32
9:20:00	15.15	7.35	4.27	16.43	7.95	4.47
9:30:00	16.48	7.76	4.38	17.86	8.45	4.61
9:40:00	17.8	8.19	4.48	19.28	8.97	4.75
9:50:00	19.23	8.64	4.57	20.64	9.5	4.87
10:00:00	20.79	9.1	4.66	22.03	10.09	4.98
10:10:00	22.28	9.61	4.75	23.5	10.69	5.09
10:20:00	23.9	10.18	4.87	25.08	11.32	5.2
10:30:00	25.61	10.81	4.99	26.74	12.03	5.32
10:40:00	27.23	11.43	5.14	28.39	12.73	5.46
10:50:00	28.99	12.04	5.3	30.06	13.39	5.61
11:00:00	30.84	12.7	5.47	31.81	14.02	5.77
11:10:00	33	13.59	5.67	33.83	14.75	5.94
11:20:00	35.55	14.82	5.91	36.14	15.83	6.14
11:30:00	38.37	16.26	6.19	38.81	17.3	6.39
11:40:00	41.61	17.85	6.54	41.74	18.89	6.7
11:50:00	45.89	19.94	6.99	45.64	20.6	7.08
12:00:00	52.27	22.65	7.64	51.29	22.72	7.6
12:10:00	62.39	26.71	8.77	59.94	25.75	8.35
12:20:00	75.88	31.95	10.03	73.22	30.51	9.55
12:30:00	96.55	36.35	11.08	94.74	35.67	11.12
12:40:00	124.37	40.6	11.52	123.28	40.68	12.09
12:50:00	158.57	48.07	11.65	157.54	48.65	12.62
13:00:00	199.3	58.49	12.03	198.71	59.43	13.26
13:10:00	246.74	67.52	13	246.68	68.46	14.4
13:20:00	295.41	76.61	14.8	295.74	77.41	16.3

13:30:00	341.62	89.5	17.04	342.14	90.12	18.71
13:40:00	381.83	107.08	19.62	382.69	107.13	21.25
13:50:00	415.82	130.92	22.19	416.95	130.57	23.66
14:00:00	440.95	157.32	24.14	443.02	156.7	25.67
14:10:00	459	180.93	25.7	461.95	180.58	27.26
14:20:00	477.14	200.46	26.96	477.47	200.18	28.57
14:30:00	485.33	215.44	28.23	485.1	215.13	29.81
14:40:00	487.04	226.42	29.74	486.51	226.02	31.22
14:50:00	484.03	234.02	31.75	483.25	233.52	33.17
15:00:00	477.08	238.64	34.47	476.05	238.01	35.78
15:10:00	466.81	240.6	37.87	465.67	239.9	39.07
15:20:00	454.05	240.08	41.68	452.68	239.37	42.83
15:30:00	439.28	237.57	45.78	437.57	236.81	46.97
15:40:00	423.26	233.54	49.93	421.22	232.73	51.16
15:50:00	406.53	228.27	53.58	404.2	227.42	54.9
16:00:00	389.55	222.02	56.5	387.14	221.15	57.73
16:10:00	372.62	215.03	58.59	370.2	214.15	59.72
16:20:00	355.91	207.42	60.14	353.48	206.55	61.18
16:30:00	339.61	199.3	61.04	337.24	198.45	62.12
16:40:00	323.96	190.71	61.33	321.67	189.89	62.43
16:50:00	308.8	181.87	61.16	306.6	181.09	62.26
17:00:00	294.25	173.08	60.62	292.13	172.44	61.73
17:10:00	280.35	164.66	59.8	278.35	164.14	60.91
17:20:00	267.31	156.64	58.76	265.41	156.21	59.87
17:30:00	255.16	148.96	57.55	253.39	148.66	58.67
17:40:00	244.03	141.65	56.21	242.36	141.48	57.33
17:50:00	233.74	134.72	54.78	232.21	134.69	55.89
18:00:00	224.13	128.24	53.29	222.71	128.37	54.39

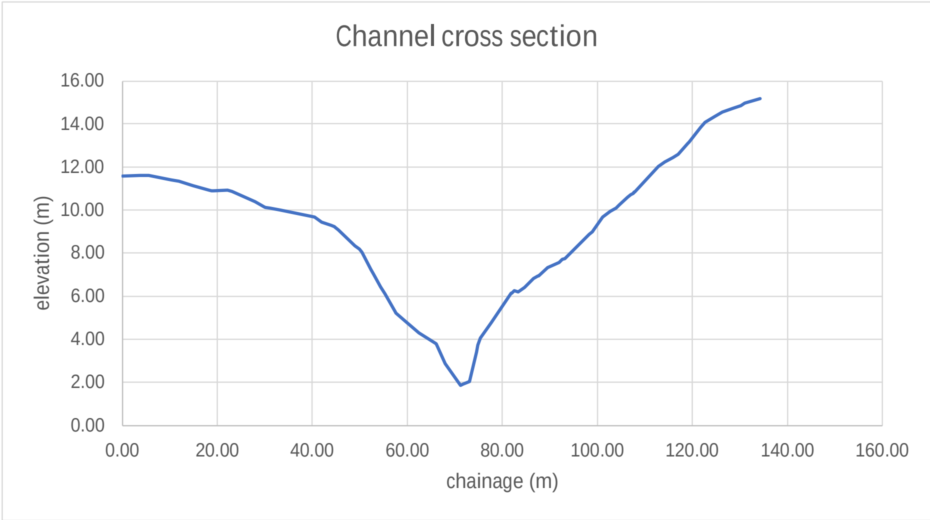
Appendix C – EST results

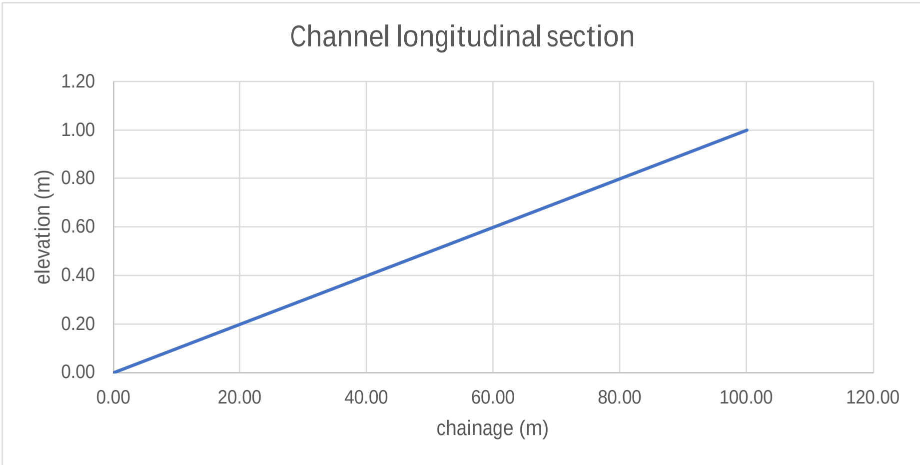
XS-01

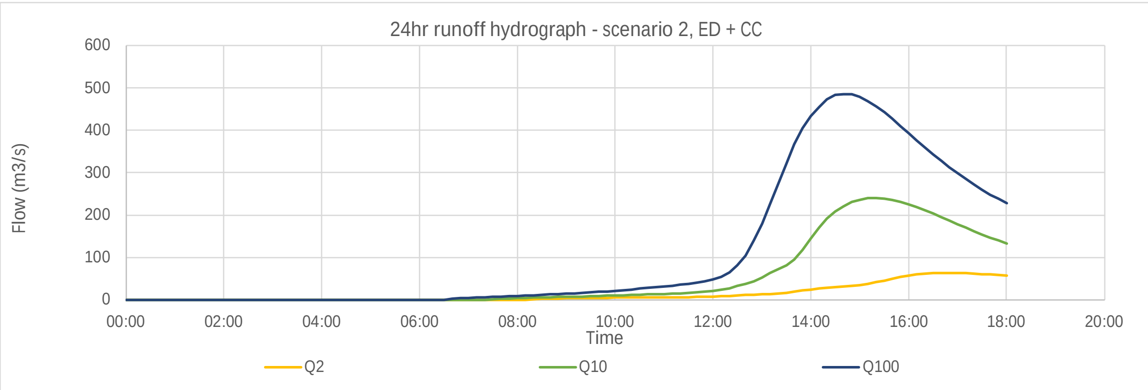
	Scenario 4 PD+CC			Scenario 2 ED+CC					
	excess shear excedence (min)			excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	480	430	370	490	440	390			
>1 & <2 (min)	160	70	50	100	50	30			
>2 & <10 (min)	440	580	660	490	590	660			
>10 (min)	0	0	0	0	0	0			

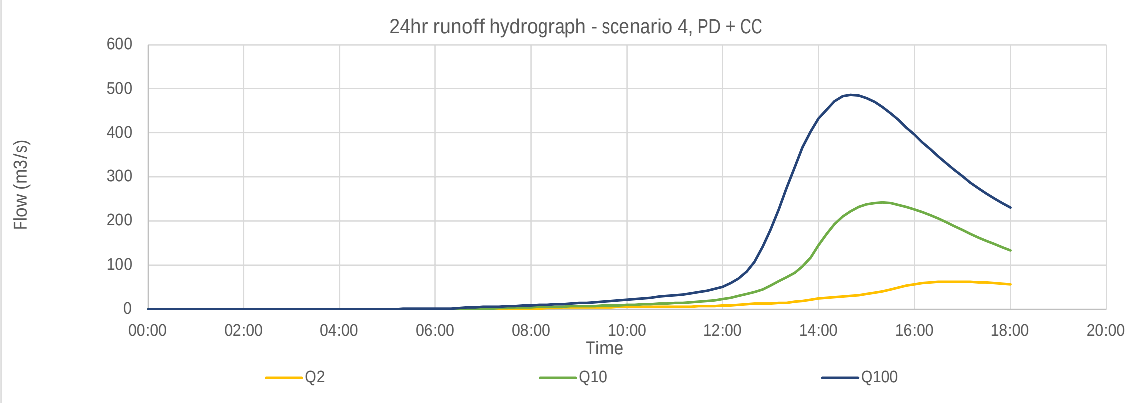
	Scenario 4 PD+CC			Scenario 2 ED+CC					
	excess shear excedence (%)			excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	44%	40%	34%	45%	41%	36%	-1%	-1%	-2%
>1 & <2 (min)	15%	6%	5%	9%	5%	3%	6%	2%	2%
>2 & <10 (min)	41%	54%	61%	45%	55%	61%	-5%	-1%	0%
>10 (min)	0%	0%	0%	0%	0%	0%	0%	0%	0%

