Appendix H:

Flood Hazard Assessment

GeoSolve Limited

GEOSOLVE

GEOTECHNICAL

WATER RESOURCES

PAVEMENTS

Flood Hazard Assessment

114 Ripponvale Road,

Cromwell

Report prepared for:

New Zealand Cherry Corp (Leyser) LP Ltd

Report prepared by:

GeoSolve Limited

Distribution:

New Zealand Cherry Corp (Leyser) LP Ltd

Town Planning Group (NZ) Ltd

Paterson Pitts Group Ltd

GeoSolve Limited (File)

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1	09/10/2018	DRAFT for Client review	DAH	EGM
2	25/10/2018	FINAL	EGM	
3	31/10/2018	Updated following site meeting with Paterson Pitts	DHA	EGM
4	25/03/2019	FINAL for ISSUE	EGM	
4	24/05/2019	Updated with new structure plan	EGM	

GEOTECHNICAL WATER RESOURCES PAVEMENTS

Table of Contents

1 Introduction

1.1 General

This report presents the results of a flood hazard assessment carried out by GeoSolve Ltd to support an application for a private plan change at 144 Ripponvale Road, Cromwell to be made to the Central Otago District Council.

Photo 1 – Property Boundary at 114 Ripponvale Road, Cromwell

The purpose of the report is to evaluate the flooding potential at the site to accompany an application for rural-residential zoning on the land. Our assessment involved:

- A walkover inspection of the site by a senior water resources engineer;
- Evaluation of catchment areas and hydrological parameters;
- Estimation of design rainfall intensities and flood flows;
- Identification of areas potentially affected by flooding; and
- Discussion of possible mitigation options as required.

This report should be read in conjunction with the other GeoSolve reports as necessary.

This work was carried out in accordance with GeoSolve Ltd.'s proposal dated 3 July 2018, ref:180137.01 which outlines the scope of work and conditions of engagement.

1.2 Site and Development

The subject property is located immediately north of Ripponvale Rd to the northwest of central Cromwell – as illustrated in Photo 1.

It is proposed to request an alternative zoning by way of a provide plan change request to the Central Otago District Council which would enable the future development of the site for up to 160 rural-residential sites (subject to further consenting).

As the application is for a zone change request and not a resource consent, no earthworks are proposed at this stage. We expect that cut and engineered fill will be required as part of the earthworks design at the time of subdivision and development should the zone request be successful and subsequent consent applied for.

Topography is gently sloping at the southern end of the site near the footfills and steepens towards Mt Michael to the north and west.

