WAIMAKARIRI DISTRICT COUNCIL

MEMO

FILE NO AND TRIM NO:	DDS-14-13-02 / 240416059923
DATE:	13 May 2024
MEMO TO:	Mark Buckley, Principal Policy Planner
FROM:	John Aramowicz, Senior Civil & Geotechnical Engineer
SUBJECT:	Proposed District Plan Rezoning Requests - Ohoka/Mandeville Stream 12C – Servicing, Natural Hazards, Geotechnical Matters

I write to summarise the issues that relate to water, wastewater and stormwater services, and the presence of any significant natural hazards or geotechnical matters that, in my professional opinion, should be taken into account when considering an application to rezone the following sites to Large Lot Residential Zone (LLRZ).

Firstly, however, I explain the existing hazard posed by groundwater resurgence that occurs in the Mandeville/Ohoka area.

Groundwater resurgence

1. Groundwater resurgence describes the effect where there is a temporary increase in groundwater levels that results in temporary surface spring flows. These typically occur in areas that have an existing low-medium flood hazard.
2. Groundwater resurgence exacerbates the extent and duration of localised surface flooding, reducing the capacity of surface channels and drains, and can lead to other consequences such as buoyancy of underground structures (i.e. septic tanks, etc.) and saturation of areas that were required for infiltration of treated wastewater.
3. The issue is complex. The interaction between rapid changes in groundwater levels, the occurrence of spring flows due to groundwater resurgence, and the subsequent effect of these on surface hydrology and the area-wide flood hazard is, frankly, not well understood. I am not aware of any modelling that has been able to effectively combine all these aspects to provide a reliable assessment of flood hazard.
4. Unfortunately, given this complexity, there has been a tendency by some professionals to over-simplify their assessment of potential effects from groundwater resurgence and to ignore, or be oblivious to, its potential contribution to the flood hazard.
5. The effects of groundwater resurgence caused significant problems in the Mandeville and Ohoka area in a 2014 storm event which was assessed[1] to have a return period of around 66 years. Further groundwater resurgence/surface flooding was also recorded in 2017, 2022 and 2023[2]. In short, groundwater resurgence in the Mandeville area is a credible, likely hazard.

[1] Purton, K., Cleary, G. 2015 "*Flood Response in the Waimakariri District*", Water New Zealand Asia Pacific Stormwater Conference, Auckland, New Zealand.

[2] https://letstalk.waimakariri.govt.nz/mandeville-resurgence-channel-upgrades

6. The Waimakariri District Council (WDC) now have considerable experience with problems caused by surface flooding and groundwater resurgence in the Mandeville area. This hazard still exists.
7. While the locations of historical groundwater resurgence are not currently shown on WDC's natural hazards interactive viewer that can be accessed by the public, it is nonetheless a significant hazard that is known by many of the Council's stormwater engineers and residents of the area.
8. WDC-initiated investigations, mostly undertaken in 2020 and 2021, identified a range of diversion and capacity improvement options that could, at considerable cost, reduce (but not eliminate) the existing effects of surface flooding, to which groundwater resurgence contributes to, in the Mandeville area. These investigations also confirmed the problem is complex and that apparent solutions to reduce local flood hazard in Mandeville could also lead to an increased flood hazard in the immediate downstream catchment, through to the Silverstream/Kaiapoi[3] area.
9. WDC have proposed capital works that seek to find a balance of these risks that reduce, but not eliminate, the risk of surface flooding in the Mandeville area. It is my understanding that, at time of writing this memo, WDC have not committed to carrying out any capital works for groundwater resurgence/surface flood mitigation.
10. Even if the capital works to mitigate the effects of surface flooding/resurgence are carried out in due course, they are not intended to provide additional capacity for the rezoning sought by the respective applicants. Given this, groundwater resurgence is likely to remain a significant hazard in the Mandeville area.

Submission 8 (McAllister) – 1379, 1401 & 1419 Tram Rd, Swannanoa

11. 1379, 1401 & 1419 Tram Rd is located on the western fringe of Swannanoa. The land can generally be described as flat but has a slight fall from the west down to the east.

