

Red Jacket Limited
PO Box 904
New Plymouth 4340

Attention: Mr L Bunn

Dear Luke

Wairau Estate Development, Oakura, Taranaki

Review of Stream Bed and Bank Stability

In accordance with our letter of engagement dated 30 October 2019, we are pleased to provide this review of stream bed and bank stability downstream of the proposed Wairau Estate development in Oakura. This letter report updates our earlier version, dated 27 November 2019.

1 Background

Oakura Farm Park Limited is planning a development of approximately 145 residential lots to the south of Oakura. The proposed development is upstream of South Road State Highway 45, and lies in the Wairau Stream catchment.

The land is presently in pastoral use. As part of the development, stormwater infrastructure including detention ponds has been designed to manage stormwater runoff and mitigate the effects of the land use change to residential.

Red Jacket Limited has prepared an Engineering Report on the proposed development (ref. RPT-2351-04, Rev A, October 2019, in response to a request by New Plymouth District Council (NPDC) for further information). The purpose of the report was a high-level assessment of the proposed stormwater management system, including assessment of the upstream catchment and potential hydrological effects due to the development.

NPDC has also advised that the *“stream bed and bank stability also needs to be considered as although peak flows may not be higher, they will last for a longer duration. This will need suitably qualified geotechnical advice”*.

This report presents the T+T review of the possible effects on downstream watercourses due to the runoff expected from the proposed development of the Wairau Estate.

2 Stormwater hydrology

Red Jacket has modelled pre-development and post-development flows in the Wairau Stream catchment, to the confluence of the West Branch and East Branch of Wairau Stream, some 400 m from the coast. This confluence is approximately 500 m downstream of SH45.

The proposed Wairau Estate lies in the catchment of the East Branch, and is upstream of SH45. The east branch itself has two principal tributaries, and the proposed development essentially lies

between these. Flow in each of the tributaries is conveyed under SH45 by a 600 mm diameter culvert. Stormwater from the development will be discharged to the western tributary, which flows under SH45 approximately 200 m south of the intersection with Wairau Road. Figure 1 shows the location, and general catchment area and stream system in the vicinity of Wairau Estate.

