Officers Report

Appendix 6

T and T Geotechnical Technical Report

Technical Experts Report on Amendments Sought Through Submissions

Date	21 March 2016
From	Michael Eden Jacka
Subject	Geotechnical engineering

Qualifications and experience

1. My full name is Michael Eden Jacka. I am a Senior Geotechnical Engineer and Principal at Tonkin & Taylor Ltd (T+T), an environmental and engineering consultancy.

2. I hold a BE (Hons) and ME (Dist) from the University of Canterbury. I have been employed with Tonkin & Taylor since 2000, primarily specialising in earthquake geotechnical engineering. I am a member of the NZ Geotechnical Society. I was awarded the Queen's Service Medal in the 2013 New Year Honours for services as a geotechnical engineer.

3. I have been extensively involved with geotechnical aspects of the Canterbury Earthquake recovery since September 2010. I have provided geotechnical advice to assist CERA with red and green zone decisions and EQC with land damage assessment and repair. I am a member of the Engineering Advisory Group convened by MBIE to develop residential foundation guidance, and the project team convened by ECan for review of liquefaction hazard in eastern Canterbury. However, this report is my personal professional opinion and does not represent the position of any of the organisations listed above.

4. I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note (updated 1 December 2014) and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Summary of submissions

5. I have read all submissions where WDC staff have identified that the submission includes geotechnical engineering matters. The geotechnical aspects of these submissions are summarised below.

6. The Crown:

    a. The submission seeks further information regarding residential development options, and suggests it would be premature to discount these options at this stage of the process (Para 3.4).

    b. The submission suggests that all areas identified for rural use should include allowance for rural-residential use, to provide future flexibility (Para 3.5).

    c. The submission notes that when considering vesting of red zone land, the Crown will need an understanding of the land's holding/market value to facilitate the necessary government processes (Para 3.6 – 3.7).

7. Michael de Hamel:

    a. The submission queries whether rising sea levels will impact the adjacent green zone public spaces not protected by stopbanks, in particular Murphy Park and Askeaton Reserve (Para 3).

    b. The submission notes that there are existing land forms in some parts of the red zone, such as sand dunes east of Jones St (Para 4).

    c. The submission suggests that a tertiary education institute could be a suitable use for a large block of red zone land, and that the scale of these buildings would mean that foundation and flood protection works could be cost-effective (Para 6).

8. J & L Meyer:

    a. The submission suggests that the stormwater pond proposed in the vicinity of Beswick St be moved to the far east end of Sewell St.

9. Claudia Kaltenstadler:

    a. The submission suggests that alternative residential development options could consider the option of floating foundation systems which prevent the house from flooding and is easily removable. Kaiapoi West and Kaiapoi East are identified as potential locations for this option.

    b. The submission suggests that heavy industrial land use would be unsuitable in the Kaiapoi South area due to geotechnical and flooding constraints (plus other non-engineering reasons).

10. Sangki Song:

    a. The submission suggests that some areas in Kaiapoi South and Kaiapoi East could be suitable for development, because it may be “much better than some TC3 land”.

11. Mark Revis:

    a. The submission suggests that high-density residential development would be a much more economical option for Kaiapoi West, South and East than the urban-residential scenario assessed to date with larger section sizes.

12. Andrew Wenborn:

    a. The submission suggests that 2 – 4 level mixed-use buildings could be considered, particularly in the Kaiapoi South area, and that this form of development may be of sufficiently high value to make the required land improvement and foundation works cost-effective.

Technical discussion

13. I have considered the geotechnical matters relating to these submissions. My comments are summarised below as they relate to each submission, using the bullet points from my summary above.

14. The Crown:

    a. The assessment undertaken by T+T to date indicates that residential development is likely to be feasible from an engineering perspective in some (or potentially all) of the Kaiapoi red zone areas. However, significant cost may be incurred in managing the significant technical constraints, and there is potential for effects on neighbouring areas from the works.

       Given the early stage of conceptual design and the limited information available, there is considerable uncertainty in the estimate of these costs and potential effects. The T+T Stage 1 report [(1)] represents this uncertainty with the use of optimistic, most likely, and pessimistic cost estimates.

       The report also identifies the most significant uncertainties for the development scenarios considered in each red zone area, and summarises these in the "Next steps" sections of the report along with options for further work that may provide greater certainty on these matters.

