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Table A.1 Radiocarbon dates used in this thesis, including Potassium Argon (P/A) and Zircon Fission Track (ZFTA) dates for the Rotoehu and Rangitawa Tephras, respectively. Radiocarbon dates on samples collected in this study are underlined.

Number	Date in years B.P	Formation	Reference	Significance
Wk-2097	Post modern	Onetapu Formation	*Hodgson (this study)*	*Date on wood from within Onm providing an age for this lahar deposit, and a maximum age for members Onn and Ono.*
NZ7388	390 ± 55	Onetapu Formation	*Donoghue (1991)*	*Date on peat overlying Onl, providing a minimum age for this lahar deposit.*
NZ1363	407 ± 56	Onetapu Formation	*Campbell (1973)*	*Date on wood in a palaeosol developed into Onh, providing a minimum age for this lahar deposit and a maximum age for overlying member Onj.*
NZ7465	450 ± 55	Onetapu Formation	*Donoghue (1991)*	*Date on wood from within Onj providing an age for this lahar deposit.*
Wk-1487	500 ± 70	Makahikatoa Sands	*Purves (1990)*	*Date on charcoal from within Makahikatoa Sands overlying Onj supports a c. 460 year B.P. age for this member.*
Wk-2680	570 ± 45	Onetapu Formation	*Hodgson (this study)*	*Date on wood in palaeosol developed in silts underlying Onh, providing a maximum age for this lahar deposit.*
Wk-1488	660 ± 50	Tufa Trig Formation	*Donoghue (1991)*	*Date on peat overlying Tufa Trig Formation tephra underlying Onh, providing a maxmum age for this lahar deposit.*
NZ1684	766 ± 56	Onetapu Formation	*Campbell (1973)*	*Date on wood in palaeosol developed into Ong, providing a minimum age for Ong, and a maximum age for overlying member Onh.*
Wk-2098	890 ± 40	Onetapu Formation	*Hodgson (this study)*	*Date on wood in soil overlying Ond providing a minimum age for this lahar deposit and a maximum age for overlying member One.*
$\bar{41}$ dates	1,850 ± 10	Taupo Ignimbrite	*Froggatt and Lowe (1990)*	*Taupo Ignimbrite underlies, and thus provides a maximum date for the Onetapu Formation in this study.*
$\bar{17}$ dates	3,280 ± 20	Waimihia Tephra	*Froggatt and Lowe (1990)*	*Waimihia Tephra overlies and provides a minimum age for the Mangaio and Manutahi Formations (Donoghue, 1991).*
NZ7729	4,600 ± 100	Mangaio Formation	*Donoghue (1991)*	*Date on wood from within and providing a date for the Mangaio Formation.*
NZ7632	4,850 ± 90	Mangaio Formation	*Donoghue (1991)*	*Date on peat underlying and providing a maximum date for the Mangaio Formation.*
NZ3951	5,370 ± 90	Motutere Tephra		*Motutere Tephra overlies and provides a minimum age for the Tangatu Formation.*
Wk-1773	7,800 ± 70	Tangatu Formation	*Hodgson (this study)*	*Wood sampled from trees presumed engulfed during emplacement of Tangatu Formation, and thus dating the continued accumulation of the Formation c. 7,800 years B.P.*
NZ716	14,700 ± 110	Rerewhakaaitu Tephra	*Froggatt and Lowe (1990)*	*Rerewhakaaitu Tephra is found between underlying Te Heuheu and overlying Tangatu Formation Formations (Donoghue, 1991) and provides a minimum age for Te Heuheu and a maximum age for Tangatu Formation deposits*
$\bar{4}$ dates	22,590 ± 230	Kawakawa Tephra	*Wilson et al (1988)*	*Kawakawa Tephra provides a persistent time plane in the regional geology of this study.*
Wk-2681	37,030 ± 730	Mangatipona pumice sand	*Hodgson (this study)*	*Charcoal sampled from within and provides a date for, the Mangatipona pumice sand.*
$\bar{3}$ dates		Omataroa Tephra	*Froggatt and Lowe (1990)*	*Omataroa Tephra overlies and provides a minimum age for Kaitieke tephra. It also provides a new minimum age for Ratan loess.*
(P/A)	64,000 ± 4,000	Rotoehu Tephra	*Wilson et al (1992)*	*Rotoehu Tephra underlies and provides a maximum age for Kaitieke Tephra, and a minimum age for Mangawhorawhora, Rangiahu and Rangiwhaia tephras. It also provides a new minimum age for Porewan loess.*
(ZFTA)	350,000 ± 40,000	Rangitawa Tephra	*Kohn et al (1992)*	*In this study Rangitawa Tephra is one geological indicator used to define the lower boundary of the late Quaternary*

Table A.2 Results of quantitative analysis of coverbeds at Site WF5, 0.2-2.5 m).