Flood hazard & groundwater resurgence

12. Current flood hazard mapping on WDC's GIS for a 0.5% AEP event (i.e. 200 yr ARI) indicates the site is almost entirely within a zone of very low flood hazard.
13. There is an area of lower ground just south of the site that WDC modelling identifies as a large overland flow path in both a 100 and 200 yr. flood event. This overland flow path conveys flood flows down to the east, across Swannanoa and Mandeville.
14. The applicant proposes to discharge stormwater into ground from a future subdivision of the site. Importantly, stormwater runoff from the site will be expected to either infiltrate into ground or to flow overland to the south and east.
15. The Applicant's consultant, E2 Environmental, assumes that onsite treatment and attenuation of stormwater runoff by disposal of treated stormwater into ground can be achieved onsite.
16. However, the E2 Environmental report does not model the potential effects of increased rates of stormwater infiltrating deeper into ground, nor does it consider the potential for that discharge to increase the risk of groundwater resurgence and flood hazard occurring further downstream in the Mandeville area.
17. Additionally, the E2 assessment does not assess whether the increased volume of stormwater runoff that would need to discharge from the site would exacerbate the extent of medium and high flood hazard in the lower eastern part of the catchment (i.e.

[3] Beca report for Waimakariri District Council, 10 June 2021: Mandeville Flooding Investigation Works – Summary of DHI Flood Modelling". Note: refer to Table 1.

Silverstream/Kaiapoi) or not. The applicant has not carried out a detailed assessment of the potential effects on the wider catchment area.

Wastewater

18. The Applicant's consultant, Survus Consultants, has proposed to either discharge wastewater to the Council main, or to provide onsite treatment/disposal.
19. The southern part of the site is within a Community Drinking Water Protection Zone (CDWSPZ), and E2 acknowledge any proposed discharge of treated effluent to land would require Resource Consent from Environment Canterbury (ECan), and that there is no guarantee that ECan would grant resource consent.
20. In relation to the option of discharging to the Council network, Survus acknowledge 'WDC will need to confirm that the existing wastewater network and treatment plant facility have capacity to cater for the additional wastewater flow that will be generated by a future subdivision…'.
21. In relation the Council's wastewater network, the existing system was constructed with capacity only for the existing land zoning, and for the zoning proposed by Council.
22. There is no capacity within the Mandeville-Rangiora rising main for the wastewater that would result from the Applicant's proposal to zone 1379, 1401 & 1419 Tram Rd as LLRZ.

Water

23. Water capacity is not a constraint to development at this site.

Summary

24. There is a known significant natural hazard to the Mandeville/Ohoka area from groundwater resurgence. Stormwater runoff from a future development of the site would need to be carefully managed to avoid exacerbation of the existing flood hazard that exists in the Mandeville/Ohoka and Silverstream/Kaiapoi areas. The existing wastewater network does not have sufficient capacity to allow the proposed LLRZ land use.

Submission 8 (McAllister) – 1275 Tram Rd

25. 1275 Tram Rd is located on the eastern fringe of Swannanoa. The land can generally be described as flat to very gently undulating, with a general fall from the west down to the east.

Flood hazard & groundwater resurgence

26. Current flood hazard mapping on WDC's GIS for a 1% and 0.5% AEP event (i.e. 100 and 200 yr ARI) indicates the site is almost entirely within a zone of either low or medium flood hazard.
27. The flood hazard area that is present at 1275 Tram Rd is part of the same overland flow path that is located immediately south of 1379 and 1419 Tram Rd. This overland flow path conveys flood flows down to the east across Swannanoa and Mandeville.
28. The applicant proposes to discharge stormwater into ground from a future subdivision of the site, or to use roof water rain tank for attenuation purposes. Importantly, stormwater runoff from the site can be expected to either infiltrate into ground or flow overland to the south and east.
29. The Applicant's consultant, E2 Environmental, assumes that onsite treatment and attenuation of stormwater runoff by disposal of treated stormwater into ground can be achieved onsite.
30. However, the E2 Environmental report does not model the potential effects of increased rates of stormwater infiltrating deeper into ground and the potential for that discharge to

increase the risk of groundwater resurgence occurring further downstream in the Mandeville area.

31. Additionally, the E2 assessment does not assess whether the increased volume of stormwater runoff that would occur from the site could exacerbate the extent of medium and high flood hazard in the lower eastern part of the catchment (i.e. Silverstream/Kaiapoi). The applicant has not carried out an assessment of the potential effects on downstream properties, or the wider catchment area, to demonstrate they are less than minor as required by PDP NH-P4.

Wastewater

32. The Applicant's consultant, Survus Consultants, has proposed to either discharge wastewater to the Council main, or to provide onsite treatment/disposal.

33. Survus acknowledge 'WDC will need to confirm that the existing wastewater network and treatment plant facility have capacity to cater for the additional wastewater flow that will be generated by a future subdivision …'.

