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31 DECEMBER 2011

SITE SEISMICITY

Active faults mapped and regional seismicity from the recent earthquakes, which have damaged Christchurch and its environs, is discussed in this Appendix.

The eleven closest active faults included in the Institute of Geological and Nuclear Sciences Active Faults Database are shown in Table C.1. Refer to Fig C.1 for fault locations. The database quotes no recurrence intervals for seven of the eleven faults and, as a result, their relative activity is unknown. The database indicated recurrence intervals of less than 2,000 years for two faults and between 2,000 and 3,500 years for one fault. The recurrence interval of the Greendale Fault is reported as being 10,000 to 20,000 years.

Table C.1 – Closest Active Faults

No.	Fault Name	Distance from Pond (km)	Recurrence Interval
1	Cust	9	Not specified
2	Hororata	13	Not specified
3	Ashley Gorge	13	Not specified
4	High Peak	14	Not specified
5	Coopers Creek	18	2,000
6	Springbank	20	Not specified
7	Townshend	21	Not specified
8	Ashley	22	2,000 – 3,500
9	Greendale	23	10,000 – 20,000
10	Porters Pass	24	2,000
11	Joyces Stream	26	Not specified

The Christchurch Geologic Map¹² also shows the approximate location of Racecourse Hill Anticline which is mapped as an active fold. The northern tip along the north side of Waimakariri River is approximately 2.8 km southeast of the proposed ponds as shown in Fig C.2.

The Greendale Fault is the source of the 4 September 2010 Darfield $M_w = 7.1$ earthquake (Cubrinovski, et al 2011¹³) and the Port Hills fault (not shown on Fig C.1) is the source of the

¹² Forsyth, P.J.; Barrell, D.J.A.; Jongens, R. (compilers) 2008: Geology of the Christchurch area: scale 1:250,000. GNS Science

¹³ Cubrinovski, M., Bradley, B., Wotherspoon, L., Green, R., Bray, J., Wood, C., Pender, M., Allen, J., Bradshaw, A., Rix, G., Taylor, M., Robinson, K., Henderson, D., Giorgini, S., Ma, K., Winkley, A., Zupan, J., O'Rourke, T., DePascale, G. and Wells, D. (2011) Geotechnical Aspects of the 22 February 2011 Christchurch earthquake. Bulletin of the New Zealand Society of Earthquake Engineering 44(4): 205-226

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NO ALTERATIONS

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22 February 2011 Christchurch $M_w = 6.2$ earthquake are shown as yellow dashed lines on Fig C.3 along with respective aftershocks recorded by magnitude. There are recent efforts by GNS and the University of Canterbury to better characterize the seismic hazards associated with these two faults (GNS Media Release 3 June 2011).

The Waimakariri Irrigation Ponds project site lies within Canterbury region which experienced aftershocks of $M_w > 3$ from these two earthquakes. The peak ground shaking associated with the main and aftershocks at the project site was estimated from Geonet ground motions database recorded at the Darfield High School station located approximately 14 km south of the site and Oxford station located 13.4 km east of the site. For the Darfield earthquake ($M_w = 7.1$), the a peak horizontal ground acceleration (PGA) of 0.50 g and 0.16 g were recorded at the Darfield High School and Oxford stations, respectively. Aftershocks with a Modified Mercalli Intensity (MI) of 4 to 6 had recorded horizontal ground accelerations of 0.12 g or less at the Darfield High School station and less than 0.04 g at the Oxford station. The PGA and aftershock ground motions from the Christchurch earthquake are lower than those from the Darfield earthquake with a PGA of 0.07 and 0.09g, at the respective recording stations.

The existing buffer storage pond embankments located adjacent to the proposed Waimakariri Irrigation storage ponds performed well during the recent seismic activity in the Canterbury Region. The existing buffer pond embankments are approximately 4 m in height, with a maximum water level at 223.00 RL for a total freeboard of 1 m.

For the stop banks along the Waimakariri River, approximately ~4 km of the ~17 km of levees were reported damaged primarily downstream of State Highway 1 near the mouth of the river in the city of Kaiapoi (Cubrinovski, et al. 2010¹⁴; Cubrinovski, et al. 2011¹⁵). The Waimakariri levee embankments are approximately 3 to 5 m in height with upstream and downstream slopes of 3H: 1V. Damage occurred where embankments were founded on loose saturated fluvial sandy deposits, which is of different foundation conditions than those of the project site.

¹⁴ Cubrinovski, M., Green, R.A., Allen, J., Ashford, S., Bowman, E., Bradley, B., Cox, B., Hutchinson, T., Kavazanjian, E., Orense, R., Pender, M., Quigley, M. and Wotherspoon, L. (2010) Geotechnical Reconnaissance of the 2010 Darfield (Canterbury) Earthquake. Bulletin of the New Zealand Society for Earthquake Engineering 43(4): 243-320.