       The intent of this approach was to enable recovery planning to proceed with confidence in locations where the information was clear-cut (e.g. where even optimistic cost estimates were assessed as being not economic), while allowing further refinement over time in areas where the recovery plan identified potential opportunities.

    b. The assessment undertaken by T+T to date indicates that rural-residential development is likely to be feasible from an engineering perspective in some (or potentially all) of the Kaiapoi red zone areas. As discussed above, there is potential for significant cost and effects on neighbouring areas (although likely to be less than for the urban–residential scenario), and there is considerable uncertainty at this time.

       There do not appear to be any obvious geotechnical engineering reasons why areas identified for rural use should not include allowance for rural-residential use, provided that there are rules put in place to ensure appropriate engineering design and mitigation of effects on neighbouring areas.

(1) "Kaiapoi Red Zones Engineering Feasibility of Potential Land Uses - Stage 1 Report", report prepared by Tonkin + Taylor for Waimakariri District Council, January 2016, Ref:52082.030.v3.

c. The residential and commercial development cost estimates presented in the T+T Stage 1 report may help to inform an assessment of the land's market value. As noted above there is considerable uncertainty in these assessments, however options for further work have been identified that may help to reduce this uncertainty.

   While some of this further work may be required regardless of the future use selected (e.g. assessment of ground contamination), other items of work would only be required for more intensive development options (e.g. confirming ground improvement details). The cost of some of these further work items may be significant. It therefore appears that there will need to be a careful balance found when undertaking further work to better understand the value of potential vested land, to ensure that the cost and detail of this work is proportionate to the final use of the land and also suitable to inform government processes.

15. Michael de Hamel:

   a. The average ground elevation at Murphy Park is approximately 0.7m above Mean High Water Springs (MHWS), and most of the land across the park is within 0.2m of this average level. This suggests that the edges of the park could start to be impacted by the tide following 0.5m sea level rise, with the majority of the park impacted following 0.9m sea level rise.

      The average ground elevation in the boat ramp carpark at Askeaton Reserve is approximately equal to MHWS, and most of the land across the carpark is within 0.1m of this average level. This suggests that even a small rise in sea level could result in regular tidal flooding of the carpark, and with 1m sea level rise the carpark could be underwater for slightly less than half of the tidal cycle.

      In addition to the regular tidal flooding discussed above (i.e. twice a day), these areas could also be flooded during large storm events which caused a storm surge (e.g. a 50 year or 200 year storm). Flooding due to storm surge could occur even at current sea levels, but would become more frequent and severe with sea level rise and climate change in future.

   b. The existing landform has been incorporated to some extent into the engineering feasibility assessment undertaken by T+T. For example, where practical there was a preference to locate stormwater ponds on the lower-lying ground (for efficient drainage to the ponds) and buildings on the higher ground (to reduce the thickness of fill required).

      However, even the locally higher ground within the red zone is still somewhat lower than the land levels likely to be necessary to manage flood risk. For example the elevation of the higher ground east of Jones St is typically between 0.8 and 1.2m above MHWS, while the land level necessary for flood management is 1.2m above MHWS for the "most likely" design scenario, or 1.6m above MHWS for the "pessimistic" scenario.

c. I have not undertaken an engineering feasibility assessment for construction of large buildings such as a tertiary institute on the Kaiapoi red zone land. However, my initial impression is that this may be possible (from an engineering perspective) in some locations, provided that large-scale ground improvement works and specialised foundations are used.

   I agree that these works are likely to be more cost-effective for a high-value development than for typical residential dwellings. However, it would not possible to determine whether this option is technically and economically viable unless a more detailed assessment was undertaken.

16. J & L Meyer:

    a. The currently proposed location of the stormwater pond in the vicinity of Beswick St is favourable from an engineering perspective, as it is lower-lying than the surrounding land (for efficient drainage to the ponds). The area at the far east end of Sewell St is also favourable from a ground elevation perspective, however this area experienced significant lateral spreading during the Canterbury earthquakes.

       This means that relocating the stormwater pond from Beswick St to Sewell St would increase the likelihood and severity of damage to the pond and associated infrastructure in a large earthquake. However, it may be possible to design the works to reduce these consequences (at some additional cost). Alternatively, it may be possible to accept the risk of damage and have a contingency plan for repair of the ponds should they be damaged in future.