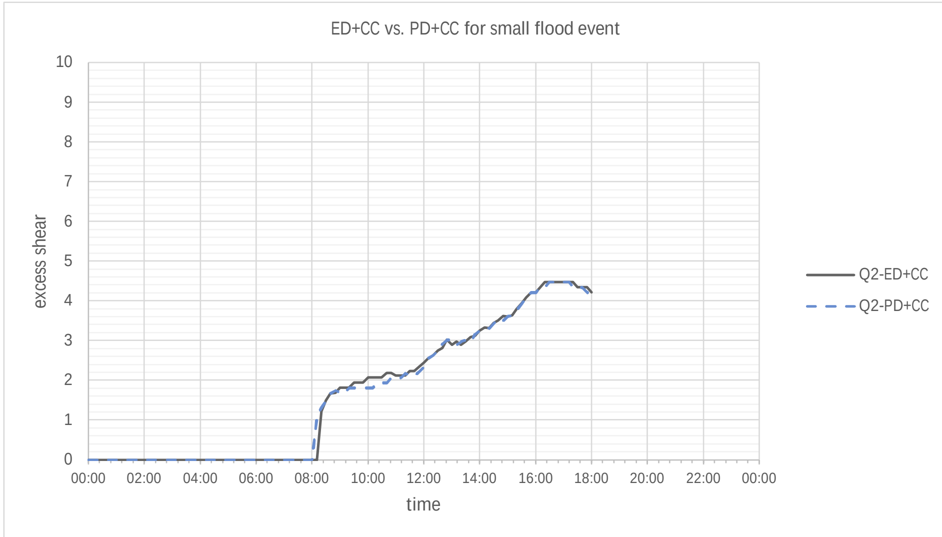
channel geometry			
manning's roughness n	0.08		
Cross section		longitudinal section	
chainage (m)	elevation (m)	Chainage (m)	Elevation (msl)
0.00	11.56	0.00	0.00
3.70	11.61	100.00	1.00
5.58	11.61		
10.33	11.40		
11.90	11.33		
14.91	11.14		
18.22	10.93		
18.81	10.89		
18.91	10.89		
19.13	10.89		
22.09	10.92		
23.04	10.87		
27.93	10.38		
29.82	10.15		
30.10	10.12		
31.00	10.08		
33.18	10.02		
40.41	9.67		
41.94	9.45		
43.93	9.28		
44.62	9.23		
44.73	9.21		
45.53	9.07		
49.01	8.34		
49.85	8.19		
50.45	8.04		
52.33	7.24		
52.88	7.04		
54.32	6.45		
55.31	6.10		
57.51	5.28		
57.64	5.22		
59.64	4.84		
62.46	4.30		
66.05	3.78		
67.97	2.88		
71.26	1.88		
71.76	1.92		
73.02	2.04		
74.55	3.41		
74.90	3.73		
75.43	4.06		
77.62	4.79		
81.84	6.14		
82.04	6.14		
82.50	6.25		
83.27	6.19		
84.62	6.42		
86.50	6.81		
87.48	6.95		
87.68	6.94		
89.46	7.31		
89.52	7.32		
91.97	7.58		
92.57	7.70		
93.19	7.74		
98.31	8.88		
98.90	9.01		
99.19	9.09		
101.11	9.66		
102.71	9.95		
103.93	10.09		
104.37	10.18		
104.62	10.23		
106.36	10.61		
107.11	10.71		
107.52	10.77		
107.57	10.78		
107.75	10.82		
107.90	10.85		
112.89	12.01		
114.14	12.23		
115.91	12.43		
117.00	12.59		
119.01	13.10		
119.28	13.17		
121.75	13.83		
122.71	14.06		
124.71	14.34		
126.34	14.55		
128.66	14.73		
130.21	14.86		
131.01	14.96		
134.19	15.19		











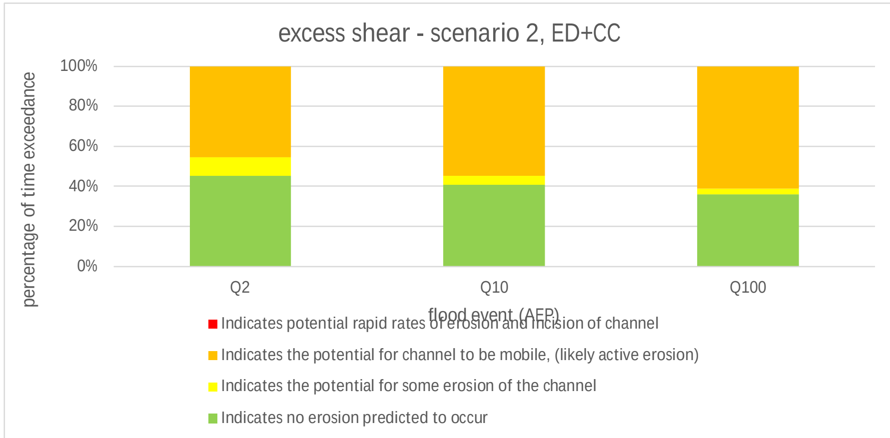
* 3month estimated rainfall does not fits well in regression calculation, not recommend to use.

EXCESS SHEAR

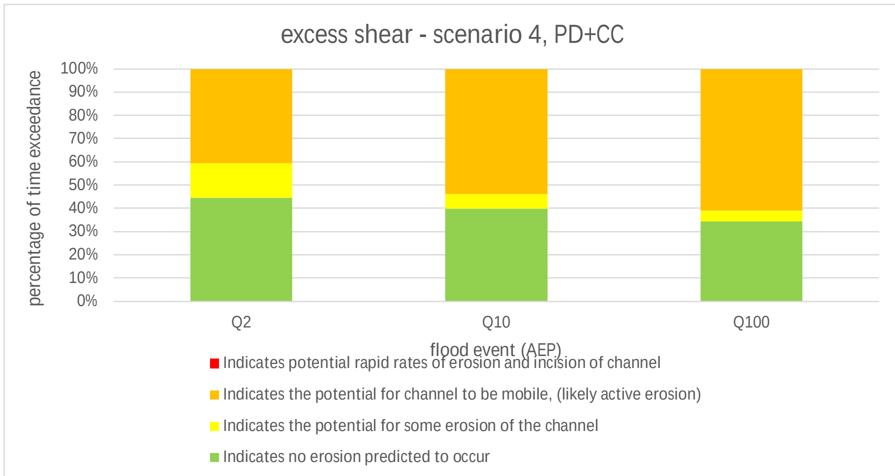
Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel

Threshold	Excess Shear	Description
Green	<1.0	Indicates no erosion predicted to occur
Yellow	>1.0 <2.0	Indicates the potential for some erosion of the channel
Orange	>2.0 <10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	>10.0	Indicates potential rapid rates of erosion and incision of channel

Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechical erosion or other associated processes. Predevelopment erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its predevelopment state.



Scenario 2 ED+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	490	0	0	440	390
>1 & <2 (min)	0	0	0	100	0	0	50	30
>2 & <10 (min)	0	0	0	490	0	0	590	660
>10 (min)	0	0	0	0	0	0	0	0



Scenario 4 PD+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	480	0	0	430	370
>1 & <2 (min)	0	0	0	160	0	0	70	50
>2 & <10 (min)	0	0	0	440	0	0	580	660
>10 (min)	0	0	0	0	0	0	0	0

bank full channel identification		
approximate channel width (m)	21.41	
bank full water depth (m)	0.00	excess shear
* bank full flow -identified by main channel (m3/s)	0.00	#DIV/0!
annual fullest flow as represented by the mean annual flood (m3/s)	#DIV/0!	#DIV/0!

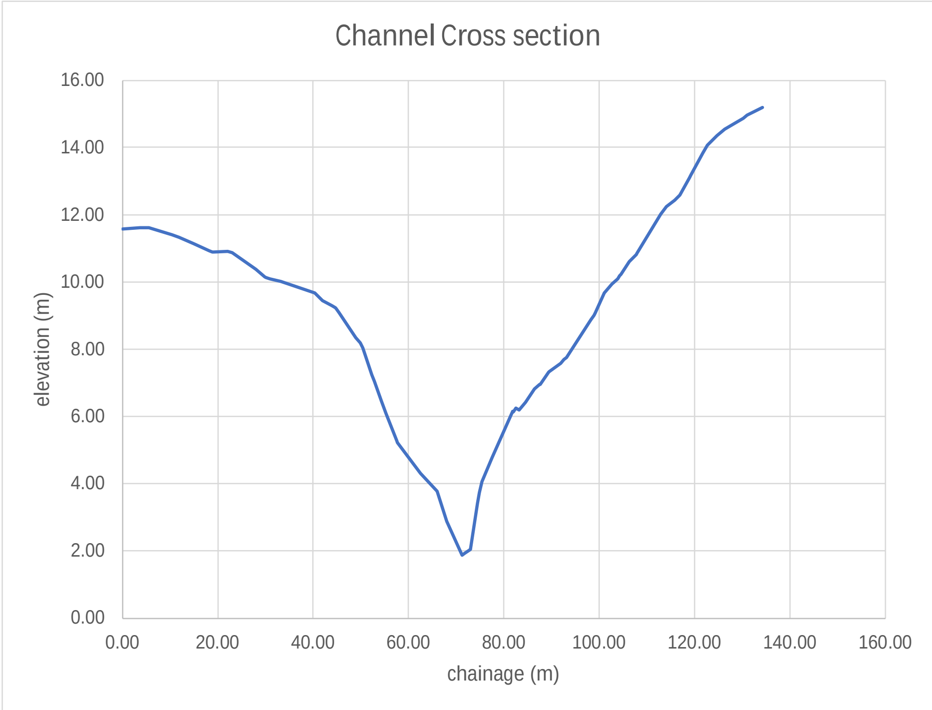
* main channel identification depends on the accuracy of topographic survey