Sample Depth	% rhyolite glass		Quantitative XRD analysis														
	250-125 μ	125-63 μ	qtz	L.A.	qtz/ L.A.	% qtz 1	qtz	L.A.	qtz/ L.A.	% qtz 2	qtz	L.A.	qtz/ L.A.	% qtz 3	mean	SD	CV
20	*	4.5	6150	18015	0.34	4.75	4595	13045	0.35	4.95	4935	17880	0.28	3.68	4.42	0.75	18.94
35	*	5.7	5680	17835	0.32	4.34	3200	13365	0.24	2.90	4345	18300	0.24	2.87	3.37	0.84	24.87
45	*	8.7	4460	20945	0.21	2.42	6655	19380	0.34	4.79	6590	17710	0.37	5.31	4.17	1.54	36.84
55	*	10	6785	21430	0.32	4.30	6760	20705	0.33	4.48	7670	18825	0.41	5.95	4.91	0.90	18.39
65	*	12.7	7530	22840	0.33	4.64	7010	19270	0.36	5.16	6900	19770	0.35	4.89	4.86	0.31	6.37
75	*	8.7	9505	20455	0.46	6.99	10315	17440	0.59	9.29	9320	20305	0.46	6.89	7.72	1.36	17.59
85	*	10.5	12355	19550	0.63	10.02	9890	19730	0.50	7.65	12265	19760	0.62	9.82	9.18	1.31	14.33
95	*	8.5	11610	21045	0.55	8.57	14695	20000	0.73	11.89	10045	16250	0.62	9.77	10.07	1.68	16.68
105	*	8.2	16120	20735	0.78	12.66	18215	19615	0.93	15.40	15865	19900	0.80	13.02	13.69	1.49	10.88
115	*	8	12100	13945	0.87	14.30	15595	17765	0.88	14.48	18370	18430	1	16.84	15.14	1.30	8.59
125	*	13.2	13205	14710	0.90	14.84	18080	18345	0.99	16.43	16280	17825	0.91	15.12	15.46	0.85	5.50
135	*	30	12320	14455	0.85	14.02	12115	17720	0.68	10.96	15900	15540	1.02	17.11	14.03	3.08	21.94
145	*	40.7	13935	17370	0.80	13.11	7785	15075	0.52	7.93	18215	19420	0.84	15.57	12.20	3.90	31.97
155	*	58.2	6065	14445	0.42	8.18	8280	17595	0.38	5.01	5805	18845	0.31	4.21	5.13	0.99	19.27
163	*	72.5	6410	14225	0.45	8.73	5900	17585	0.34	4.65	5155	17430	0.30	3.93	5.10	1.48	28.58
170	5.5	3	17010	14590	1.17	19.70	19380	19975	0.97	18.15	19655	18740	1.05	17.58	17.81	1.79	10.02
180	3.2	1.8	15285	13520	1.13	19.08	13570	12865	1.05	17.88	19440	18380	1.08	17.73	18.18	0.78	4.30
190	8.2	5.2	8980	13880	0.72	11.82	9145	13770	0.68	10.80	18880	19245	0.98	18.35	12.88	3.07	23.85
205	8	8.2	9315	14735	0.63	10.03	11170	18410	0.61	9.58	17985	19150	0.94	16.57	11.72	3.34	28.53
215	5.5	8	14730	14325	1.03	17.21	18385	18700	0.98	18.37	18190	20250	0.90	13.08	16.55	2.18	14.11
238	10.7	8.5	18935	14820	1.30	22.05	18080	19835	0.91	14.89	15835	20735	0.78	12.41	18.48	4.98	30.27
250	17.5	18.8	8970	15235	0.48	8.88	9450	20815	0.48	8.87	9115	20015	0.48	8.82	8.86	0.03	0.41

Table A.3 Results of quantitative analysis of coverbeds at Site WF5, 2.5-4.55 m.