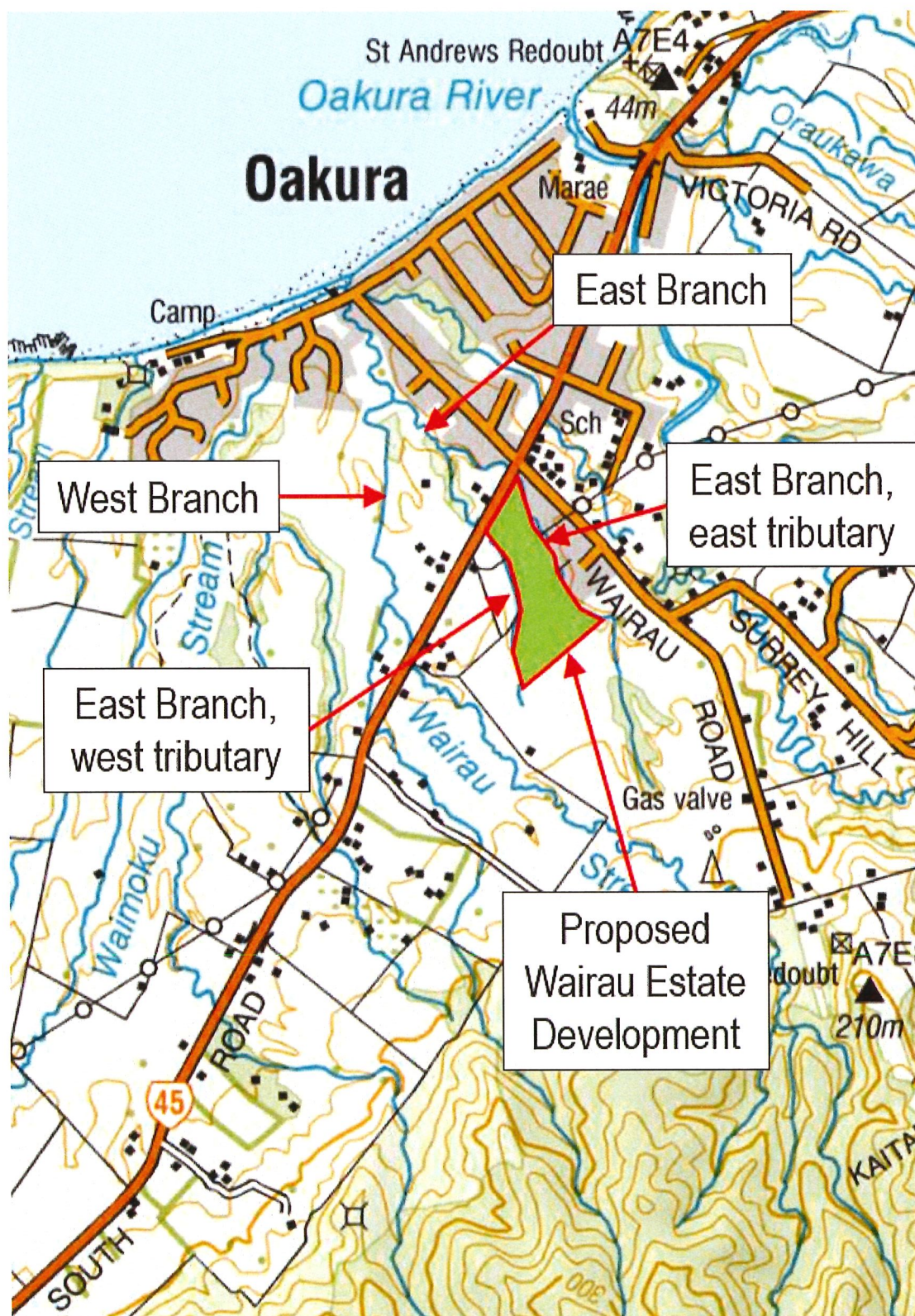


Figure 1 Wairau Estate Location

It is noted that there will be a reduction in the subcatchment to the eastern tributary, due to the diversion of runoff in the new stormwater infrastructure. There will be a commensurate increase in the catchment to the western tributary, and the increased runoff due to this and the land use change will be mitigated by detention ponds incorporated in the stormwater management system.

Red Jacket has modelled flows for various frequencies, from 20 % Annual Exceedance Probability (AEP) to 1 % AEP. In terms of the effects for stream bed and bank stability, this report has considered the 1 % AEP modelling results. The schematisation for the hydrological model is shown in Figure 2.