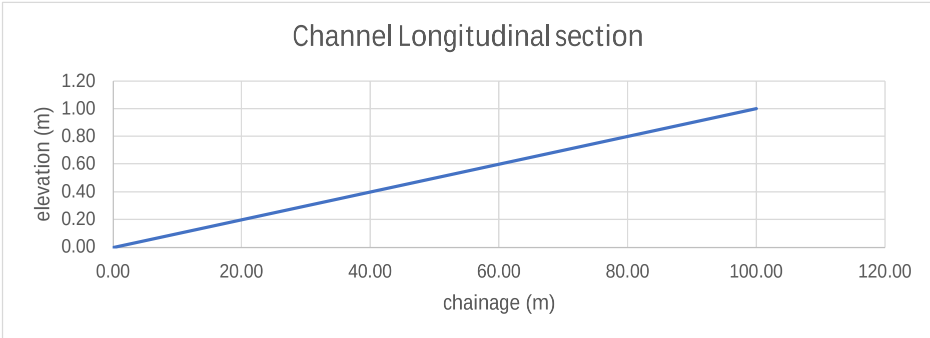
XS-02

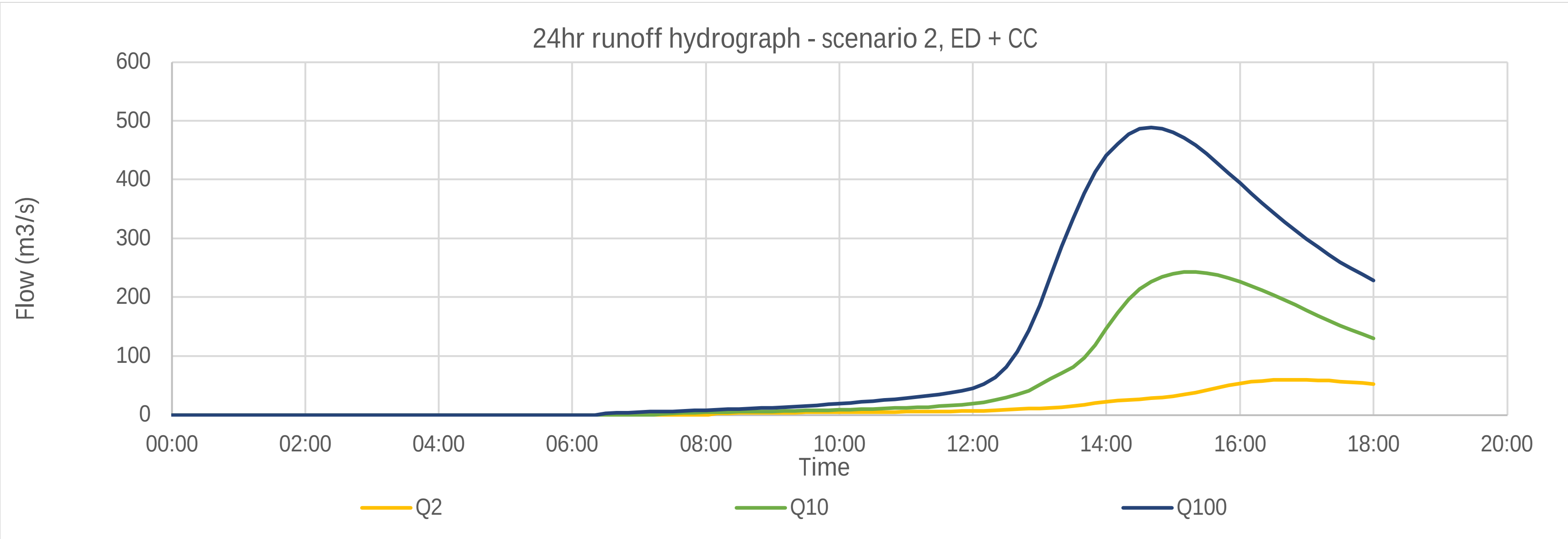
	Scenario 4 PD+CC excess shear excedence (min)			Scenario 2 ED+CC excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	470	410	350	480	430	380			
>1 & <2 (min)	50	40	40	40	20	10			
>2 & <10 (min)	560	630	690	560	630	690			
>10 (min)	0	0	0	0	0	0			

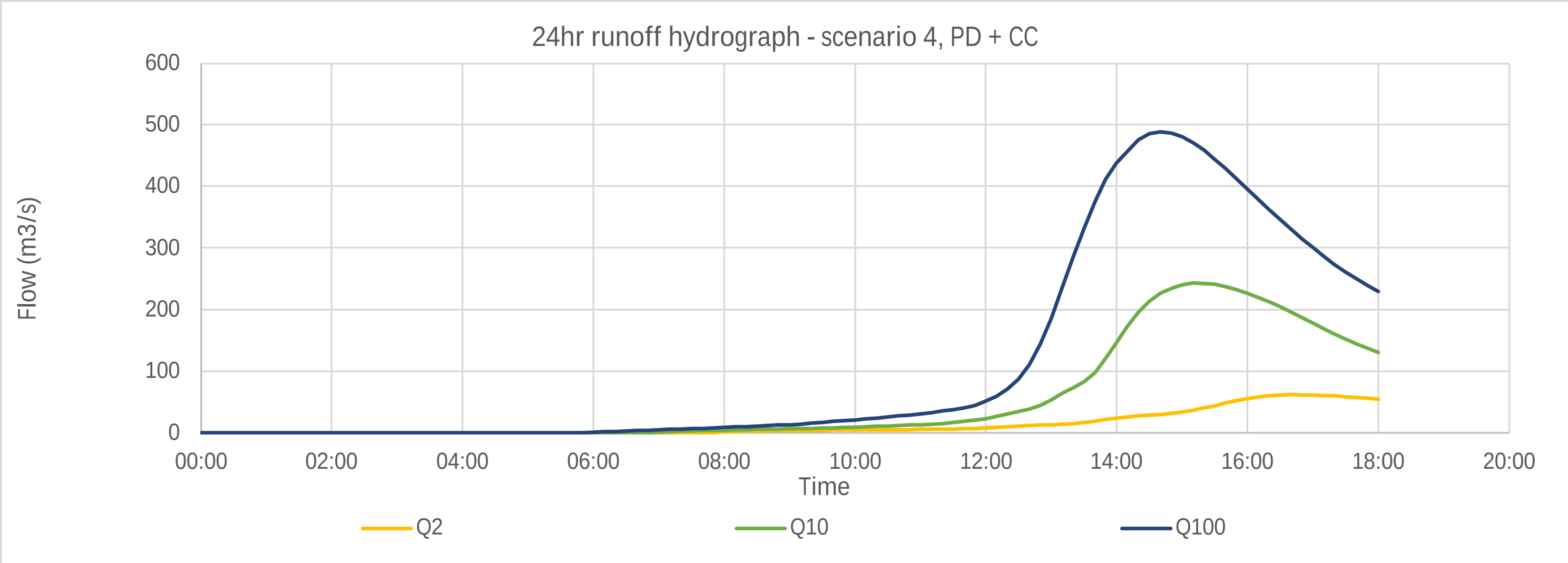
	Scenario 4 PD+CC excess shear excedence (%)			Scenario 2 ED+CC excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	44%	38%	32%	44%	40%	35%	-1%	-2%	-3%
>1 & <2 (min)	5%	4%	4%	4%	2%	1%	1%	2%	3%
>2 & <10 (min)	52%	58%	64%	52%	58%	64%	0%	0%	0%
>10 (min)	0%	0%	0%	0%	0%	0%	0%	0%	0%

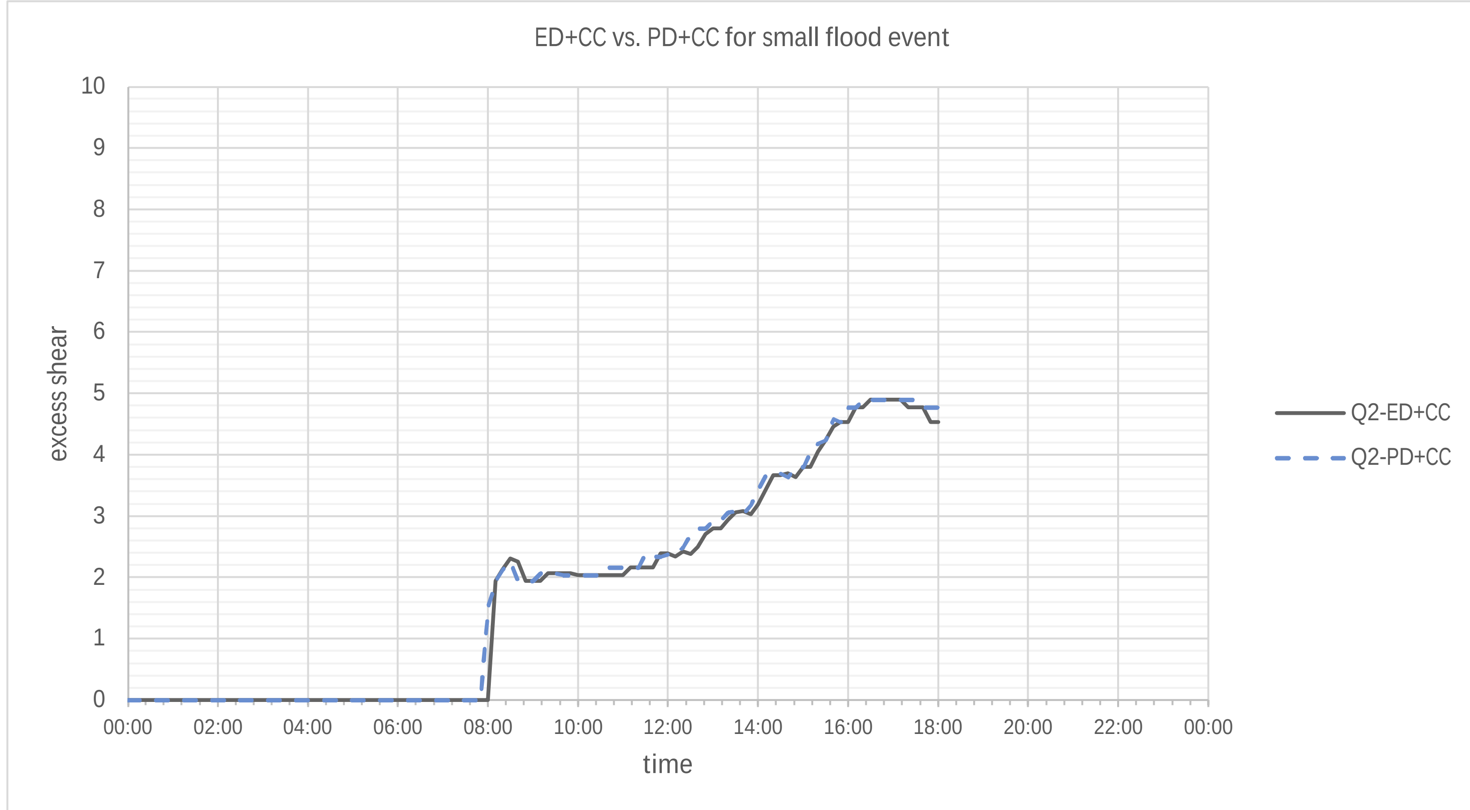
channel geometry			
manning's roughness n	0.08		
Cross section		longitudinal section	
chainage (m)	elevation (m)	Chainage (m)	Elevation (msl)
0.00	11.56	0.00	0.00
3.70	11.61	100.00	1.00
5.58	11.61		
10.33	11.40		
11.90	11.33		
14.91	11.14		
18.22	10.93		
18.81	10.89		
18.91	10.89		
19.13	10.89		
22.09	10.92		
23.04	10.87		
27.93	10.38		
29.82	10.15		
30.10	10.12		
31.00	10.08		
33.18	10.02		
40.41	9.67		
41.94	9.45		
43.93	9.28		
44.62	9.23		
44.73	9.21		
45.53	9.07		
49.01	8.34		
49.85	8.19		
50.45	8.04		
52.33	7.24		
52.88	7.04		
54.32	6.45		
55.31	6.10		
57.51	5.28		
57.64	5.22		
59.64	4.84		
62.46	4.30		
66.05	3.78		
67.97	2.88		
71.26	1.88		
71.76	1.92		
73.02	2.04		
74.55	3.41		
74.90	3.73		
75.43	4.06		
77.62	4.79		
81.84	6.14		
82.04	6.14		
82.50	6.25		
83.27	6.19		
84.62	6.42		
86.50	6.81		
87.48	6.95		
87.68	6.94		
89.46	7.31		
89.52	7.32		
91.97	7.58		
92.57	7.70		
93.19	7.74		
98.31	8.88		
98.90	9.01		
99.19	9.09		
101.11	9.66		
102.71	9.95		
103.93	10.09		
104.37	10.18		
104.62	10.23		
106.36	10.61		
107.11	10.71		
107.52	10.77		
107.57	10.78		
107.75	10.82		
107.90	10.85		
112.89	12.01		
114.14	12.23		
115.91	12.43		
117.00	12.59		
119.01	13.10		
119.28	13.17		
121.75	13.83		
122.71	14.06		
124.71	14.34		
126.34	14.55		
128.66	14.73		
130.21	14.86		
131.01	14.96		
134.19	15.19		











* 3month estimated rainfall does not fits well in regression calculation, not recommend to use.