Sample Depth	% rhyolite glass		Quantitative ZRD analysis														
	250-125 μ	125-63 μ	qtz	L.A.	qtz/L.A.	% qtz 1	qtz	L.A.	qtz/ L.A.	% qtz 2	qtz	L.A.	qtz/L.A.	% qtz 3	mean	SD	CV
260	18.5	20.2	5985	13740	0.44	6.46	7930	17480	0.45	6.78	11015	19615	0.56	8.74	7.33	1.23	16.84
270	10.2	9	9300	15120	0.62	8.72	11325	20825	0.55	8.52	8530	19385	0.44	6.64	8.26	1.60	19.41
280	2.5	4.2	6335	15125	0.42	6.16	6925	18215	0.38	5.46	6485	20295	0.32	4.36	5.32	0.91	17.05
295	2	6.5	4845	18060	0.27	3.43	5725	19730	0.29	3.82	3935	19725	0.20	2.18	3.14	0.86	27.29
310	2.8	8	4105	19770	0.21	2.33	4460	19365	0.23	2.74	3875	20560	0.19	1.98	2.35	0.38	16.16
320	4.5	21	4090	13565	0.30	4.03	3415	19080	0.18	1.81	3450	19695	0.18	1.74	2.53	1.30	51.53
328	2	3.2	3005	23680	0.13	0.86	2495	21830	0.11	0.64	2355	20355	0.12	0.66	0.72	0.13	17.39
334	0.2	1.2	7865	15800	0.50	7.59	11525	19040	0.61	9.64	8825	18365	0.48	8.83	7.98	1.40	17.52
345	0	0.2	10200	16505	0.62	8.77	15775	18440	0.81	13.28	11160	22060	0.51	7.74	10.28	2.80	27.32
355	0.2	1.5	10820	14585	0.74	12	16675	22160	0.75	12.21	11020	18605	0.58	8.76	10.88	1.84	17.83
365	0.2	0.8	8320	17475	0.48	7.20	10805	17885	0.60	8.52	12435	20385	0.61	8.62	8.78	1.37	15.81
375	0.2	1	8850	14180	0.63	10.01	12190	17880	0.68	11.06	12620	20875	0.60	8.52	10.20	0.79	7.72
385	0.2	1	11085	14810	0.75	12.15	8320	18600	0.50	7.85	11785	18420	0.61	8.57	8.78	2.28	23.08
395	0.5	0.2	10765	15180	0.71	11.44	15075	20300	0.74	12.03	14700	18850	0.78	12.70	12.08	0.83	6.25
405	0.2	2	10015	14375	0.70	11.20	17280	18825	0.88	14.53	15795	19585	0.81	13.18	12.87	1.88	12.83
415	0	2	13100	14105	0.93	15.40	14885	17875	0.83	13.68	18000	19715	0.91	15.12	14.73	0.82	8.27
425	0	0.2	12385	15680	0.78	12.81	13515	19750	0.68	10.97	16370	16310	1	18.78	13.55	2.95	21.75
435	0	0	9830	14340	0.69	11.12	11520	18810	0.68	11.14	18780	21675	0.87	14.28	12.17	1.81	14.84
445	0.5	0	8950	14340	0.62	9.88	11280	29821	0.38	5.41	11570	20015	0.58	9.04	8.11	2.38	29.30
455	0.5	0	5785	14825	0.39	5.84	9115	18480	0.49	7.51	8390	21280	0.30	4.01	5.72	1.75	30.57

Table A.4 Results of quantitative analysis of coverbeds at Site WF5, 4.55-4.7 m.