17. Claudia Kaltenstadler:

    a. The T+T Stage 1 report presents several alternative approaches for residential building on liquefaction and flood prone land. As discussed further in the T+T report, one of the main challenges with alternative approaches is that it is still necessary to comply with the Building Act and Resource Management Act.

       I am not familiar with the specific details of the floating foundation system referred to in the submission. It is possible that it might be a technically feasible option, provided it is able to meet Building Consent and Resource Consent requirements. If this option was to be investigated further, then consideration should be given to matters such as economic analysis, market demand, ability to secure insurance and finance, and infrastructure provision.

    b. In my opinion, from an engineering perspective, it is likely that the geotechnical and flooding constraints in the Kaiapoi South red zone area could be addressed sufficiently to allow heavy industrial or commercial land use if this was desired. As with the other development scenarios presented in the T+T Stage 1 report, there would likely be significant cost involved in managing these constraints, and the potential for effects on neighbouring areas – so industrial land use might not necessarily be economically viable or consentable.

18. Sangki Song:

    a. I have assessed the observed performance of the land during the Canterbury earthquakes and analysed the available subsurface geotechnical data. Based on this assessment, it is my opinion that the red zone land in Kaiapoi South and Kaiapoi East, in its current condition, would not be suitable to adequately support a TC3-type residential foundation (i.e. it is not "similar to TC3 condition").

       As detailed in the T+T Stage 1 report, making this land suitable for residential development would require area-wide engineering works to meet foundation and flood level requirements. Alternatively, in some areas it may be possible to implement specialised alternative foundation systems – but these would need to be more robust than typical TC3 foundations. Either of these options for residential development are likely to be feasible from an engineering perspective, however this work may be costly and there is potential for effects on neighbouring areas.

19. Mark Revis:

    a. The urban-residential development scenario considered in the T+T Stage 1 report assumed the same residential density as was present before the earthquakes, where lot sizes were typically about 650m^2. This assumption was intended to keep demand on infrastructure approximately the same as before the earthquakes, and to re-use the existing road layout.

       Apart from these potential efficiencies, there are no significant engineering factors governing the choice of residential lot size, so smaller lots are likely to be feasible from an engineering perspective. The urban-residential cost estimates presented in the T+T Stage 1 report assume that the land is raised and strengthened across the entire residential area. This means that houses could be built anywhere across the area, on any size of lot. So as suggested in the submission, it would be possible to spread the cost over a greater number of smaller properties, reducing the per-lot cost.

       However, there are some limitations related to the land improvement approach assumed for the cost estimates. The land improvement works are intended to be sufficient to allow a typical single-level "brick and tile" dwelling to be constructed on a TC2 waffle slab foundation. Two-level dwellings would likely be limited to lightweight construction (e.g. weatherboard cladding and steel roof), or would require more robust foundations. The land improvement works assumed in the current cost estimates would likely not be sufficient for terrace-type blocks of houses or dwellings higher than 2 levels.

       These land improvement limitations may impose constraints for some of the details of high-density development, but it appears likely that these constraints could be managed (at some additional cost). Alternatively, a higher standard of land improvement could be specified to better meet the requirements for high-density development. Careful assessment of infrastructure provision would also be required, particularly stormwater management, wastewater disposal, and road network

capacity.

If this option was to be investigated further, then consideration should be given to matters such as foundation requirements, economic analysis, market demand and infrastructure provision.

20. Andrew Wenborn:

    a. As discussed in Paragraph 19 above, the residential and commercial development cost estimates presented in the T+T Stage 1 report are based on a land improvement approach that would be suitable only for certain types of building. The land improvement concepts assumed to date would not be sufficient for 3 – 4 level buildings.

    I have not undertaken an engineering feasibility assessment for construction of 3 – 4 level buildings on the Kaiapoi red zone land. However, my initial impression is that this may be possible (from an engineering perspective) in some locations, provided that large-scale ground improvement works and specialised foundations are used.

    I agree that these works are likely to be more cost-effective for a high-value high-occupancy building than for typical residential dwellings. Also, large-scale ground improvement works at the river's edge for the foundations of these buildings could provide some protection against lateral spreading for areas further inland, potentially reducing foundation requirements for other buildings. However, as noted in the submission, it would not possible to determine whether this option is technically and economically viable unless a more detailed assessment was undertaken.