¹⁵ Cubrinovski, M., Green, R.A., Wotherspoon, L. (2011) Geotechnical Reconnaissance of the 2011 Christchurch, New Zealand Earthquake. [Online] Available: <http://www.geerassociation.org/>

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Damage from strong ground shaking to the proposed pond embankments is discussed further in Sections 7.8 and 7.9 of the Design Report.

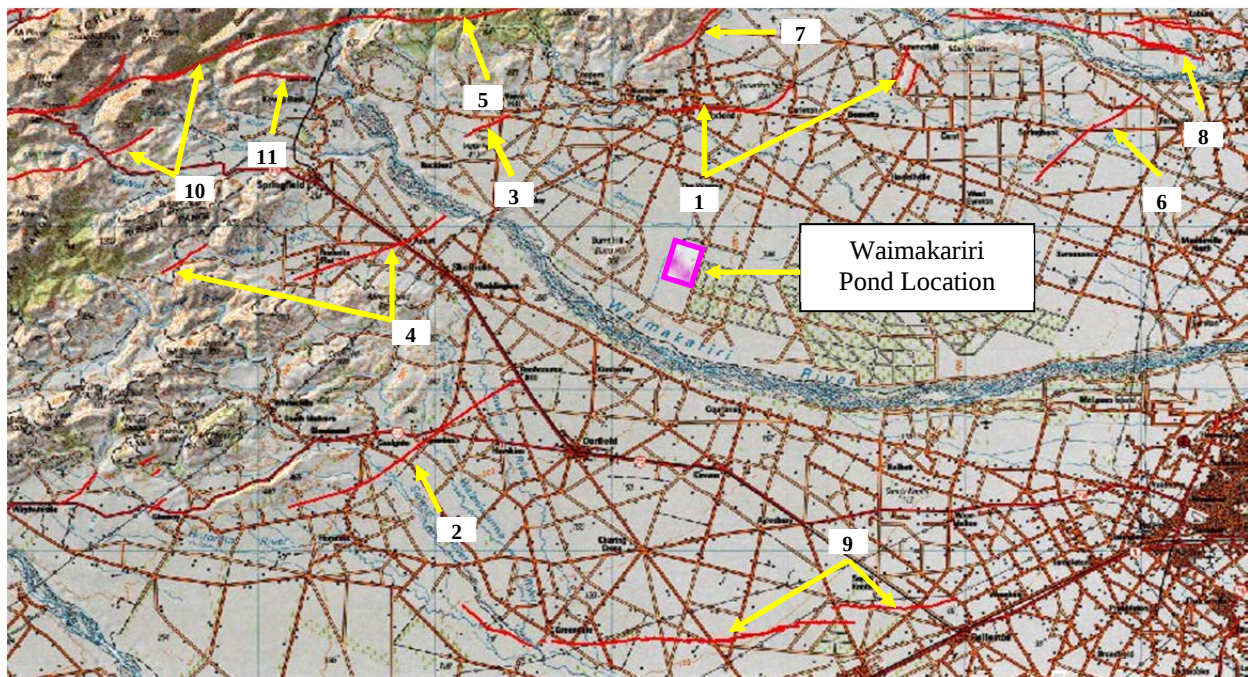


Fig C.1 – Fault Location Plan

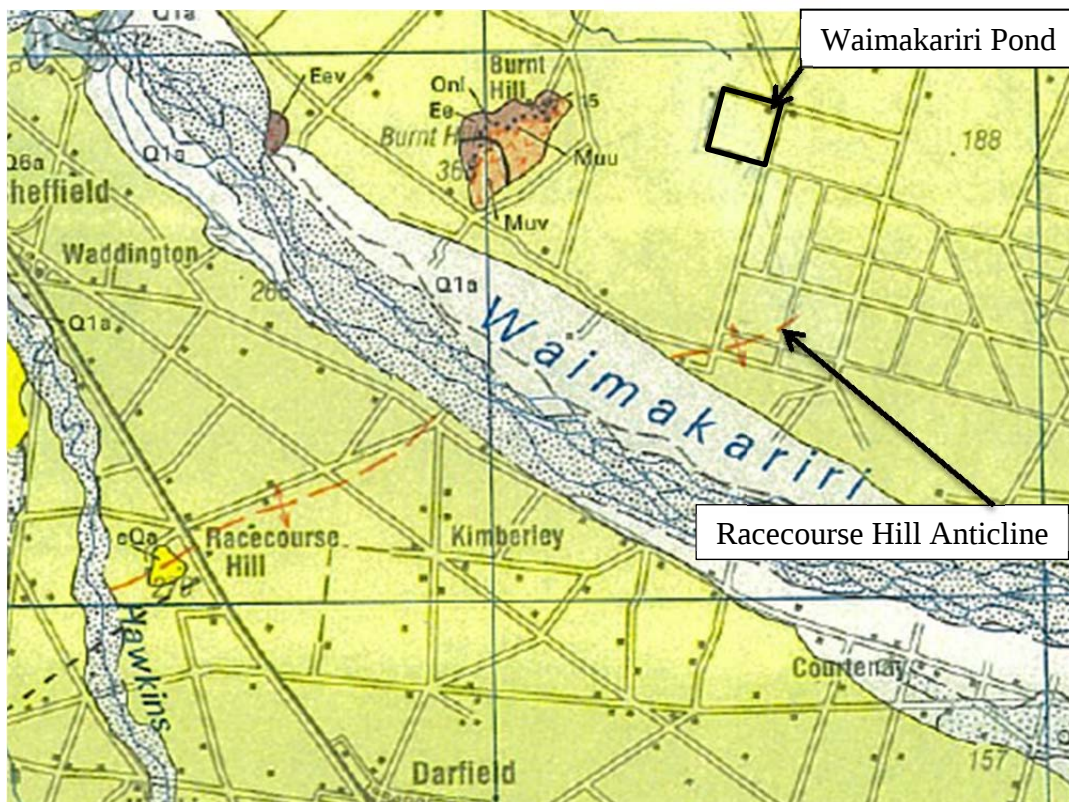


Fig C.2 – Christchurch Geologic Map (GNS 2008)

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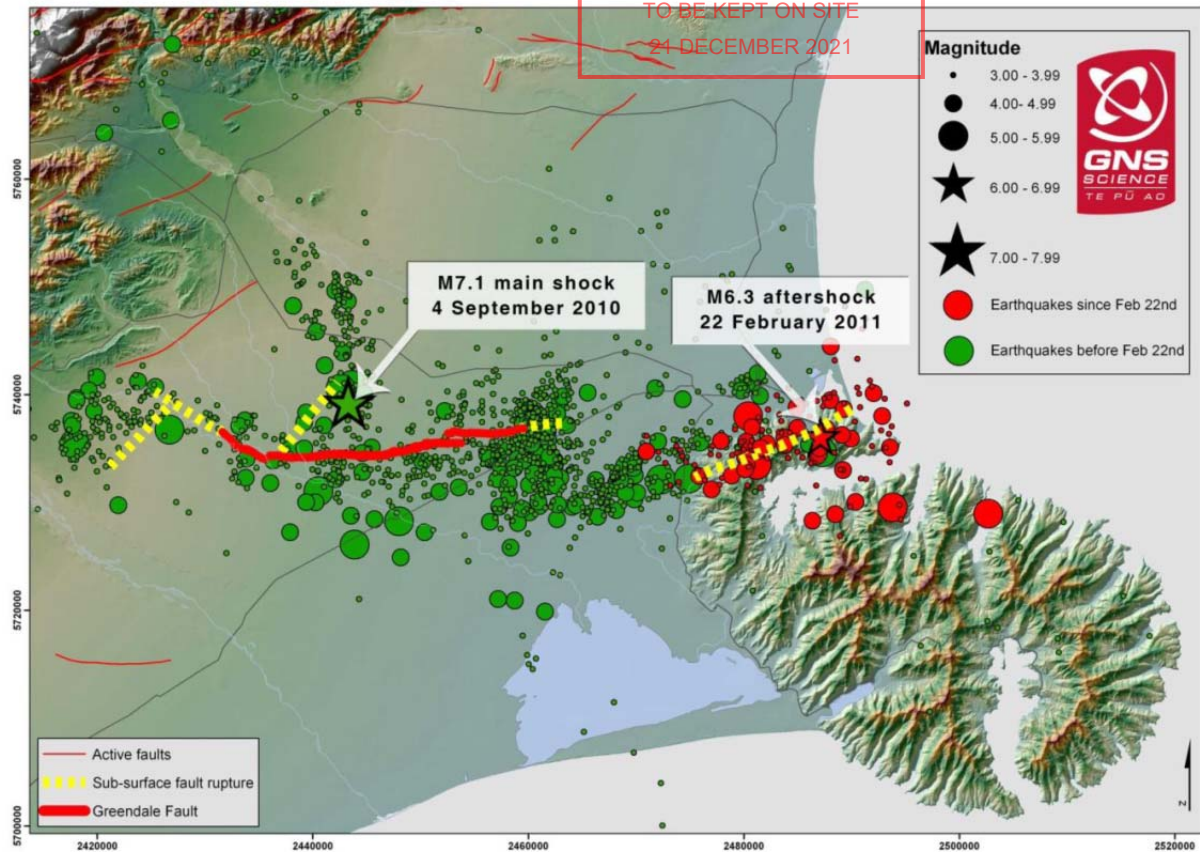


Fig C.3 – Location of main shock, aftershocks $M_w > 3$, and fault ruptures in Canterbury region relative to project site (after Allen et al 2011).