Sample Depth	% rhyolite glass		Quantitative ZRD analysis														
	250-125 μ	125-63 μ	qtz	L.A.	qtz/ L.A.	% qtz 1	qtz	L.A.	qtz/ L.A.	% qtz 2	qtz	L.A.	qtz/ L.A.	% qtz 3	mean	SD	CV
485	0.2	0.5	5960	14900	0.40	5.82	6420	19695	0.33	4.47	4325	19250	0.22	2.64	4.31	1.80	37.04
475	0.2	0	4340	15190	0.29	3.74	5730	20725	0.28	3.58	5070	17175	0.30	3.92	3.75	0.17	4.53
485	0.5	0.4	4620	15130	0.31	4.10	4005	17140	0.23	2.80	5200	20075	0.26	3.26	3.39	0.86	19.48
495	0.2	0.2	3800	14405	0.26	3.35	5785	18600	0.31	4.20	6080	21110	0.29	3.79	3.78	0.43	11.33
505	0	0.2	5885	14380	0.41	5.98	6820	19180	0.36	5.02	9575	17780	0.54	8.33	6.44	1.70	26.42
517	0	0.5	15160	13170	1.15	19.43	23920	19625	1.22	20.66	25105	16405	1.53	26.31	22.14	3.67	16.57
527	0	0.5	14595	14455	1.01	16.87	19935	19875	1.01	16.93	20655	19760	1.05	17.52	17.11	0.38	2.08
535	0.2	0.2	15105	13650	1.11	18.63	21870	18220	1.20	20.33	23475	16950	1.38	23.67	20.88	2.57	12.30
547	0	0	3420	14210	0.24	2.93	5070	16560	0.31	4.11	3340	18580	0.18	1.82	2.95	1.15	38.79
555	0.2	0.2	15835	13445	1.18	19.92	21640	19615	1.10	18.57	21010	19045	1.10	18.56	19.02	0.78	4.10
570	0	0.2	17790	14270	1.25	21.17	24635	18705	1.32	22.44	28630	20225	1.42	24.23	22.61	1.54	6.80

Table A.5 Results of quantitative analysis of coverbeds at Site WF6.

Sample depth	% rhyolite glass 125-63 μ	Quantitative XRD														
		qtz	L.A.	qtz/L.A	%qtz1	qtz	L.A.	qtz/L.A.	%qtz2	qtz	L.A.	qtz/L.A.	%qtz3	mean	SD	CV
19	0.6	17655	11250	1.58	28.86	21555	17945	1.20	20.34	17335	18845	1.03	17.22	21.47	4.92	22.89
31	15.6	6210	12515	0.50	7.58	8360	17115	0.49	7.42	7765	18265	0.43	6.27	7.08	0.71	9.99
45	0.8	4200	13035	0.32	4.41	3545	16890	0.21	2.37	3160	19200	0.16	1.55	2.77	1.47	53.04
55	0.6	3950	13760	0.29	3.77	5900	17295	0.34	4.75	8150	19105	0.32	4.40	4.31	0.50	11.54
65	0.2	3370	13820	0.24	2.98	3340	15315	0.22	2.52	5930	18645	0.32	4.33	3.28	0.94	28.71
75	0	3185	12245	0.26	3.26	5190	15205	0.34	4.75	7125	18585	0.38	5.52	4.52	1.14	25.22
85	0	4700	12860	0.37	5.19	4345	17255	0.25	3.13	4130	17085	0.24	2.95	3.76	1.24	33.12
92	0	2595	12425	0.21	2.35	3790	18585	0.20	2.26	3985	17715	0.22	2.84	2.42	0.20	8.25
108	0.2	3080	12930	0.24	2.88	5395	16390	0.33	4.53	5175	17995	0.29	3.78	3.73	0.83	22.13
122	0.8	2325	13385	0.17	1.71	3980	15195	0.26	3.31	3860	18805	0.21	2.28	2.44	0.81	33.26
132	1.2	2625	13725	0.19	2.03	2250	19025	0.12	0.71	3300	19505	0.17	1.63	1.46	0.68	48.60
142	0.2	3450	17560	0.20	2.13	3115	15855	0.20	2.17	3865	17875	0.21	2.28	2.19	0.08	3.64
152	0	3000	13065	0.23	2.73	2320	14705	0.16	1.42	3435	18420	0.19	1.94	2.03	0.66	32.28
162	0	2780	13740	0.20	2.21	3405	18855	0.18	1.87	3535	17185	0.21	2.29	2.12	0.22	10.44
172	0.2	2555	14200	0.18	1.83	3055	18290	0.17	1.59	2875	18070	0.16	1.45	1.62	0.19	11.75
199	1.2	3365	15345	0.22	2.54	3580	18190	0.20	2.13	5325	16655	0.32	4.36	3.01	1.19	39.42
210	0.2	3655	13325	0.27	3.54	2745	19475	0.14	1.12	8115	17855	0.45	8.80	3.82	2.85	74.69
220	1.2	3640	14310	0.25	3.18	4380	15670	0.28	3.81	2855	19145	0.15	1.27	2.88	1.25	46.42
230	1	2360	13795	0.17	1.87	6790	18075	0.38	5.37	4265	18300	0.23	2.79	3.28	1.90	58.06
240	1	2720	12875	0.21	2.39	3365	19155	0.18	1.75	3020	18215	0.17	1.57	1.90	0.43	22.77
248	0.2	3195	12725	0.25	3.12	4345	17395	0.25	3.09	4040	18695	0.24	2.95	3.05	0.09	2.92