EXCESS SHEAR

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel

Threshold	Excess Shear	Description
Green	<1.0	Indicates no erosion predicted to occur
Yellow	>1.0 <2.0	Indicates the potential for some erosion of the channel
Orange	>2.0 <10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	>10.0	Indicates potential rapid rates of erosion and incision of channel

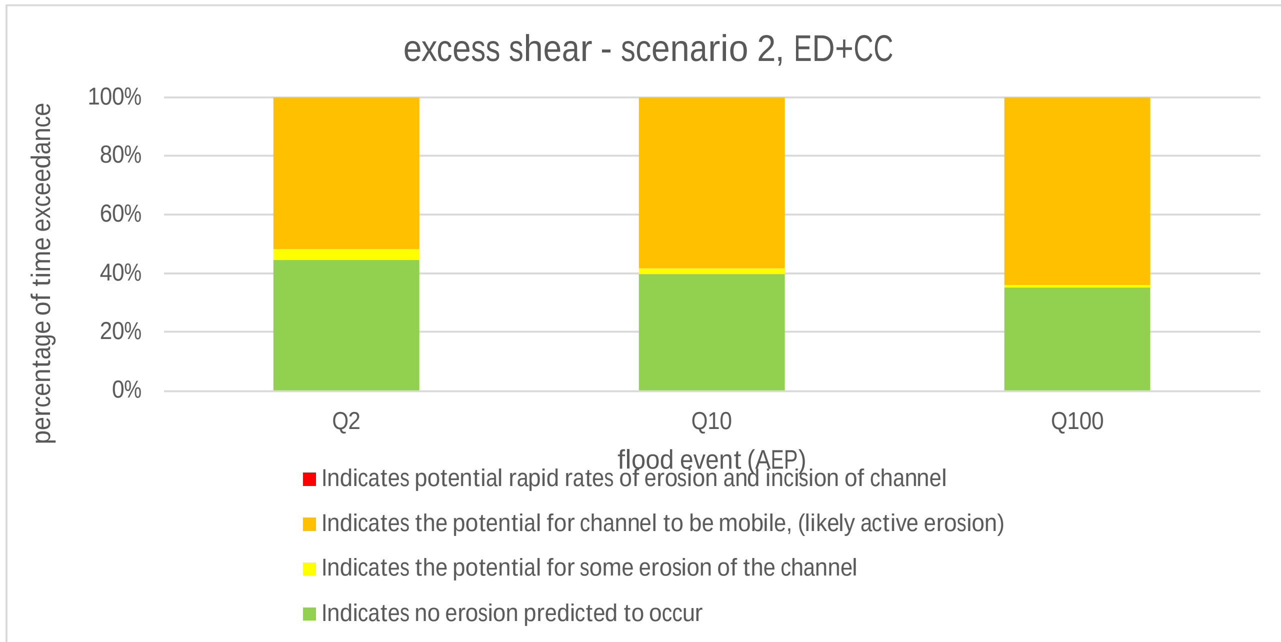
Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechnical erosion or other associated processes. Predevelopment erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its predevelopment state.

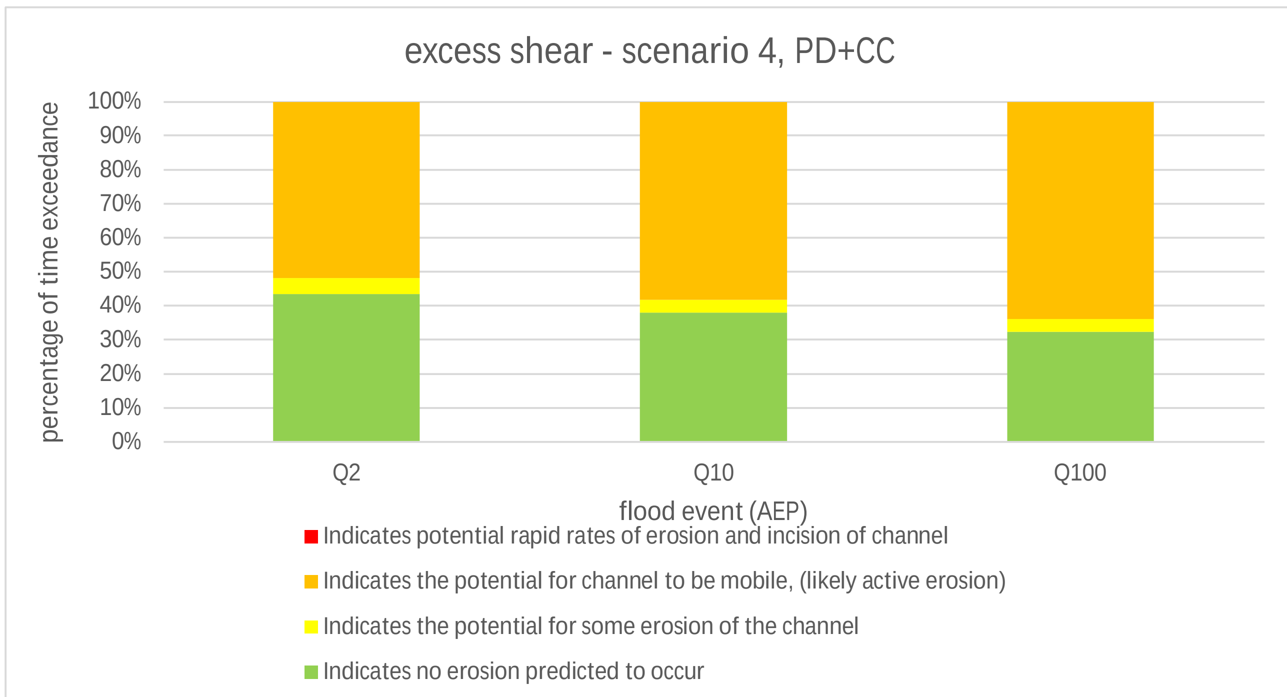
Scenario 2 ED+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	480	0	0	430	380
>1 & <2 (min)	0	0	0	40	0	0	20	10
>2 & <10 (min)	0	0	0	560	0	0	630	690
>10 (min)	0	0	0	0	0	0	0	0

Scenario 4 PD+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	470	0	0	410	350
>1 & <2 (min)	0	0	0	50	0	0	40	40
>2 & <10 (min)	0	0	0	560	0	0	630	690
>10 (min)	0	0	0	0	0	0	0	0

bank full channel identification		
approximate channel width (m)	21.41	
bank full water depth (m)	0.00	excess shear
* bank full flow -identified by main channel (m3/s)	#N/A	#N/A
annual fullest flow as represented by the mean annual flood (m3/s)	#DIV/0!	#DIV/0!

* main channel identification depends on the accuracy of topographic survey



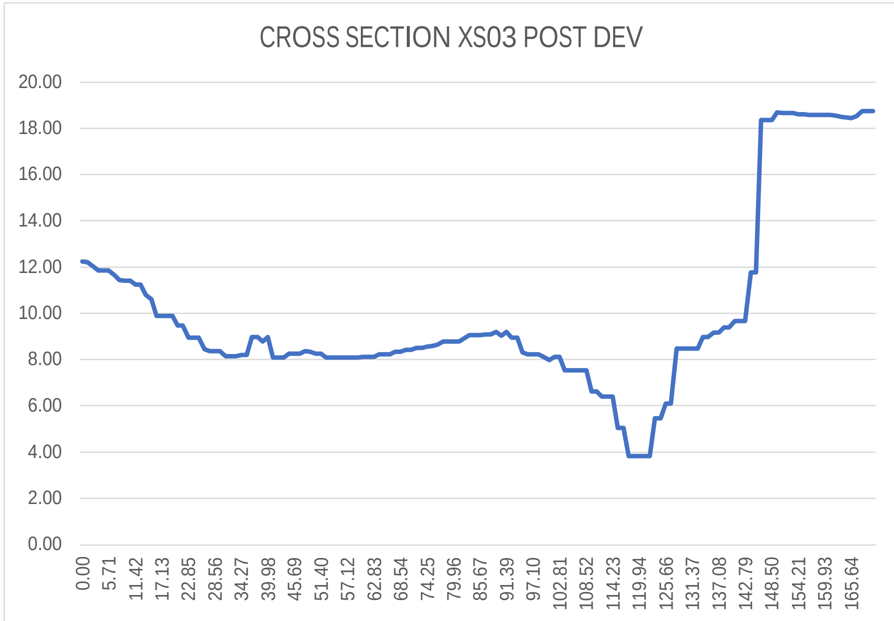


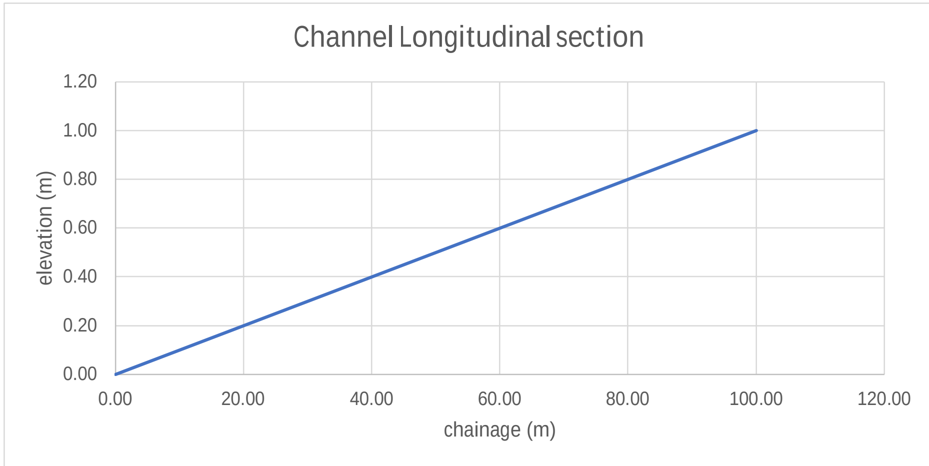
XS-03 POST DEVELOPMENT

	Scenario 4 PD+CC excess shear excedence (min)			Scenario 2 ED+CC excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	450	400	340	450	410	350			
>1 & <2 (min)	0	10	10	50	30	30			
>2 & <10 (min)	630	590	710	580	640	700			
>10 (min)	0	80	20	0	0	0			