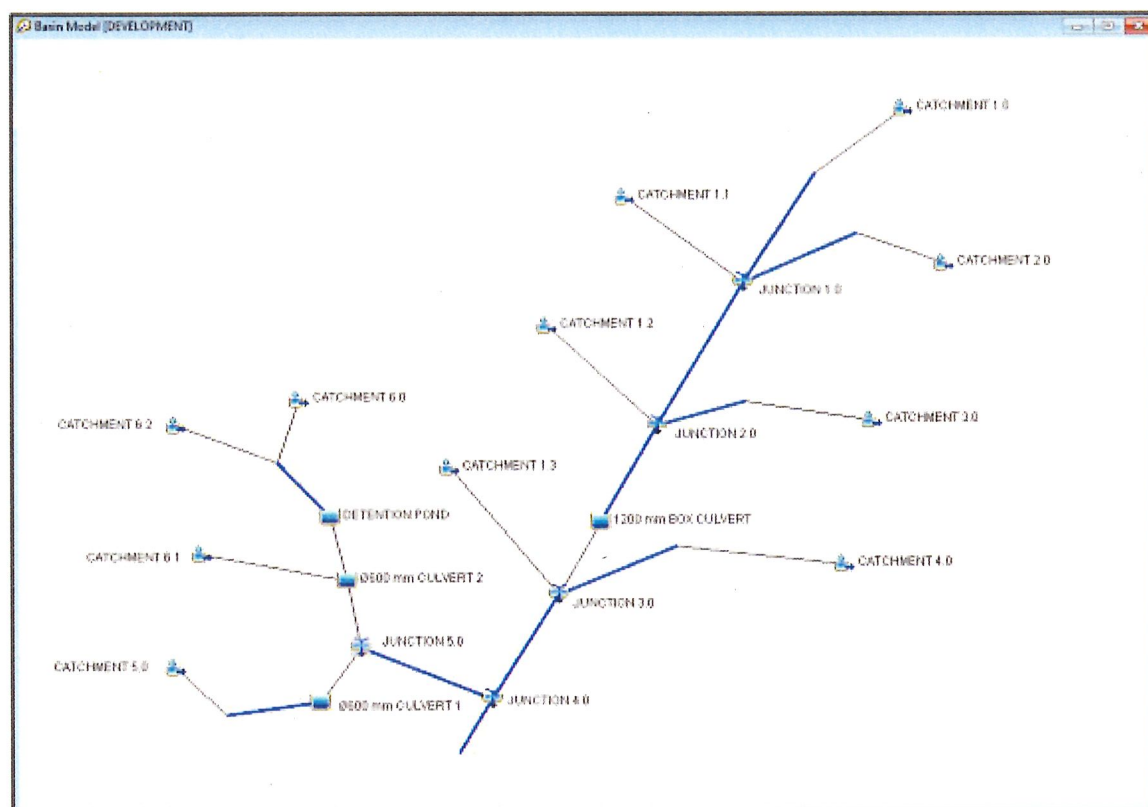


Figure 2 Wairau Estate Hydrological Model Schematisation

In the hydrological model:

- Catchment 5.0 represents the east tributary of the East Branch of Wairau Stream.
- Catchment 6.0 represents the west tributary, and includes the proposed development area.
- Junction 5 is the confluence of the two tributaries 500 m downstream of SH45.
- Junction 4 is the confluence of the two Wairau Stream branches 400 upstream of the coast.

For the 1 % AEP event, the Red Jacket modelling results indicate that:

- The peak pre-development discharge is approximately $1.3 \text{ m}^3/\text{s}$ in the east tributary. Flows in this will be reduced overall throughout the event, by approximately $0.1 \text{ m}^3/\text{s}$ at the peak and through the recession limb of the design hydrograph.
- The peak pre-development discharge in the west tributary is approximately $0.7 \text{ m}^3/\text{s}$.
 - Flows in this will be initially be reduced over four to five hours due to the detention of runoff from the development.

- Thereafter through the recession limb of the design hydrograph the post-development flows will be up to 0.2 m³/s greater than prior to development, for more than 12 hours.
- Downstream of the east-west tributary confluence in the East Branch, the modelled peak pre-development flow is approximately 2 m³/s.
 - Post-development, there will be a reduction of flows at or near the peak over nine hours, by up to 0.4 m³/s.
 - On the recession limb, modelled post-development flows are up to 0.15 m³/s greater for up to 12 hours.
- At the confluence of the west and east branches of Wairau Stream, the peak pre-development 1 % AEP discharge is approximately 56 m³/s. Modelling results show:
 - a reduction of flows at the peak, by up to 0.45 m³/s over an hour.
 - an increase of flows on the recession limb by up to 0.13 m³/s for more than six hours.

3 Geology

Soil testing results from geotechnical site investigations conducted by Red Jacket in February and March 2017, indicate that the site is underlain by volcanic ashfall deposits comprising very stiff to hard (greater than 100 kPa), sandy silt. The investigations did not encounter the base of the volcanic ash but did confirm the unit is at least 4 m thick.

The existing stream banks are likely incised within the volcanic ash to an equilibrium between the local climate, catchment hydrological processes, and the geology of the area which comprises relatively cohesive soils at the surface.

Based on review aerial photographs, there is evidence of historic shallow slope failures along the gully slopes in the Wairau Stream catchment. Appropriate setbacks will be needed for structures within proximity of the gully slopes. Otherwise, if structures are proposed within close proximity to the steep slope crests, site-specific detailed foundation design or retention structures will be required to consider lateral movement from potential slope instability. Any further assessment can be carried out for specific areas during detailed design.

4 Hydraulic assessment

4.1 East Branch, west tributary

Hydrological modelling shows that post-development flows in the East Branch, west tributary:

- Will be initially be reduced over nine hours by up to 0.4 m/s.
- Will thereafter be up to 0.2 m³/s greater for more than 12 hours through the recession limb of the design hydrograph.

Hydraulic analysis of flows in the stream channel indicates pre-development velocities at the peak of the 1 % AEP event up to approximately 2.1 m/s at a depth of up to 0.6 m.

For post-development flows on the recession limb, the velocity and depth of the increased flows (by up to 0.2 m³/s) will be less than the peak. Although flows will be greater than pre-development for a period of maybe more than 12 hours, the increased depth will be only approximately 0.1 m, with velocities at times 0.4 m/s faster (cf. 1.7 m/s post-development, 1.3 m/s pre-development).