Table A.6 Results of quantitative analysis of coverbeds at Site WF6.

Sample depth	% rhyolite glass 125-63 μ	Quantitative XRD														
		qtz	L.A.	qtz/L.A	%qtz1	qtz	L.A.	qtz/L.A.	%qtz2	qtz	L.A.	qtz/L.A.	%qtz3	mean	SD	CV
260	0.5	3625	14025	0.26	3.25	2955	18285	0.16	1.49	4035	19330	0.21	2.35	2.36	0.88	37.15
270	0	3830	14555	0.26	3.33	5085	18725	0.27	3.49	4150	18405	0.23	2.65	3.18	0.44	14.09
280	0	3760	11900	0.32	4.29	6645	17790	0.37	5.34	5645	19005	0.30	3.95	4.53	0.72	15.96
288	0.2	4130	13520	0.31	4.10	4975	19710	0.25	3.14	6180	19035	0.32	4.45	3.90	0.68	17.41
300	0.2	5770	14020	0.41	6.03	5760	18970	0.30	4.07	6450	19040	0.34	4.71	4.93	1.00	20.23
309	0.5	3720	18230	0.20	2.26	3540	20025	0.18	1.77	4440	17390	0.26	3.19	2.41	0.72	30.02
326	0.2	4780	12950	0.37	5.26	7710	19285	0.40	5.81	7375	16920	0.44	6.47	5.84	0.61	10.37
335	0	504	13750	0.37	5.21	4595	15420	0.30	3.97	4955	18035	0.27	3.54	4.24	0.87	20.41
344	0	5000	12945	0.39	5.57	7345	19600	0.37	5.36	8800	18800	0.47	7.05	5.99	0.92	15.40
355	0.5	4960	13725	0.38	5.12	8110	19285	0.42	6.20	5415	18900	0.32	4.37	5.23	0.92	17.54
385	0.2	5620	13515	0.42	6.10	13020	18985	0.69	11.00	4605	18035	0.26	3.19	6.76	3.94	58.31
375	0.2	4550	13625	0.33	4.62	6055	19190	0.32	4.28	4870	18765	0.28	3.27	4.06	0.70	17.32
385	0.5	4380	13765	0.32	4.33	8925	17910	0.50	7.60	6050	17900	0.34	4.69	5.54	1.79	32.32
395	0.2	3925	13715	0.29	3.75	5905	19655	0.30	4.01	6940	17660	0.39	5.69	4.48	1.05	23.45

Table A.7 Results of quantitative analysis of coverbeds at Sites TE1 and TG1.

Percentage of rhyolite glass in very fine sand fraction			
Grid reference TE1		Grid reference TG1	
Sample depth (m)	% glass	Sample depth (m)	% glass
0.1	30.7	17.5	95
0.3	31.7	22.5	71
0.4	29.5	32.5	48.5
0.525	13.7	37.5	34.7
0.575	14.5	42.5	31.7
0.625	17.2	47.5	32.2
0.675	11.7	52.5	34
0.725	14.2	57.5	31.7
0.775	10	62.5	23.2
0.825	10.2	67.5	26
0.875	13.2	72.5	20.7
0.925	12.5	77.5	23
0.975	11.5	82.5	22
102.5	14.2	87.5	23.2
107.5	14.5	92.5	19.5
114.5	16.5	97.5	16.2
120.5	14.2	102.5	12.5
125.5	11.5	107.5	19
130.5	14.5	112.5	15.5
135.5	15.2	117.5	15.5
140.5	16.7	122.5	12.7
145.5	15.5	127.5	11.7
150.5	15		
155.5	17		
163	21		
171.5	28		
177.5	32.7		
182.5	40.7		
187.5	49		
192.5	51.7		
197.5	57.2		
202.5	53.2		
207.5	58.2		
212.5	62.2		
217.5	56.7		
222.5	50.2		
227.5	45		
232.5	21.5		
237.5	18.5		