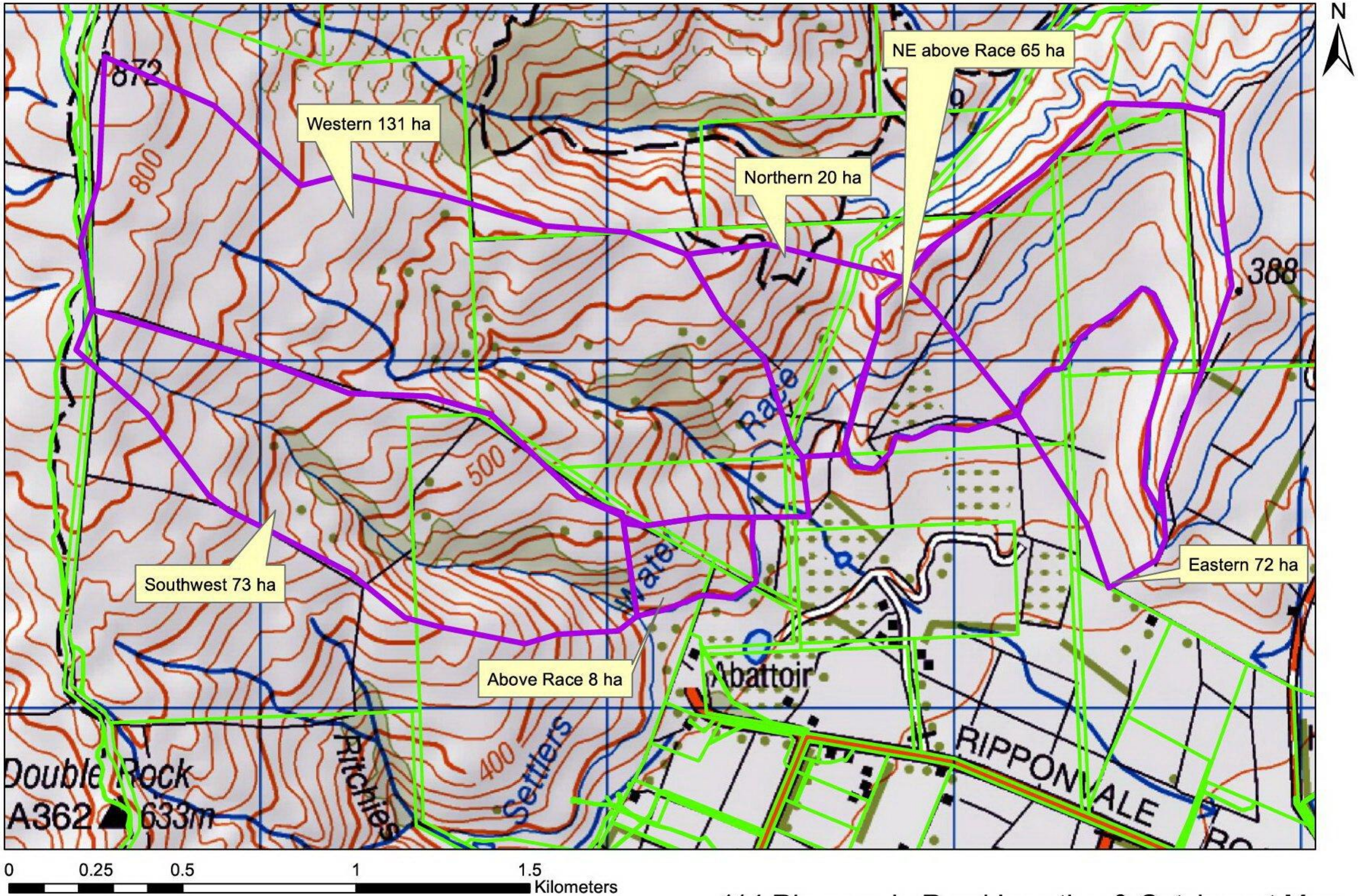
Present land use comprises of a working farm with the flatter land irrigated by border-dykes and spray irrigation. There are a number of orchard blocks that are generally spray irrigated. Most of the irrigation water is supplied by the Ripponvale Irrigation Company Limited race that utilises pumped supply from the Kawarau River. A number of water races are present throughout the property, and these can intercept runoff from land above and divert this to other parts of the property. Such runoff could be irrigation runoff water or overland flow after rainfall.

2 Catchments

There are three main catchments identified as West, North and East and one that touches the southwestern margins of the property identified as Southwest. Catchment boundaries, together with smaller internal catchment areas, are shown in Figure 1 attached.

Table 1. Catchment particulars

Catchment	Area (ha)	Length (m)	Max Elevation (mRL)	Outlet Elevation (mRL)	Elevation Difference (m)	Average Slope (%)	Soil Type
Southwest	73	1,850	790	300	490	26	Arrow
Western	131	2,675	872	278	594	22	Arrow + Annan
Northern	20	825	520	290	230	28	Shallow sandy
Eastern	72	1,435	410	250	160	11	Clare & Letts shallow sand-sandy loam
SW above race Abbattoir	8	400	420	295	125	31	Annan mod deep fine sandy loam
NE above race	65	500	420	300	120	24	Clare & Letts shallow sand-sandy loam
Border dyked paddocks per ha	1					5	Annan & Waenga sandy loam



Geosolve Ltd October 2018. Base topographic map by LINZ

114 Ripponvale Road Location & Catchment Map

Figure 1. Location and catchment map

3 Design Floods

3.1 Previous flood observations

In the 1999 flood, the property owner, who had been on the property since the early 1970s, estimated that he observed [at an unspecified location] a peak flow of approximately 15 heads (0.4 m^3/s) down the western gully which is considerably less than estimated in Table 2. We have no way of verifying the accuracy of these observations or whether flows had already reduced by some mechanism upslope, i.e. via overspill or diversion.