4.2 East Branch upstream of confluence

Hydrological modelling results show that post-development flows in the East Branch upstream of the confluence with the West Branch (Junction 4):

- will be initially be reduced over four to five hours due to the detention of runoff from the development.
- Will thereafter be up to 0.15 m³/s greater for up to 12 hours through the recession limb of the design hydrograph.

Hydraulic analysis of flows downstream of the tributaries indicates velocities at the peak of the 1 % AEP event up to 2.8 m/s at depths up to 0.9 m.

For post-development flows on the recession limb, the increased depth will be less than 0.05 m, with velocities 0.1 m/s faster for up to 12 hours.

4.3 Downstream of East Branch-West Branch confluence

Hydrological modelling results show that post-development flows downstream of the East Branch-West Branch confluence (Junction 4):

- will be initially be reduced over an hour by up to 0.4 m³/s.
- Will thereafter be up to 0.14 m³/s greater for approximately ten hours through the recession limb of the design hydrograph.

Compared to pre-development peak flow of 56 m³/s, the changes in the hydraulic regime downstream of the East Branch-West Branch confluence are not considered to be significant.

5 Erosion risk

Analysis of pre-development flows in the stream channel downstream of the proposed development indicate:

- Velocities up to 2.1 m/s at the peak in the East Branch-west tributary.
- Depths up to 0.6 m.

Post development, peak velocities will not increase, however, on the recession limb of the design hydrograph velocities will be sustained at up to 1.7 m/s for more than 12 hours (cf. 1.3 m/s pre-development).

In the East Branch channel upstream of the West Branch confluence, post development peak velocities will not increase. On the recession limb of the design hydrograph velocities will be typically be 0.05 m/s faster than pre-development.

With regard to erosion risk, it is noted that the stream channels are likely to be in a morphological equilibrium, formed in the relatively cohesive volcanic ash soils.

Research published by the Construction Industry Research and Information Association (CIRIA) indicates that a well-chosen grass cover can withstand 2 m/s for prolonged periods, i.e. more than ten hours (cf. Use of Vegetation in Civil Engineering, 1990). Available photographs indicate that the Wairau tributary flows through pastoral land, with stream banks either in grass or fenced with vigorously re-vegetated riparian margins.

Therefore, it is considered that the effects of the proposed development on bed and bank stability (due to recession flows prolonged at slightly higher levels) will not be significant. Flow velocities will generally be less than 1.7 m/s, and the existing stream banks will be resistant to erosion for this flow regime.

6 Summary

Based on Red Jacket modelling results, peak 1 % AEP flows in Wairau Stream from the proposed Wairau Estates development will be unchanged or reduced. However, on the recession limb of flood hydrographs, there will be periods of up to 12 hours or more where in the post-development scenario flows will be higher than prior to the development. This will be most notable in the west tributary downstream of the development, and then in the combined East Branch channel upstream of the West Branch confluence. Typically, post-development recession flows may be up to 200 l/s greater.

However, post-development flows in the east tributary of the East Branch will be reduced due to diversion of part of the catchment to the proposed stormwater management detention ponds.

Downstream of the East Branch-West Branch confluence the effects of the development on flows in, and the hydraulic regime of, the Wairau Stream are not considered to be significant given the significance of the much larger West Branch catchment on the stream hydrology.

Nonetheless flow velocities in the East Branch stream channels upstream of the confluence while slightly increased (up to 0.4 m/s) are expected to be less than 2 m/s. The vegetated Wairau Stream banks, formed in relatively cohesive soils, are expected to be resistant to erosion from such a hydraulic regime. Based on the information available at this stage, it is not expected that the proposed development will have significant effects on stream bed and bank stability.

7 Applicability

This report has been prepared for the exclusive use of our client Red Jacket Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

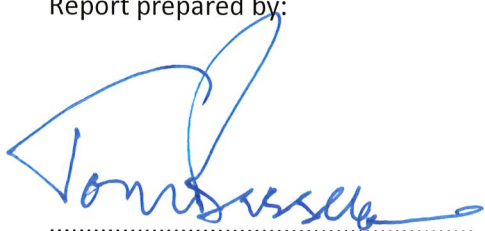
We understand and agree that our client will submit this report as part of an application for resource consent and that Taranaki Regional Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

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