Table A.8 Results of field based particle size analysis of Onetapu Formation informal members Onf, Ong, Onh and Onj at selected sites in the catchment of the Whangaehu River.

Particle size analyses of Onetapu Formation members Onj, Oh, Ong, and Onf									
Member identifier	Site	Total weight of sample and weight of each size fractions (in kg).							
		Total weight	256-64 mm	64-32 mm	32-16 mm	16-8 mm	8-4 mm	< 4 mm	total
Onj	Q	6.3	0.00	0.1	0.04	0.28	0.7	4.46	5.58
	R	7.42	0.00	0.00	0.22	0.48	0.92	5.72	7.38
	S	7.84	0.00	0.00	0.00	0.04	1	6.76	7.82
	X	5.34	0.00	0.00	0.00	0.02	0.12	4.98	5.18
Onh	E2	72	26.90	19.40	7.80	3.80	1.30	10.80	69.00
	G8	60	2.10	2.50	4.40	5.60	6.80	38.20	59.60
	H2	89	0.00	3.00	13.90	10.80	9.20	31.10	68.00
	Q	7.94	0.00	0.82	0.44	0.7	0.92	4.94	7.82
Ong	E2	31	0.00	0.00	0.20	0.30	0.80	27.80	28.90
	H2	30	0.00	0.00	0.00	0.01	0.15	31.80	31.98
	L1	21	0.00	0.00	0.00	0.30	1.30	19.00	20.80
	L1	31	0.00	0.00	0.00	0.20	1.20	26.80	28.00
	[illegible]	35	0.00	0.00	2.70	3.50	5.00	23.00	34.20
Onf	E2	72	16.30	18.30	12.30	8.80	5.80	11.00	87.50
	H2	71	0.00	31.90	11.40	6.60	5.00	17.30	72.20
	L1	77	38.30	17.20	8.40	1.90	1.70	11.30	78.80
	P	78	4.40	21.40	20.10	7.80	3.80	18.10	75.80

Table A.9 Results of laboratory based particle size analysis of Onetapu Formation informal members Onf, Ong, Onh and Onj, at selected sites in the Whangaehu River Catchment.

Particle size analysis for sand and granule size fraction subsamples of Onetapu Formation members (in g).											
Member identifier	Site	Total weight in each size fraction (g)									
		subsample	2-4	c. 30g sub	100-200 μm	0.5-1 μm	500-250 μm	250-125 μm	125-63 μm	63-4 μm	< 4 μm
Onj	Q	1000	35	30.665	4.928	5.918	7.435	4.933	3.412	4.150	1.100
	R	1000	47	30.234	5.352	6.354	6.745	4.297	2.926	3.750	0.350
	S2	1000	99	30.656	9.935	6.070	5.971	2.455	1.473	2.000	0.500
	X	1000	13	30.617	3.445	6.137	7.121	4.546	3.413	4.200	0.800
Onh	E1	1000	10	29.935	5.517	6.008	5.347	3.727	2.944	4.550	1.030
	G8	1000	129	30.207	2.522	7.475	7.990	4.261	2.261	2.395	0.000
	H2	1000	93	29.961	5.381	5.618	6.319	4.544	3.359	4.385	0.645
	Q	1000	99	30.456	5.065	5.621	6.539	4.563	3.456	3.750	0.450
Ong	E2	1000	140	29.975	3.656	6.196	6.276	4.137	2.075	1.700	0.475
	H2	1000	148	30.088	1.352	6.983	10.748	5.434	2.728	2.085	0.225
	L1	1000	151	30.100	7.617	6.335	5.952	2.983	1.681	2.485	0.810
	L1	1000	16	30.176	3.878	6.662	7.695	3.591	1.984	2.600	0.760
	P	1000	116	30.028	5.077	6.658	6.030	4.484	2.580	1.450	0.000
Onf	E2	1000	65	29.909	6.719	7.108	6.127	3.648	2.481	1.420	1.025
	G6	1000	122	31.003	3.237	5.918	7.167	4.947	3.294	4.230	0.265
	H2	1000	4	29.969	4.033	4.974	4.951	4.268	3.671	5.650	1.045
	L1	1000	147	30.191	2.568	5.084	6.748	4.634	3.478	5.670	1.050
	P	1000	71	29.504	3.545	4.764	5.368	4.244	3.601	5.945	1.005