34. In relation the Council's wastewater network, the existing system was constructed with capacity only for the existing land zoning, and for the zoning proposed by Council.

35. There is no capacity within the Mandeville-Rangiora rising main for the wastewater that would result from the Applicant's proposal to zone 1275 Tram Rd as LLRZ.

Water

36. Water capacity is not a constraint to development at this site.

Summary

37. There is a known significant natural hazard to the Mandeville/Ohoka area from groundwater resurgence. Stormwater runoff from a future development of the site will need to be carefully managed to avoid exacerbation of the existing flood hazard that exists in the Mandeville/Ohoka and Silverstream/Kaiapoi areas. The existing wastewater network does not have sufficient capacity to allow the proposed LLRZ land use.

Submission 224 (Prosser) – 2 Ashworths Road, Ohoka

38. 2 Ashworths Rd is located on the northern fringe of Mandeville. The land can generally be described as flat to very gently undulating, with a general fall from the west down to the east. There are at least 3 areas that cross the site that are a wide, shallow alluvial channel that visually appear to be a subtle topographic depression.

Flood hazard & groundwater resurgence

39. Current flood hazard mapping on WDC's GIS for a 0.5% AEP event (i.e. 200 yr. ARI) indicates that around a third to one half of the site is affected by a low or medium flood hazard that flows down to the east, within four alluvial channels.

40. The southern-most area of flood hazard that is present across 2 Ashworths Rd flows to the east, across the northern part of the San Dona area.

41. The applicant's consultant, Aurecon, acknowledges groundwater resurgence has occurred at the site, and states they 'have reviewed and provided feedback on the ODP (Figure 3, below) to ensure that the internal layout site will maintain the status quo for stormwater and groundwater runoff to the greatest extent possible'. No modelling is provided to support this statement.

42. Aurecon also state "Existing overland flowpaths will be maintained through the provision of swales on either side of the proposed roading network. This will allow for floodwaters flowing onto the site from the west to flow across the site, ultimately remaining within the existing catchments without diversion of floodwaters between catchments". Aurecon's

ODP identifies overland flow paths alongside new roads which are orientated to suit a residential layout, and the formation of two stormwater management areas that are intended to treat and attenuate the rate of runoff from road surfaces before discharge beyond the eastern boundary. Aurecon identify the intention to discharge stormwater runoff from impervious surfaces on private lots into ground via soak pits.

43. My observation is that the location and alignment of the roads and overland flow paths shown on Aurecon's proposed ODP are quite different to the location and alignment of the natural overland flow paths that are highlighted by WDC flood modelling. This raises a concern that the proposed realignment could lead to an adverse effect to surrounding property if the design is not supported by detailed hydraulic modelling, particularly if the road layout has the effect of diverting flows from the north towards the south where it is more likely they could contribute to the existing flood hazard at San Dona.

44. The Applicant's consultant assumes that onsite treatment and attenuation of stormwater runoff by disposal of treated stormwater into ground can be achieved, but provides no modelling as evidence.

45. Aurecon propose a 'a detailed groundwater study should be undertaken prior to any detailed design for future development of the Site to confirm groundwater levels, identify any potential resurgence locations and to inform groundwater and infiltration management approaches'. In short, Aurecon have not assessed the potential effects from stormwater runoff from the site and have not demonstrated there will be no adverse effects on downstream properties from the proposed LLRZ.

46. Aurecon do not explain what the effect would be if stormwater runoff from a future subdivision was unable to be disposed into ground, such as when groundwater levels increase resulting in resurgence, which is a known hazard at this site.

47. Aurecon have not yet modelled the potential effects of increased rates of stormwater infiltrating deeper into ground, nor have they assessed the potential for that discharge to increase the risk of groundwater resurgence occurring further downstream in the San Dona area.

48. Additionally, Aurecon state attenuation will only be provided for a 24 hour event, but they have not assessed whether the increased volume of stormwater runoff that would occur from a longer duration event would exacerbate the extent of the existing medium and high flood hazard in the lower eastern part of the catchment (i.e. Silverstream/ Kaiapoi).

Wastewater

49. In relation the Council's wastewater network, the existing system was constructed with capacity only for the existing land zoning, and for the zoning proposed by Council.

50. There is no capacity within the Mandeville-Rangiora rising main for the wastewater discharge that would result from the Applicant's proposal to zone 2 Ashworths Rd as LLRZ.