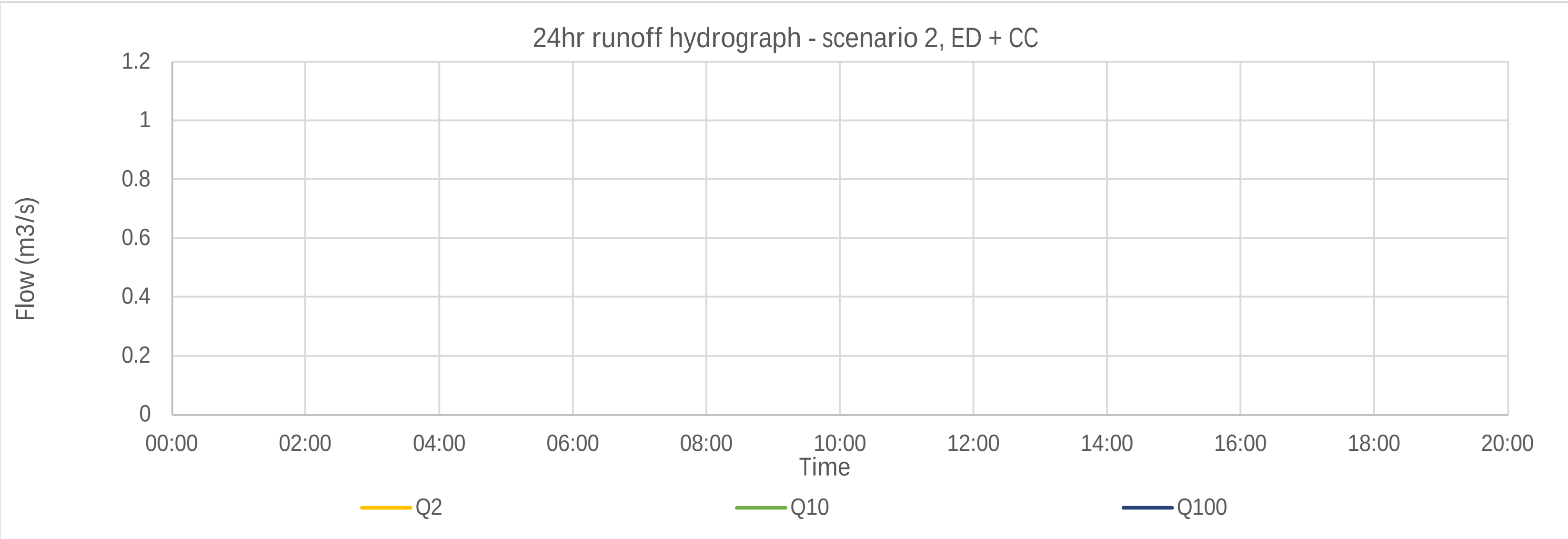
	Scenario 4 PD+CC excess shear excedence (%)			Scenario 2 ED+CC excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	42%	37%	31%	42%	38%	32%	0%	-1%	-1%
>1 & <2 (min)	0%	1%	1%	5%	3%	3%	-5%	-2%	-2%
>2 & <10 (min)	58%	55%	66%	54%	59%	65%	5%	-5%	1%
>10 (min)	0%	7%	2%	0%	0%	0%	0%	7%	2%

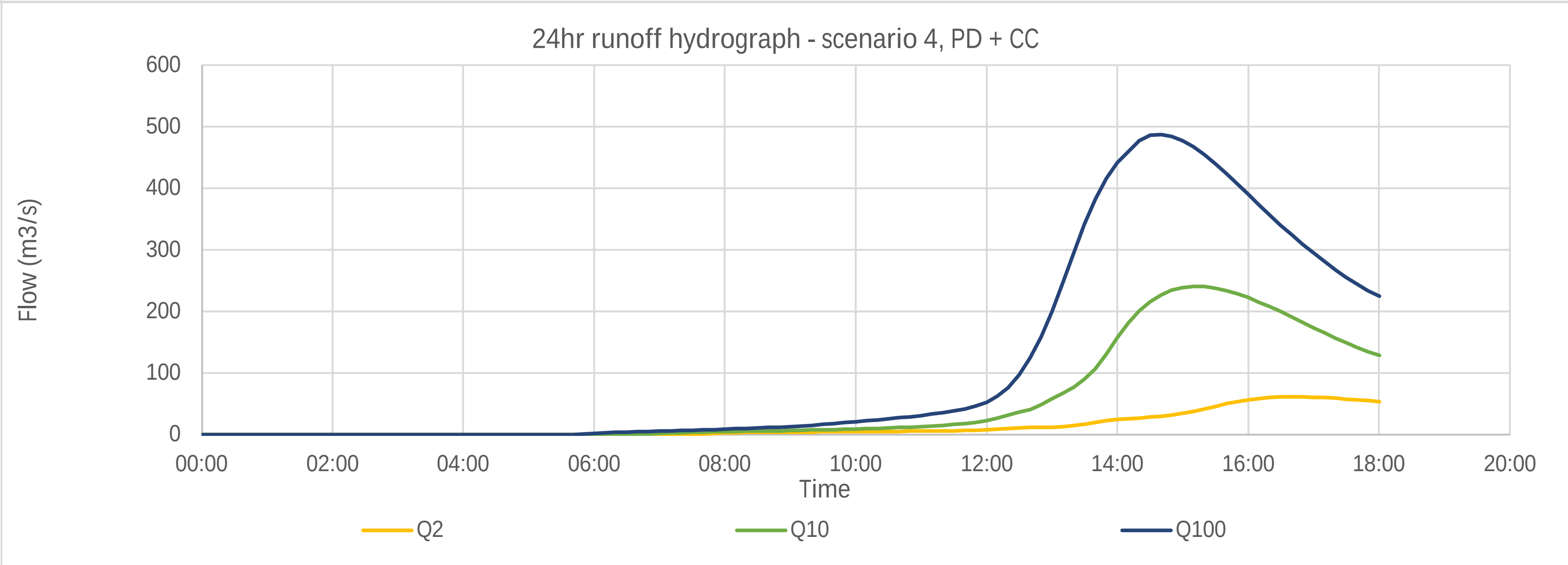
channel geometry			
manning's roughness n	0.08		
Cross section		longitudinal section	
chainage (m)	elevation (m)	Chainage (m)	Elevation (msl)
0.00	12.23	0.00	0.00
1.14	12.21	100.00	1.00
2.28	12.05		
3.43	11.85		
4.57	11.85		
5.71	11.85		
6.85	11.65		
8.00	11.45		
9.14	11.41		
10.28	11.41		
11.42	11.24		
12.57	11.24		
13.71	10.80		
14.85	10.61		
15.99	9.89		
17.13	9.89		
18.28	9.89		
19.42	9.89		
20.56	9.47		
21.70	9.47		
22.85	8.94		
23.99	8.94		
25.13	8.94		
26.27	8.46		
27.42	8.37		
28.56	8.37		
29.70	8.37		
30.84	8.15		
31.99	8.15		
33.13	8.15		
34.27	8.19		
35.41	8.19		
36.55	8.97		
37.70	8.97		
38.84	8.78		
39.98	8.97		
41.12	8.10		
42.27	8.10		
43.41	8.10		
44.55	8.24		
45.69	8.24		
46.84	8.24		
47.98	8.36		
49.12	8.33		
50.26	8.26		
51.40	8.26		
52.55	8.08		
53.69	8.08		
54.83	8.08		
55.97	8.08		
57.12	8.09		
58.26	8.09		
59.40	8.09		
60.54	8.12		
61.69	8.12		
62.83	8.12		
63.97	8.22		
65.11	8.22		
66.26	8.22		
67.40	8.33		
68.54	8.33		
69.68	8.42		
70.82	8.42		
71.97	8.49		
73.11	8.49		
74.25	8.56		
75.39	8.57		
76.54	8.64		
77.68	8.78		
78.82	8.78		
79.96	8.78		
81.11	8.78		
82.25	8.91		
83.39	9.06		
84.53	9.06		
85.67	9.06		
86.82	9.08		
87.96	9.08		
89.10	9.19		
90.24	9.04		
91.39	9.19		
92.53	8.94		
93.67	8.94		
94.81	8.31		
95.96	8.23		
97.10	8.23		
98.24	8.23		
99.38	8.10		