Table A.10 Geometrical measurements for Onetapu Formation lahar deposits Onj, Onh, Ong and Onf at Sites E, H, L and S.

Geometrical measurements (in m) for Onetapu Formation lahar deposits									
		Onf		Ong		Onh		Onj	
Locality	R*	ΔH	W	ΔH	W	ΔH	W	ΔH	W
Site E	75	-	-	4	142	4	114	4	88
Site H	50	2	289	2	274	4	272	-	-
Site L	25	-	-	2	209	1	208	-	-
Site S	99	-	-	-	-	2	153	0	175

Table A.11 Measured cross-sectional area for Onetapu Formation lahar deposits.

Measured cross-sectional areas (in m^2) for Onetapu Formation deposits				
Locality	Member	Minimum	Intermediate	Maximum
Site E	Onj	13.99	43.94	204.78
	Onh	80.88	119.8	241.9
	Ong	119.51	155.78	258.07
Site H	Onh	149.03	229.33	977.32
	Ong	123.08	171.51	582.92
	Onf	284.98	395.81	838
Site L	Onh	40.28	79.73	987.38
	Ong	77.91	147.52	880.89
Site S	Onj	157.98	737.08	1181.9
	Onh	282.8	937.28	849.3

WF1 822/106515

Type Locality

Whangaehu Formation deposits are exposed in a north facing ridge *c.* 1.5 km west of Mangamahu on the west bank of the Whangaehu River. The base of this section is at 250 m A.S.L., the top of the uppermost diamictite bed 300 m A.S.L., and the top of the ridge is 309 m A.S.L. The exposure is *c.* 300 m wide, trending west to east. The lowermost diamictite infills a channel cut into the underlying siltstone, and overlying diamictites have spilled out onto terraces on either side of this channel.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Whangaehu Formation	(veneer)	3	-	Clast-supported gravel; hard; very poorly sorted; ungraded; weakly defined cm thick laminae; clasts subangular to subrounded; largest clast 0.2 m; common grey and black lithic clasts; occasional to few Tertiary siltstone pebbles.
				Contact obscured
Whangaehu Formation	(veneer)	3	-	Clast-supported gravel; hard; very poorly sorted; ungraded; distinct cm thick laminae; discontinuous zones which are weakly cross-bedded; clasts subangular to subrounded; common grey scoriaceous lithic clasts.
				Contact obscured
Whangaehu Formation	(marginal-B)	18	-	Clast-supported gravels; very poorly sorted; ungraded; hard; clasts subrounded to rounded; largest clast 1.5 m; common grey, black and few red and maroon lithic clasts; few to common Tertiary silstone boulders, concentrated at the base, and the top of this unit; contains discontinuous zones of bedded andesitic sands and granules.
				Very distinct, irregular erosional contact

ON NUKUMARUAN SANDSTONE AND SILTSTONE.