Water

51. Water capacity is not a constraint to development of this site.

Summary

52. There is a known significant natural hazard to the Mandeville/Ohoka area from groundwater resurgence. Stormwater runoff from a future development of the site will need to be carefully managed to avoid exacerbation of the existing flood hazard that exists in the Mandeville/Ohoka and Silverstream/Kaiapoi areas. The existing wastewater network does not have sufficient capacity to allow the proposed LLRZ land use.

Combined Section 32AA - San Dona

53. The existing San Dona subdivision is a rural subdivision that is located on the north-eastern side of Mandeville. The land can generally be described as flat to very gently undulating, with a general fall from the west down to the east. There are at least 3 areas that cross the site that appear to be just a subtle, shallow topographic depression but are in fact wide, alluvial channels that convey overland flows of stormwater in larger rainfall events.

Flood hazard & groundwater resurgence

54. Current flood hazard mapping on WDC's GIS for a 1% and 0.5% AEP event (i.e. a 100 yr and 200 yr ARI) indicates that, roughly, around a quarter of the site is affected by a low or medium flood hazard that flows down to the east, within the three alluvial channels.

55. The applicant's consultant, Eliot Sinclair, acknowledges groundwater resurgence has occurred at the site, but states 'There have been recent upgrades and regrades to the existing stormwater channels and water races as part of the Capital Works and are seen as positive for the Site and the wider community. The future upgrades to the channels as per the Capital Works will improve the capacity of drains to manage the stormwater and resurgence flows within the Site.

56. As I explain in my introduction, whilst WDC have proposed capital works, these have not yet been approved, and even if they are carried out in due course, they are not intended to provide additional capacity for the area of LLRZ sought by the Applicant. Given this, I do not agree with Eliot Sinclair's statement above. I remain concerned the groundwater resurgence is, and will remain, a significant hazard at this site.

57. Eliot Sinclair have carried out hydraulic modelling to assess the potential effects to surface stormwater flows arising from the proposed LLRZ zoning sought by the Applicant. That assessment concluded flood levels at nearby private property would increase by up to 75mm, and flow levels within Council open drains would increase by up to 100mm.

58. There are several existing dwellings that are within the existing areas of low flood hazard. Any increase in flood level that arises from the proposed LLRZ will therefore reduce the freeboard to the existing dwellings. It is very unlikely the dwellings can be protected or easily raised as mitigation. Eliot Sinclair have not provided existing floor and ground levels, and therefore it is not possible to determine if the increase in flood level would reduce the freeboard to less than the 400mm minimum required by Council (note this is 500mm in medium flood hazard areas). The submitters need to provide an assessment of how existing dwellings are affected by the proposed rezoning. One property is identified as experiencing up to 191mm increase in flooding on site in the 200 year event, but the impact on the existing freeboard of the house is not assessed.

59. Eliot Sinclair do not provide an ODP for the proposed LLRZ, rather it is assumed each existing property would need to provide its own assessment and onsite mitigation for stormwater.

60. As I have explained for the other submissions above (Tram and Ashworths Roads), there is a risk that disposal of stormwater into ground may not be possible in all scenarios, and that increased rates of stormwater runoff from a LLRZ land use may lead to increased problems with groundwater resurgence and surface flooding to downstream properties in Silverstream/Kaiapoi.

Wastewater

61. In relation the Council's wastewater network, the existing rural subdivision is serviced with a Septic Tank Effluent Pumping system, (STEP) that discharges to the Council network.

62. WDC have previously considered whether it would be possible to provide for additional development in the Mandeville area. While there are a number of options on how additional land could be serviced, typically using some form of attenuation to allow pumping at off-peak times, the biggest constraint is the Mandeville-Rangiora rising main which was designed and constructed with capacity only for the existing land zoning, and for the zoning that is currently proposed by Council.

63. In short, there is no capacity within the existing Mandeville-Rangiora rising main for the wastewater that would result from the Applicant's proposal to rezone the San Dona area as LLRZ.

Summary

64. There is a known significant natural hazard to the Mandeville/Ohoka area from groundwater resurgence. Stormwater runoff from a future development of the site will need to be carefully managed to avoid exacerbation of the existing flood hazard that exists in the Mandeville/Ohoka and Silverstream/Kaiapoi areas. The existing wastewater network does not have sufficient capacity to allow the proposed LLRZ land use.