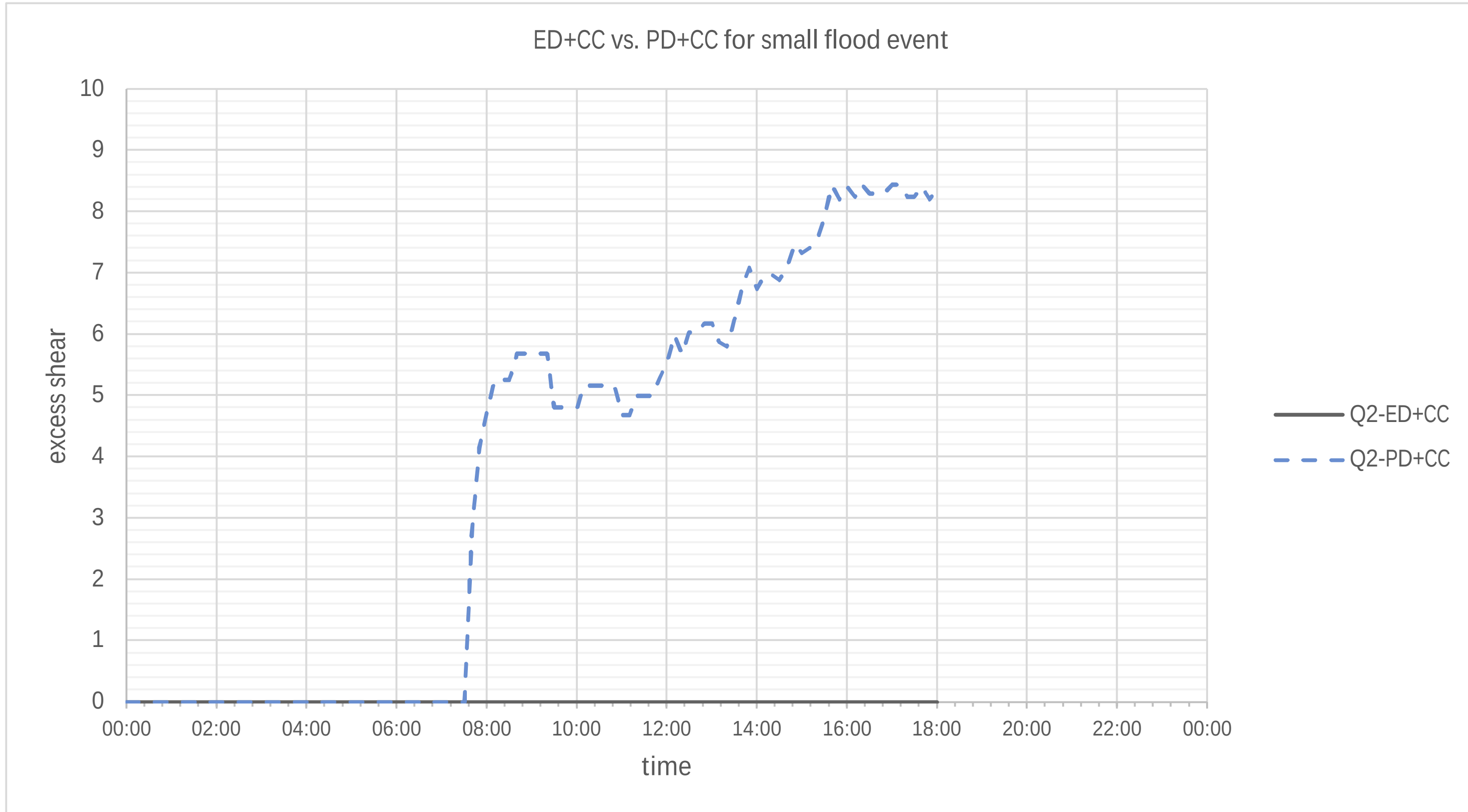




100.53	7.97		
101.67	8.10		
102.81	8.10		
103.95	7.53		
105.09	7.53		
106.24	7.53		
107.38	7.53		
108.52	7.53		
109.66	6.61		
110.81	6.61		
111.95	6.39		
113.09	6.39		
114.23	6.39		
115.38	5.04		
116.52	5.04		
117.66	3.82		
118.80	3.82		
119.94	3.82		
121.09	3.82		
122.23	3.82		
123.37	5.44		
124.51	5.44		
125.66	6.09		
126.80	6.09		
127.94	8.47		
129.08	8.47		
130.23	8.47		
131.37	8.47		
132.51	8.47		
133.65	8.96		
134.80	8.96		
135.94	9.15		
137.08	9.15		
138.22	9.39		
139.36	9.39		
140.51	9.66		
141.65	9.66		
142.79	9.66		
143.93	11.76		
145.08	11.76		
146.22	18.36		
147.36	18.36		
148.50	18.36		
149.65	18.67		
150.79	18.67		
151.93	18.67		
153.07	18.67		
154.21	18.61		
155.36	18.61		
156.50	18.57		
157.64	18.57		
158.78	18.57		
159.93	18.58		
161.07	18.58		
162.21	18.53		
163.35	18.50		
164.50	18.47		
165.64	18.43		
166.78	18.52		
167.92	18.77		
169.07	18.77		
170.21	18.77		







* 3month estimated rainfall does not fits well in regression calculation, not recommend to use.

EXCESS SHEAR

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel

Threshold	Excess Shear	Description
Green	<1.0	Indicates no erosion predicted to occur
Yellow	>1.0 <2.0	Indicates the potential for some erosion of the channel
Orange	>2.0 <10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	>10.0	Indicates potential rapid rates of erosion and incision of channel

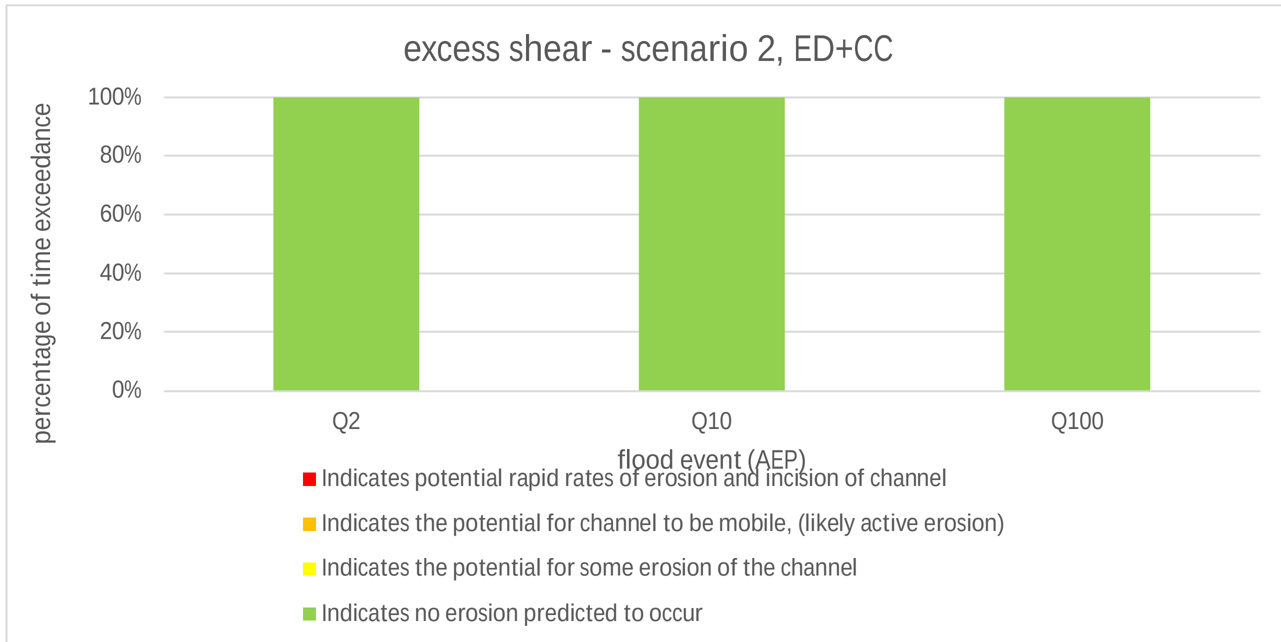
Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechical erosion or other associated processes. Predevelopment erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its predevelopment state.

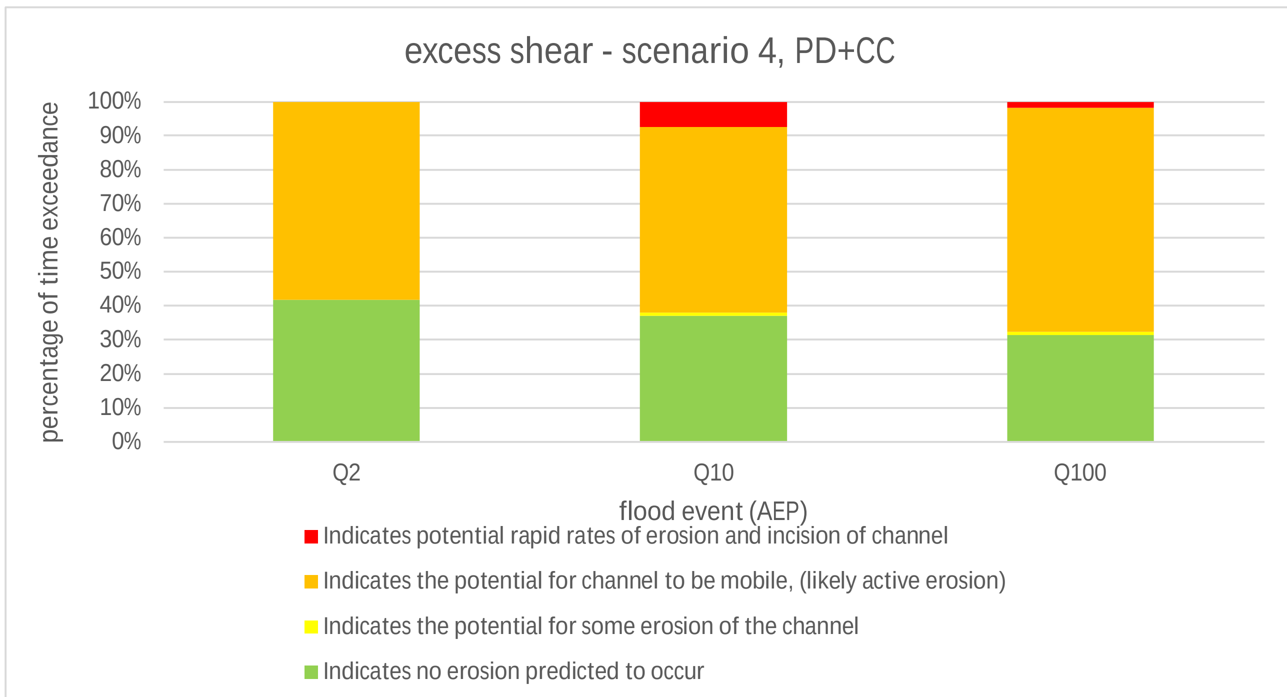
Scenario 2 ED+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	1080	0	1080	1080	1080
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0

Scenario 4 PD+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	450	0	1080	400	340
>1 & <2 (min)	0	0	0	0	0	0	10	10
>2 & <10 (min)	0	0	0	630	0	0	590	710
>10 (min)	0	0	0	0	0	0	80	20

bank full channel identification		
approximate channel width (m)	21.41	
bank full water depth (m)	0.00	excess shear
* bank full flow -identified by main channel (m3/s)	#N/A	#N/A
annual fullest flow as represented by the mean annual flood (m3/s)	#DIV/0!	#DIV/0!