21. Memorial Garden:

    a. I have been asked to comment on geotechnical matters relating to the proposed Memorial Garden. The initial preliminary draft recovery plan proposed that a Memorial Garden be located in the vicinity of Gray Cres / Blackwell Cres. I understand that the proposed location has now changed to the vicinity of Cass St / Jollie St.

    b. Both of these locations are prone to high groundwater levels, flooding and liquefaction, as detailed below. These constraints are not unique to these locations - similar conditions exist across most of the Waimakariri District red zone land.

        i. Groundwater levels fluctuate throughout the seasons and from year to year. Monitoring data collected over the past four years shows an average depth to groundwater of about 0.6 – 0.8m for both locations, but this level has regularly risen to within 0.4m of the surface, and has sometimes risen as high as 0.1m below the surface. Future sea level rise may result in higher water levels in the river, which could cause the groundwater level to rise to the ground surface and pond (assuming the ground is not raised significantly as part of the Memorial Garden construction work).

ii. Floodwater depths of 1m or more are predicted in the WDC flood model for this area (200 year flood with sea level rise and climate change), with significant depth of flooding (several hundreds of mm) likely to occur even in more commonplace flood events.

iii. Both the locations are susceptible to severe land damage due to liquefaction in large earthquakes – such as ejection of sand and water, ground cracking, ground settlement and flotation of buried structures. Additionally, the Cass St / Jollie St area is also prone to major lateral spreading, resulting in more severe ground cracking.

c. The proposed Memorial Garden would need to be carefully designed to manage these constraints. The key design considerations would likely include the following:

i. Because of the high groundwater levels, subsoil drainage measures may be needed to avoid amenity issues due to boggy ground.

ii. The details of ashes burial would need to be carefully considered, to avoid buoyancy issues in the event of high groundwater, flooding, or liquefaction. There are a range of design concepts that may be suitable to manage this issue, for example:

- A heavy weight (such as concrete or steel) could be incorporated into the base of the burial box.
- An underground footing could be constructed, and the burial box fastened down onto the footing.
- Ashes could be held in above-ground structures.

iii. Excavating holes below groundwater level is likely to be difficult, due to the tendency for the natural sandy soil to collapse and flow into the hole. The Memorial Garden operators would need to develop a methodology to efficiently excavate in these ground conditions. This might require temporary casing and/or dewatering. Alternatively, a thin layer of fill material (several hundred mm thick) could be placed across the site during construction, carefully selected and compacted so it remains stable during excavation.

iv. Lateral spreading during a large earthquake could result in damage to structures such as footpaths, fences and pipelines. It may be possible to design these elements to be more robust and readily-repairable, but it is unlikely to be practical to design them to be undamaged after a large earthquake.

Technical recommendation / conclusion

22. Based on the technical analysis summarised above, I make the following recommendations:

23. The suggestion that rural-residential use be allowed for in areas currently identified for rural use appears to be feasible from a geotechnical perspective. I recommend that the technical experts and other parties involved in the plan process be consulted regarding this option. If this option is implemented, then I recommend that rules be included to ensure appropriate engineering design and mitigation of effects on neighbouring areas.

24. Land on the river side of the stopbank (such as Murphy Park and the boat ramp carpark at Askeaton Reserve) is likely to become influenced by tidal flooding due to sea level rise in future. I recommend that the plan take account of this as appropriate when considering future land use in these areas.

25. My initial impression is that it may be possible (from an engineering perspective) to build larger, higher-value buildings (e.g. tertiary institute or 3 – 4 level mixed-used buildings) in some locations, provided that large-scale ground improvement works and specialised foundations are used. However, it would not be possible to determine whether this option is technically and economically viable unless a more detailed assessment was undertaken. I recommend that the technical experts and other parties involved in the plan process be consulted regarding this option.

26. The suggested alternative location for the stormwater pond, at the far east end of Sewell St, may be feasible from a geotechnical perspective. This location presents more challenging ground conditions than the currently identified location in Beswick St. However, it is possible that these challenges may be outweighed by other benefits. I recommend that the technical experts and other parties involved in the plan process be consulted regarding this option.

27. High-density residential development appears to be feasible from a geotechnical perspective. However, it would not be possible to determine whether this option is technically and economically viable unless a more detailed assessment was undertaken. I recommend that the technical experts and other parties involved in the plan process be consulted regarding this option.