Submission 250 (Aston) – 25 Ashley Gorge Road, Oxford

65. Stormwater - Onsite treatment and attenuation will be required to avoid adverse effects to downstream properties. Development needs to allow for the two drainage channels on site. This can be addressed as part of engineering design for a future subdivision of the site, but the ODP should make it clear these features are to be protected, and the SMA areas may change in size when detailed design is completed.
66. Wastewater - can be accommodated in the existing Council system. The site is within the 31-50yr period in the WDC 50yr growth model, but rezoning in the PDP can be accommodated with appropriate engineering design/construction.
67. Water - the site is located in an area where it could be supplied from the Oxford Urban scheme. There is an opportunity to relocate the existing main that crosses the NW corner of the site, which can be addressed in the future at time of subdivision.

Submission 158 (Andy Carr) – 308 Cones Road

68. Stormwater - Note, the PDP report identifies a small part of the site that is recorded on the LLUR as HAIL. This is unlikely to prevent the rezoning of the site to LLRZ. Providing the effects of the proposed development are mitigated by provision of onsite attenuation of SW, the site is capable of being rezoned to LLRZ. The flowpaths and existing drains need to be protected - and these should be identified on the ODP.
69. Pattle Delmore & Partners Dec 2022 report advises that onsite attenuatiuon is able to be provided at 308 Cones Rd utilising a series of small check dams within a conveyance swale that is to be provided along the south part of the site, whilst PDP's 29 Sept 2023 report for 90 Dixons Rd (the larger parcel to the south of 308 Cones Rd) advises two SW attenuation basins (of indeterminate size) should be used to limit discharges offsite to predevelopment levels. Given the land area required by the conceptual attenuation basins sizes has not been determined by PDP, I am unable to comment on whether the areas shown for stormwater management/attenuation on the ODP will be sufficient. Given this, I recommend calculations to determine a conservative area needed for SW management be undertaken by PDP, and that the conservative area be allowed for on a revised OD. Alternatively, it could be noted on the ODP that the size and location of the SWMAs are indicative only.
70. Wastewater - Council staff have confirmed wastewater will need to be piped and discharge to the existing WDC network further south along Cones Rd where there is sufficient capacity for the proposed LLRZ land use.
71. Water - Water supply from existing supply is possible, and therefore rezoning to LLRZ can be provided with sufficient water supply.
72. The PDP report identifies a small part of the site that is recorded on the LLUR. This is unlikely to prevent the rezoning of the site to LLRZ. There are no significant geotechnical or natural hazards that would prevent to the proposed LLRZ land use.
73. The overland flow paths need to be properly protected to allow for conveyance. Suggest adding to ODP that sizing of SMAs is indicative only, and basins will require detailed design to confirm area required.

Submission 180 (Alistair Cameron) – 2 Auckland Street

74. Stormwater - WDC agree that there are no significant stormwater hazards/constraints at the site, and that the site is capable of being used for the proposed LLRZ zone.
75. Wastewater - WDC have confirmed that a new gravity network for the development draining to a new pump station that discharges to the WDC network on Cones Rd will need to be constructed. WDC should consider whether the pump and rising main to Cones Rd should be upsized to cater for other parts of the Ashley village to be connected to a

reticulated sewer. In summary, there is sufficient capacity within the WDC WW network to accept the discharge from the site if it is rezoned to LLRZ.

76. Water - There is an existing HDC restricted supply that serves the Ashley village. HDC have advised there is sufficient capacity for the proposed land use but, dependingh on the outcome of future modelling, local upgrades to the network may be needed. It is WDC's opinion that the site can be provided with water supply to the proposed LLRZ land use.

77. There are no significant geotechnical features that would prevent the site being zoned LLRZ.

Submission 299 (Crichton Group) – 145 & 167 Gladstone Road

78. Stormwater- I agree that there are no significant stormwater hazards/constraints at the site, and that the site is capable of being used for the proposed LLRZ zone.

79. Wastewater - I accept there will be sufficient capacity in the WDC WW network to accept the discharge from the LLRZ site, providing a low-pressure sewer system is provided by the applicant.

80. Water - I accept that a restricted water supply can be provided to supply the proposed LLRZ of this site, but that the supply to this site may bring forward the date at which the local network needs to be upgraded. The developer may need to lead this work.

81. There are no significant geotechnical hazards that would prevent the site being zoned LLRZ.

Submission 409 (McRae Land Company) – 409 Kintyre Lane

82. Stormwater - Large parts of the application area are subject to a medium flood hazard. The submission seeks to reduce the minimum lot size and allow for increased densification, but does not propose to increase the total number of lots. Intensification must not result in more than minor flooding effects to upstream and downstream properties. Given the nature of the site, I recommend any proposal to densify development rules be rejected as there should be no additional development allowed in areas of medium flood hazard. Clarify redistribution of density - if density is proposed to increase in the overland flow path areas this is not supported.