It is considered that these observations are anomalously low, considering that peak floods in Central Otago catchments are typically in the order of 1m^3/s per km^2 but are variable. Although the 1999 flood, generally accepted to be the flood of record, was in the order of a 100-year flood in major catchments (owing to snowmelt etc.), this did not necessarily apply in smaller catchments such as on this site. For this event the short-duration, high-intensity floods that will generate large peak runoffs were not particularly high during this event either, and hence greater flows are likely to apply for a design 100-year flood.

Where there are defined hill catchments leading to a valley floor the pattern of drainage and therefore flood flow is fairly self-evident and could be observed on site. Once however, floodwater is captured by water races the exit point, if such races reach full capacity, can vary depending on what state the races have been maintained and managed prior.

Gate structures can be altered, and flows distributed in several directions. Branches, debris, dead animals, etc. can accumulate and block culverts resulting in overspill. If purposefully manipulated however, the flows could be spread out and minimise concentrated flows at any one point (as apparently occurred in the November 1999 floods) – refer photos 3509 and 3511 below.

Floods would have normally been actively managed in this manner under the previous land use, by sharing flood flows between the dam and upslope water races to reduce flooding effects downslope. This is unlikely to be available under the planned zoning and eventual future subdivision. Further, the pattern of flooding will be modified depending on the final road and earthworks layout.

Capacity of the sidling water race heading NE past the main buildings is estimated to be 1.5 m^3/s on a much flatter gradient S=0.0063, bottom width 0.6m, top width 2.5m and 0.9m deep.

450 mm diameter concrete culverts within the water races will have a capacity of approximately 110-170 l/s (~4 to 6 heads in irrigation terms) depending on slope and may choke or attenuate incoming flows.

Photo 3509: Looking from water race up western gully, dam in middle distance. Flood path to left of road.

Photo 3511: Water race downstream of western gully outflow. 450mm culvert could block and overtop

3.2 Flood Parameters

The NZ Building Code Clause E1.3.2 Surface Water requires that *"Surface water, resulting from an event having a 2% probability of occurring annually, shall not to enter buildings."* This applies to housing, communal residential and communal non-residential buildings.

NZS 4404:2010: Land Development and Subdivision Engineering clause 4.3.5.2 states:

"4.3.5.2 Freeboard The minimum freeboard height additional to the computed top water flood level of the 1% AEP design storm should be as follows or as specified in the district or regional plan:

	Minimum height Freeboard
Habitable dwellings (including attached garages)	*0.5 m*
Commercial and industrial buildings	*0.3 m*
Non-habitable residential buildings and detached garages	*0.2 m*

The minimum freeboard shall be measured from the top water level to the building platform level or the underside of the floor joists or underside of the floor slab, whichever is applicable."

The Standard also states in Table 4.1 that the recommended annual exceedance probability (AEP) for primary systems where no secondary flow path is available should be the 1% AEP flood event.

For the purposes of this report the 1% AEP event has been used. An allowance for climate change has also been provided based on an 8% increase in high intensity rainfall per degree Celsius rise in predicted mean annual temperature.

3.3 High Intensity Rainfall

The National Institute of Water and Atmospheric Research (NIWA) provides information through their web application High Intensity Rainfall Design System (HIRDS) v3[1]. The rainfall Depth-Duration-Frequency information has been obtained for the climate change scenario of a 2 degree rise in mean annual temperature.

The rainfall for durations of up to one hour are plotted for the 1% annual exceedance probability (AEP) event. This is shown as Figure 2 below.