* main channel identification depends on the accuracy of topographic survey



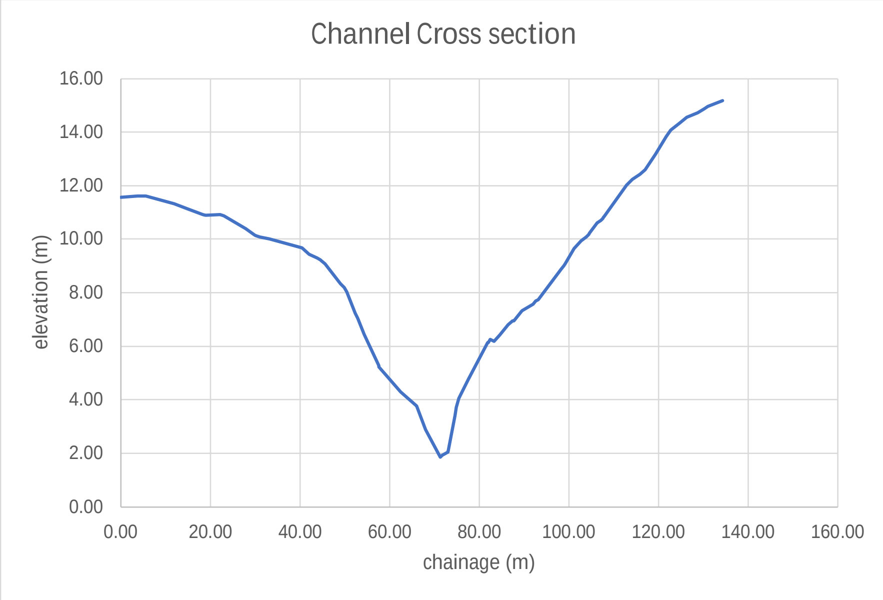


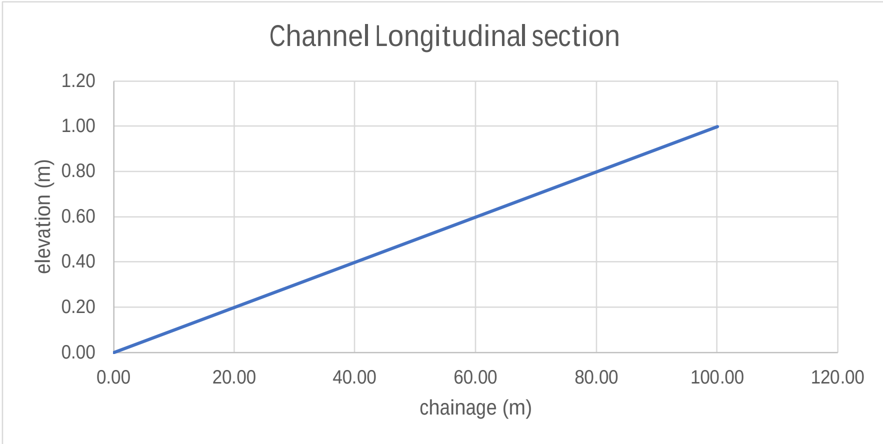
XS-03 PRE DEVELOPMENT

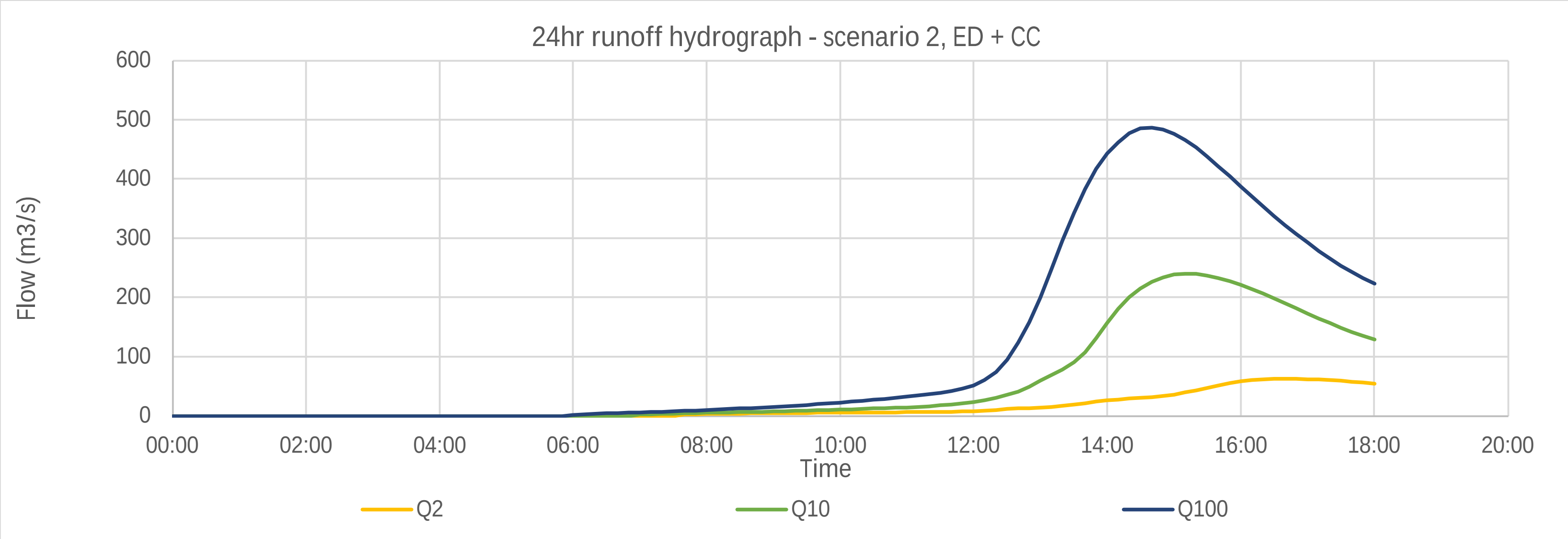
	Scenario 4 PD+CC			Scenario 2 ED+CC					
	excess shear excedence (min)			excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	1080	1080	1080	450	410	350			
>1 & <2 (min)	0	0	0	50	30	30			
>2 & <10 (min)	0	0	0	580	640	700			
>10 (min)	0	0	0	0	0	0			

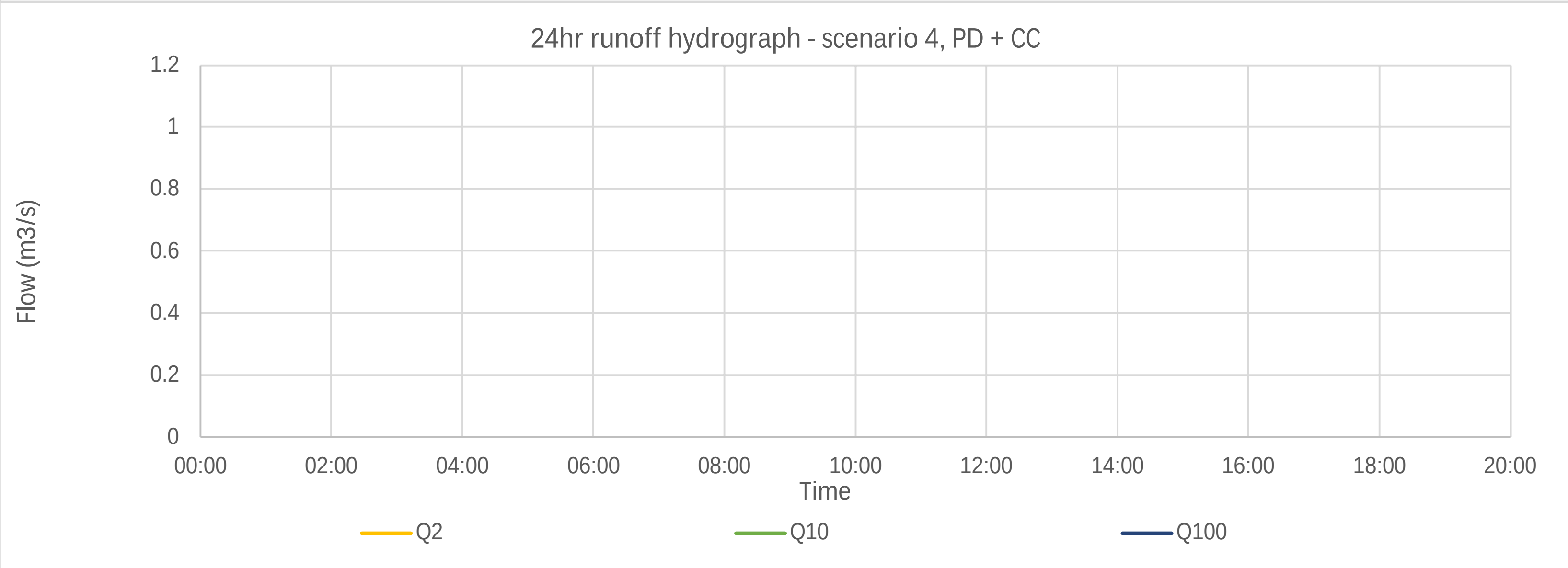
	Scenario 4 PD+CC			Scenario 2 ED+CC					
	excess shear excedence (%)			excess shear excedence (min)			Change		
	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C	2-YEAR 3.8°C	10-YEAR 3.8°C	100-YEAR 3.8°C
<1 (min)	100%	100%	100%	42%	38%	32%	58%	62%	68%
>1 & <2 (min)	0%	0%	0%	5%	3%	3%	-5%	-3%	-3%
>2 & <10 (min)	0%	0%	0%	54%	59%	65%	-54%	-59%	-65%
>10 (min)	0%	0%	0%	0%	0%	0%	0%	0%	0%