83. Wastewater - There is a pressure main in Mill Rd. Any wastewater from the development would need to discharge to the existing main. The total number of lots is not proposed to change from what is currently permitted under the ODP (81)

84. Water - there is a 125mm dia main along Mill Rd that would have sufficient capacity to supply the additional lots that would result from the proposed densification.

85. Large parts of the site are within an area of medium flood hazard. As per PDP NH-P4, development should not be allowed to occur in high flood hazard areas.

Submission 123 (Various) - Fawcetts Boundary

86. Stormwater - The Applicant's Proposed Outline Development Plan in Appendix 1 of their application identifies only the road alignment and the location of the Transpower High Voltage Lines. No provision has been made on the ODP for onsite stormwater management areas. E2 Environmental's report identifies there will need to be at least 5 stormwater attenuation basins to limit post development discharges to pre-development flow rates. The E2 report includes a concept scheme plan that identifies at least one of the SW attenuation areas will need to be located quite close to the existing dwelling on proposed Lot 16. This suggests to me that the ODP and the scheme plan do not make adequate provision for onsite stormwater management. While I agree that it will be

possible to attenuate stormwater onsite, I recommend an ODP be provided which makes adequate provision for the location and areas of the basins that will be needed to avoid stormwater runoff causing adverse effects to nearby and downstream properties. The size and location of the SWMAs shown on the ODP should be noted as indicative only.

87. Wastewater - Council staff have confirmed there is sufficient capacity in the existing network for water, wastewater and stormwater to service the proposed LLRZ zone. There is a pressure along Cones Rd that will have sufficient capacity to accept the flows from the LLRZ site. The developer will need to provide a main from the site to connect into the Cones Rd main.

88. Water - Council staff have confirmed there is sufficient capacity in the existing network for water, wastewater and stormwater to service the proposed LLRZ.

Submission 214 (Stokes) – 33 Gressons Road

89. Stormwater - There is a large overland flow path that crosses below the southern boundary of the site, into 1369 Main North Road. There is a small area of 33 Gressons Road affected by the overland flow at the southeast corner of the site. The Applicant's SW engineer, DLS, have not provided any calculations or modelling that demonstrate the effect of the proposed land use, nor to demonstrate how SW runoff from the site needs to be managed to avoid exacerbating the risk of inundation to existing properties. However, the stormwater runoff from this area should be able to be managed between the larger lot sizes. The proposed scheme plan by Eliot Sinclair shows two stormwater basins in the two areas where the overland flow path crosses the site; this is appropriate, but the ODP should note the sizing of the SMA will be subject to detailed design and may be larger than indicated on the ODP.

90. Wastewater - Council staff advised there are no existing services to the site, therefore, wastewater would need to connect to the existing services located at either Waikuku Beach or Ravenswood. WDC should consider whether it requires any developer-laid services to be upsized to allow for additional connections/capacity. This could be done at subdivision stage.

91. Water - Council staff advised that while there are no existing services to the site, water would need to connect to the existing services located at either Waikuku Beach or Ravenswood. WDC should consider whether it requires any developer-laid services to be upsized to allow for additional connections/capacity. Note there is a CDWSPZ in the area.

92. Providing the areas at high risk of subsidence/liquefaction are remediated as a condition of subdivision engineering approval, the remainder of the site is unlikely to be subject to significant hazards and can be suitable for the proposed LLRZ.

93. The 2021 Engeo report assessed a large area parcel of land that was located between Ravenswood and 33/81 Gressons Rd. The Engeo report included analysis of CPT data that indicates various parts of the site have a high risk of earthquake-induced liquefaction and consolidation settlement occurring to the soft loose soils under static conditions. Engeo proposed that these conditions can be addressed at time of subdivision, and therefore do not prevent the proposed residential land use. In relation to the mitigation of these risks, I agree with ENGEO that works can be undertaken to mitigate the risk of liquefaction and subsidence.

94. 33 Gressons Road is largely located outside the overland flow path, with SMAs proposed in the two areas where the flow path does cross the site.

95. Note groundwater is quite shallow at 1m bgl in winter conditions, and surface soils have low permeability, and therefore it is unlikely SW will be able to be disposed by way of rapid soakage into ground. This may require more stormwater infrastructure than shown on the scheme plan. The DLS report does not provide the results of any modelling or stormwater calculations that demonstrate the effects of the proposed LLRZ and the SWMA's on the surrounding environment.