[1] https://hirds.niwa.co.nz/

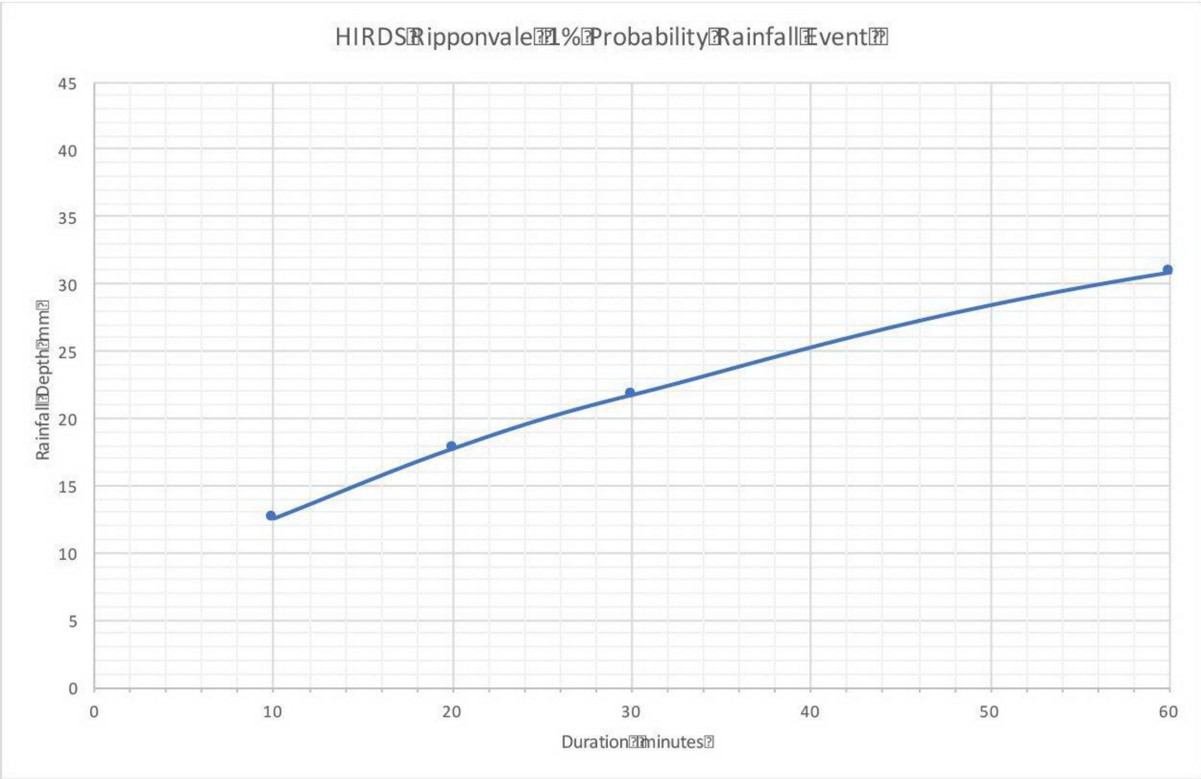


Figure 2. High Intensity Rainfall data for 1% AEP event. Source: https://hirds.niwa.co.nz/

3.4 Design Flood Flows

One method to estimate flood flows for a design storm is the Rational Method which is based on a runoff coefficient C, time of concentration and rainfall intensity. The time of concentration represents the time it takes for the entire catchment area to be full contributing to the flood flow and is estimated using catchment characteristics such as surface cover, soil types, length of catchment and slope.

A second method available is using Stream Explorer[2] software from NIWA and the Pearson Method (1991). This has derived specific discharge figures of 1.4 to 2.4 $m^3/s/km^2$ that are generally lower than the Rational method even though they have also been adjusted for the 2 degree climate change scenario. The higher Pearson method figure has been used. For the purposes of this report the two methods estimates have been averaged as shown in the last column of Table 2.

Table 2 shows the derivation of the flood flows for the catchments in Table 1.

A check has been made using the most up-to-date Henderson & Collins (2018) method developed by NIWA, accessible through the web-based application on the NIWA website[2]. Results indicate the adopted flood estimates are conservative, which is appropriate in this context.

[2] *New Zealand River Flood Statistics, based on the Henderson & Collins 2018 Method:* https://niwa.maps.arcgis.com/apps/webappviewer/index.html?id=933e8f24fe9140f99dfb57173087f27d

Table 2. Flood estimates for 1% AEP flood including allowances for climate change

Catchment	Area (ha)	Rational Method including 2° climate change					Peason (1991) Method Q m³/s	Average Q m³/s	Check[1]
		Runoff Coefficient c	Time of concentration Tc minutes	Rainfall Depth (mm)	Rainfall intensity i mm/hr	Flood Flow Q m³/s			
Southwest	73	0.4	27	20.8	47	3.81	2.03	2.92	0.78
Western	131	0.4	35	23.5	40	5.85	3.65	4.74	1.12
Northern	20	0.4	19	17.2	56	1.23	0.56	0.90	
Eastern	72	0.35	27	20.8	46	3.22	2.00	2.61	0.73
SW above race Abbattoir	8	0.4	15	14.8	61	0.54	0.22	0.38	
NE above race	65	0.4	16	15.8	58	4.16	1.81	2.98	
Border dyked paddocks per ha	1	0.3	13	13	59	0.05	0.03	0.04	