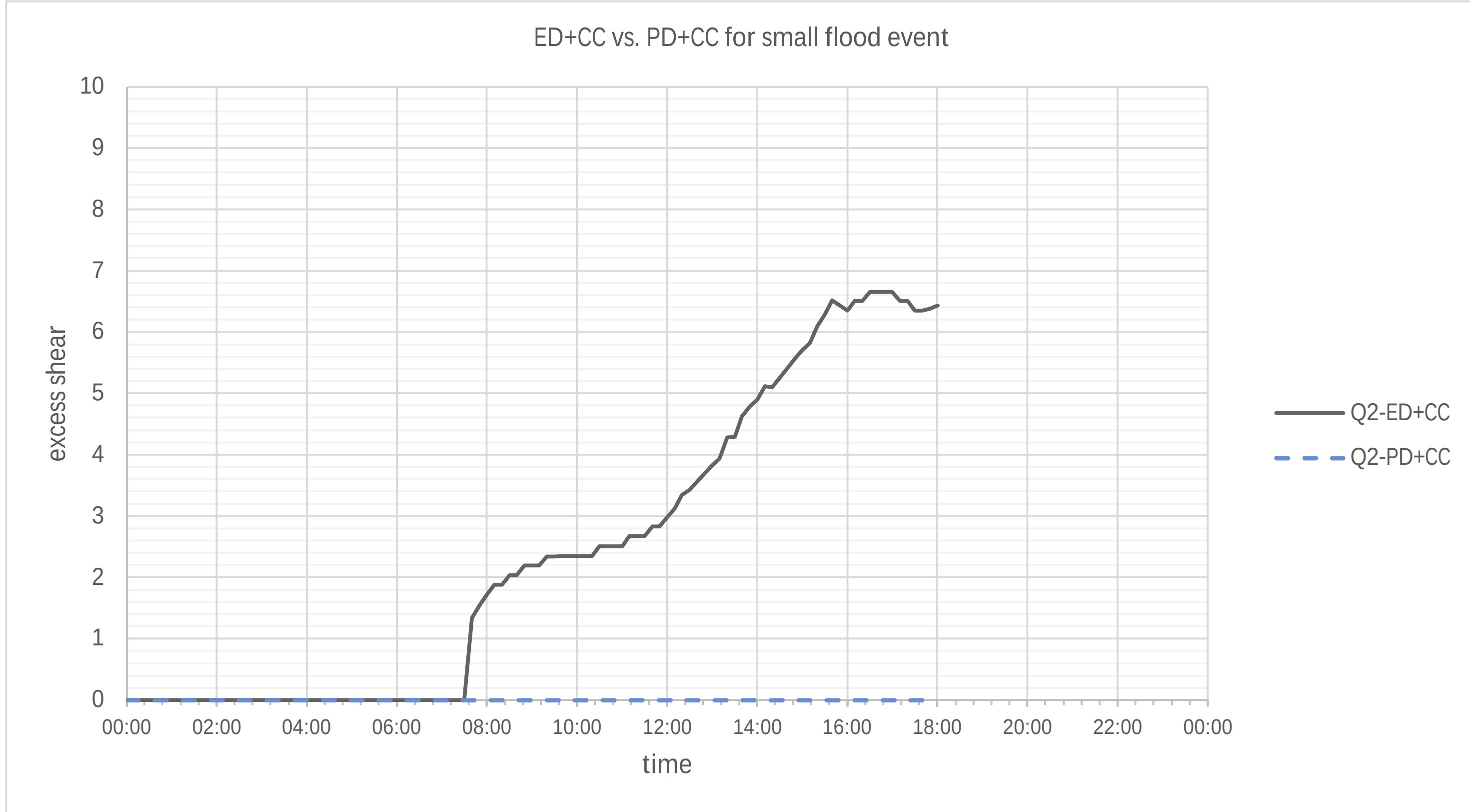
channel geometry			
manning's roughness n	0.08		
Cross section		longitudinal section	
chainage (m)	elevation (m)	Chainage (m)	Elevation (msl)
0.00	11.56	0.00	0.00
3.70	11.61	100.00	1.00
5.58	11.61		
10.33	11.40		
11.90	11.33		
14.91	11.14		
18.22	10.93		
18.81	10.89		
18.91	10.89		
19.13	10.89		
22.09	10.92		
23.04	10.87		
27.93	10.38		
29.82	10.15		
30.10	10.12		
31.00	10.08		
33.18	10.02		
40.41	9.67		
41.94	9.45		
43.93	9.28		
44.62	9.23		
44.73	9.21		
45.53	9.07		
49.01	8.34		
49.85	8.19		
50.45	8.04		
52.33	7.24		
52.88	7.04		
54.32	6.45		
55.31	6.10		
57.51	5.28		
57.64	5.22		
59.64	4.84		
62.46	4.30		
66.05	3.78		
67.97	2.88		
71.26	1.88		
71.76	1.92		
73.02	2.04		
74.55	3.41		
74.90	3.73		
75.43	4.06		
77.62	4.79		
81.84	6.14		
82.04	6.14		
82.50	6.25		
83.27	6.19		
84.62	6.42		
86.50	6.81		
87.48	6.95		
87.68	6.94		
89.46	7.31		
89.52	7.32		
91.97	7.58		
92.57	7.70		
93.19	7.74		
98.31	8.88		
98.90	9.01		
99.19	9.09		
101.11	9.66		
102.71	9.95		
103.93	10.09		
104.37	10.18		
104.62	10.23		
106.36	10.61		
107.11	10.71		
107.52	10.77		
107.57	10.78		
107.75	10.82		
107.90	10.85		
112.89	12.01		
114.14	12.23		
115.91	12.43		
117.00	12.59		
119.01	13.10		
119.28	13.17		
121.75	13.83		
122.71	14.06		
124.71	14.34		
126.34	14.55		
128.66	14.73		
130.21	14.86		
131.01	14.96		
134.19	15.19		











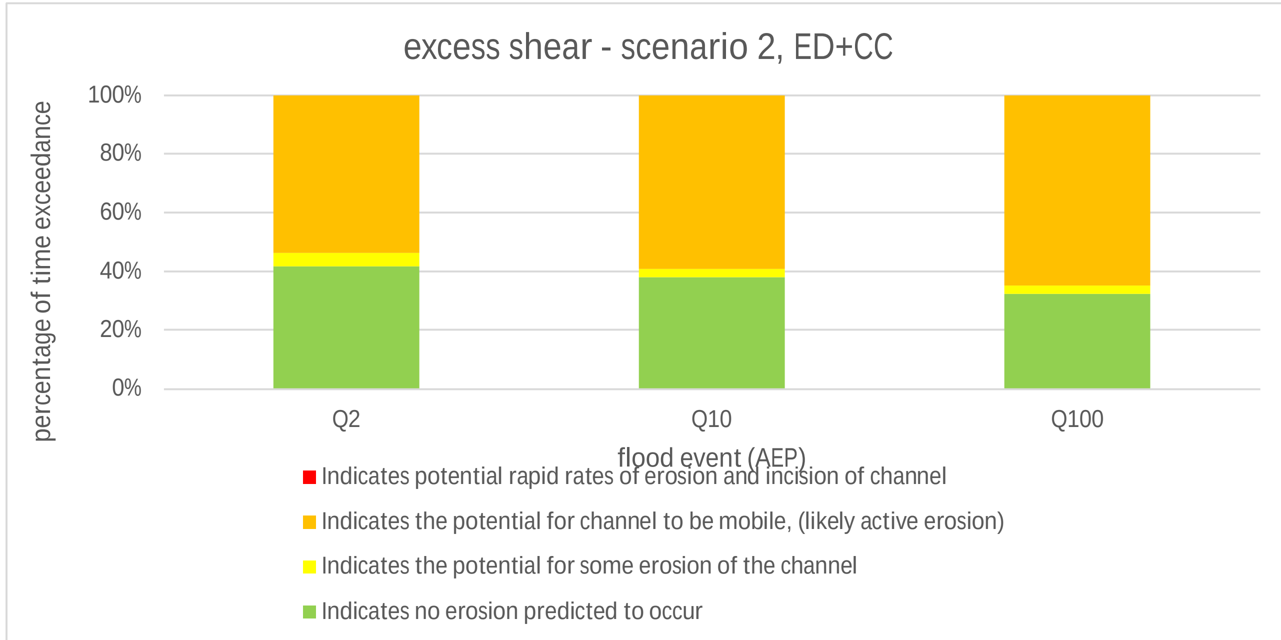
* 3month estimated rainfall does not fits well in regression calculation, not recommend to use.

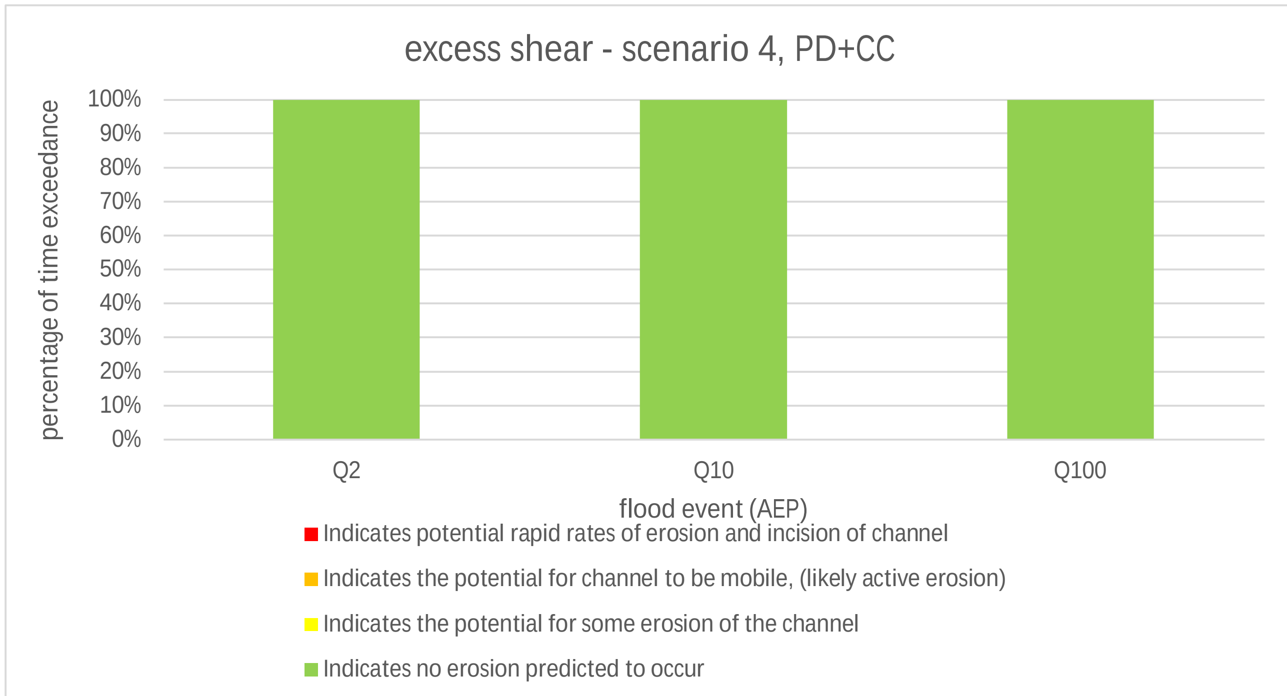
EXCESS SHEAR

Excess shear for this screening tool is a metric (ratio) representing how much the hydraulic forces applied by the stream flow differs from the resisting forces provided by the channel boundary conditions. The values obtained provide an indication of what flows and to what extent the applied shear stresses within a channel can cause erosion and incision of the stream channel

Threshold	Excess Shear	Description
Green	<1.0	Indicates no erosion predicted to occur
Yellow	>1.0 <2.0	Indicates the potential for some erosion of the channel
Orange	>2.0 <10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	>10.0	Indicates potential rapid rates of erosion and incision of channel

Estimates provided are associated with the hydraulic component of stream bank erosion and do not account for geotechical erosion or other associated processes. Predevelopment erosion thresholds may still exceed the green "no erosion predicted" threshold as current channel geometry would differ from its predevelopment state.





Scenario 2 ED+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	450	0	0	410	350
>1 & <2 (min)	0	0	0	50	0	0	30	30
>2 & <10 (min)	0	0	0	580	0	0	640	700
>10 (min)	0	0	0	0	0	0	0	0

Scenario 4 PD+CC								
boundary shear stress at peak (N/m2)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear at peak	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
excess shear excedence (min)								
<1 (min)	0	0	0	1080	0	1080	1080	1080
>1 & <2 (min)	0	0	0	0	0	0	0	0
>2 & <10 (min)	0	0	0	0	0	0	0	0
>10 (min)	0	0	0	0	0	0	0	0

bank full channel identification		
approximate channel width (m)	21.41	
bank full water depth (m)	0.00	excess shear
* bank full flow -identified by main channel (m3/s)	#N/A	#N/A
annual fullest flow as represented by the mean annual flood (m3/s)	#DIV/0!	#DIV/0!

* main channel identification depends on the accuracy of topographic survey