[1]Check based on the web-based "Regional Flood Estimation Tool" developed by Henderson & Collins (2018) correlating relative catchment areas A_1/A_2^0.8 and including a 25% factor for climate change
https://niwa.maps.arcgis.com/apps/webappviewer/index.html?id=933e8f24fe9140f99dfb57173087f27d

4 Areas Potentially Affected by Flooding

4.1 General

We have reviewed the proposed Structure Plan (ref: 201902415_Shannon Farm Structure Plan L1.1 Rev0 dated: 20/05/2019 – reproduced in Appendix B). This shows an "Indicative Open Space and Stormwater Corridor" that provides for a 20 m width that will allow a 3 m bottom width channel, 0.6 m deep with 2:1 batters plus 7 m berm on either side. This is a no-build zone, as shown on the plan. Culverts on this main channel should be designed to accommodate 5.6 m^3/s (Western plus Northern catchments) so should be a nominal 1600 mm to 1800 mm diameter pipe, depending on depth of cover. The northern catchment flood channel zone is also shown as 20 m, but the formed channel can be a nominal 1 m bottom width and 0.5 m deep grassed swale, also nominated a no-build zone.

There is an existing formed channel along the South-eastern boundary that directs flows along the boundary towards Ripponvale Road (refer Image 2130). The proposed flood channel zone will discharge into this channel so that outflow locations from the property will remain the same.

Appendix A presents the existing flows paths and areas potentially subject to inundation. As part of the development it is proposed to clear out water race structures including culverts.

Image 2130: Existing channel about 1.5 m bottom width 0.6 m deep along SE boundary looking upstream from Ripponvale Road (taken: 30 October 2018)

In general, it will be possible to locate future building sites well away from and above active watercourses. Accordingly, most future lots will only require a minimum level of flood protection to deal with localised shallow runoff, such as establishing minimum floor levels above surrounding ground as outlined in Section 3.2. The CODC minimum floor level is 300 mm above natural ground, but in some cases, this will need to be greater.

All building sites should be located away from flood flow paths.

Those building sites that are on slopes requiring excavation (cut and fill) should incorporate a stormwater catch drain placed at the base of the cut slope.

As previously noted, the old water races around the hill slopes can intercept runoff from the slopes above and redirect those flows. It is recommended that lowered sections of the downstream race bank be formed and grassed at larger watercourses so that if the old races become full they can overflow at known and manageable locations. If the building sites have been sited away from flood flow paths, then this will reduce the chances of them being affected by breakout at unexpected locations.

Shallow, grassed swales and roadside stormwater drains are typically also included in rural type subdivisions to deal with shallow runoff and retaining the system of existing border dykes could help in this regard. Roadside culverts and drainage infrastructure should be designed to accommodate any upstream catchment which is normal.

Confirmation of final earthworks plan and building locations could be assisted by the development of a hydraulic model to ensure that conveyance systems and minimum flood levels are appropriately set.

4.2 Specific Issue – Downstream of dams

Three small water storage dams are present on the site as illustrated on Figure 3:

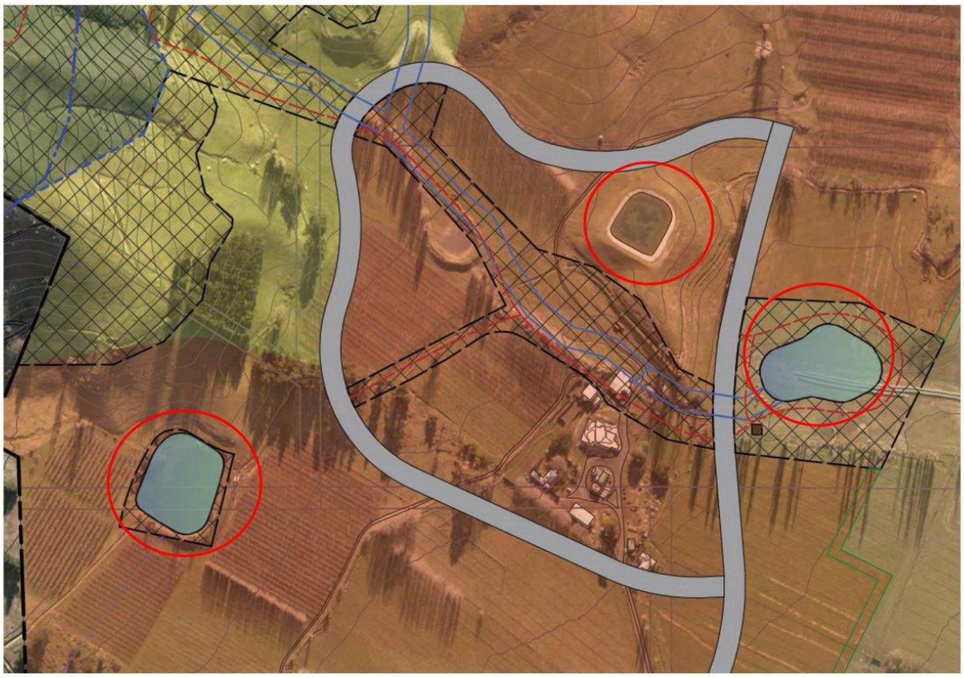


Figure 3. Location of existing small dams circled in red

These dams could present a flood hazard to land immediately downstream if these were to fail, either through failure during normal operation say via piping or during an extreme weather event. This flood hazard would be additional to the hazard from stormwater runoff discussed previously, although the incremental increase in hazard may only be small.

If retained, these could also have a positive effect by storing and gradually releasing floodwater, reducing the impacts of flooding downstream, i.e. as stormwater retention basins. Emergency spillway capacities appear to be in excess of their respective upstream channel capacities, meaning that channels upslope are likely to overflow away from the dams in a large flood rather than enter the dam. Further engineering assessment can be undertaken at a later date to ensure that the dams comply with current standards if they were to perform as stormwater retention basins.

The largest of the dams is located on the Southwestern catchment and is fed by a Ripponvale Irrigation Company water race as well as the natural catchment – see bottom left on Figure 3. It has an estimated surface area of ~6,000 m^2, is up to about 3.5 m deep and has a storage potential of about 8,000 m^3. On the basis of these estimates, it would note be classified as a 'Large Dam' in the Building Act.

Future building sites immediately downstream may require specific engineering works to manage flood risk of these dams. Conceptually, this this may involve a small flood diversion swale and bund upstream of building sites and/or a suitable minimum flood level established above the potential floodplain level to accommodate shallow flows arising from s potential dam failure. Final solutions should be subject to detailed design once development plans are confirmed.

5 Conclusions

Three main catchments totalling 370 ha were identified at the site. Flood flows from these catchments were estimated for a 1% AEP flood event using the Pearson (1991) method and Rational Method, with a check using the new Henderson & Collins (2018) method.

The proposed Structure Plan allows for a stormwater corridor capturing the western and northern catchments that will be directed into an existing formed channel along the South-eastern boundary to maintain existing outlet locations from the property. Culverts on the main channel should be designed to accommodate 5.6 m^3/s. Roadside infrastructure should be designed to accommodate any upstream catchment as normal.

Generally, it will be possible to locate future building sites well away from and above active watercourses, meaning that minimum floor levels and shallow stormwater swales are likely to be all that is required in most areas.

The three existing small water storage dams present an additional flood hazard to land immediately downstream, although the incremental increase in hazard may only be small. If retained as stormwater retention ponds, these could be modified to have a positive effect by reducing the impacts of flooding downstream. Further engineering assessment is recommended at a later date to confirm their suitability for reuse in this way, and to inform any requirements for managing flood risk downstream.

6 Applicability

This report has been prepared for the benefit of New Zealand Cherry Corp (Leyser) LP Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Report prepared by:

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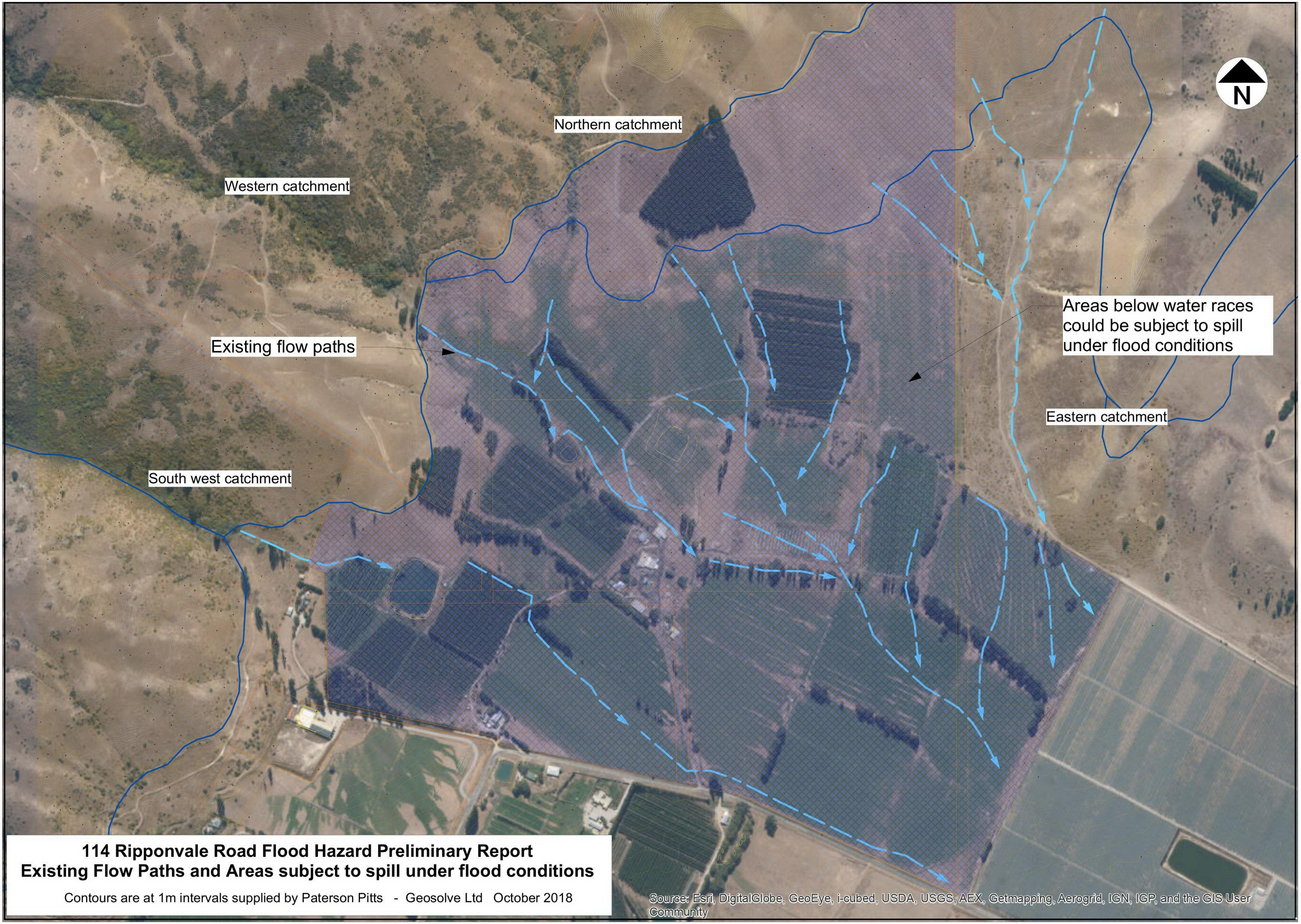

114 Ripponvale Road Flood Hazard Preliminary Report
Existing Flow Paths and Areas subject to spill under flood conditions

Contours are at 1m intervals supplied by Paterson Pitts - Geosolve Ltd October 2018

*This exhibit has been amended for the proposed plan change regarding RuRA5.

SCHEDULE 19.23 : STRUCTURE PLAN – RURAL RESOURCE AREA (5)

See Rules 4.7.2(ib), 4.7.2(ii)(a)(i), 4.7.2(ii)(a)(vi), 4.7.2(ii)(a)(vii), 4.7.5(viii), 4.7.5(ix), 4.7.6A(f), 4.7.6A(l), 4.7.6A(m), 4.7.6A(n), 4.7.6C(f)