WF2 822/106515

Reference section
2
Whangaehu Formation is exposed in a north facing ridge on the east side of Ruatangata Road. The base of the gravels underlying the Formation at this locality is at 37 m A.S.L. The Whangaehu Formation terrace surface is 72 m A.S.L. The top of the Ngarino terrace, to the east and northeast of this section, is at 88 m A.S.L. Here andesitic diamictites infill a valley cut into older the Ngarino marine terrace. The exposure is *c.* 500 m long. Diamictites are also observed on the south facing side of the ridge, beside State Highway 3.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.15	0.15	Slightly gritty yellow grey sandy clay loam; blocky structure breaks to coarse nut and crumb; yellow-brown mottles on peds; few black, grey and red sands scattered throughout; black manganese staining.
				Graded contact
•	•	0.4	0.55	Clast-supported, low angle cross-bedded well sorted andesitic sands;; lenses of coarse sand and granules.
				Distinct contact
•	•	0.01	0.56	Pinky grey silty clay; blocky structure; non sticky; non plastic; pale brown colour on peds.
				Distinct contact
•	•	0.45	0.01	Dark brown carbonaceous silty sand; very well sorted.
				Distinct contact
•	•	0.1	1.11	Pale yellow silty loam with yellow brown mottles; common fine and medium pores with orange brown stains; non sticky; non plastic.
				Distinct contact
•	•	1	2.11	Clast-supported steeply cross-bedded andesitic sands; very well sorted.
				Distinct contact
•	•	0.3	2.44	Pinky grey silts with fine sand beds; moderately hard.
				Graded contact
•	•	0.4	2.84	Clast-supported sands; very ell sorted; moderately hard.
				Distinct contact
•	•	0.2	3.04	Grey silts; moderately hard.
				Graded contact
Whangaehu Formation	•	3	6.04	Clast-supported gravel; ungraded; massive; very poorly sorted; largest clast 0.11 m; clasts angular to subangular; cm thick lenses of clast-supported sands; common black and grey and few red hard scoriated clasts; unit is very hard.
				Distinct contact
•	•	0.6	6.64	Very hard lithified pinky grey silts; contains thin andesitic lapilli bed c. 0.08 m from contact with overlying unit; silts contain flecks of carbonaceous material; strongly iron/manganese staining at lower contact.
				Graded contact
•	•	0.2	6.84	Clast-supported cross-bedded sands; well sorted; thin silty laminae; mottled orange brown at contact with overlying unit.
				Contact obscured

WF2 S22/106515

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Whangaehu Formation	•	2.8	9.64	Clast-supported gravel; inversely graded; very poorly sorted; massive; largest clast 0.07 m; clasts angular to subangular; common black and grey and few red hard scoriated lithic clasts; occasional Tertiary pebbles; very hard.
				Distinct contact
•	•	0.15	9.79	Silts
				Distinct contact
•	•	0.1	9.89	Grey fine sandy silt with yellow-brown mottles; flecks of carbon scattered throughout.
				Distinct contact
•	•	0.17	10.06	Slightly gritty yellow grey sandy clay loam; yellow-brown stains on peds; fine black sand scattered throughout.
				Distinct contact
•	•	1.2	11.26	Clast-supported sands; massive; ungraded; poorly sorted; clasts angular to subangular; abundant grey and black and few red and yellow lithic clasts; occasional Tertiary siltstone pebbles; very hard.
				Contact obscured
•	•	1.5	12.78	Clast-supported laminated sands; well sorted; ungraded; strong yellow-brown mottles at top of unit.
				Graded contact
•	•	0.7	13.46	Clast-supported sands; contains common dacitic pumice lapilli and blocks.
				Distinct contact
•	•	0.6	14.06	Alternate beds of silt and sand
				Distinct contact
•	•	0.8	14.86	Sands; contains common dacitic pumice blocks.
				Distinct contact
•	•	1.7	16.56	Silty sands
				Distinct contact
•	•	0.3	16.86	Silty sand
				Distinct contact
•	•	2.5	19.36	Andesitic fluvial gravels

WF3 S22/965295

Reference section

Whangaehu Formation distal lithofacies are exposed in a north facing ridge on the left of Budge Road, below Kauangaroa Road, and 4.6 km east of Fordell. The exposure is *c.* 800 m long, and the gravels at the base of this section are at 129 m A.S.L. The upper terrace surface is 167 m A.S.L.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Whangaehu Foramtion	•	1	1	Clast-supported sands; ungraded; poorly sorted; weak cm thick beds; clasts angular to subrounded; common grey, black and few red scoriated lithics; deposit is hard.
				Distinct contact
•	•	0.2	1.2	Pinky grey silty sands.
				Graded contact
Whangaehu Formation	•	2.6	3.6	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 200 mm; clasts angular to subrounded; common grey and black and few red and purple scoriated lithic clasts.
				Distinct contact
•	•	1	4.6	Grey brown silty sands; very hard.
				Contact obscured, base of silts and sands at 162 m.
Whangaehu Formation	•	5	9.6	Clast-supported sands and granules; normally graded; distinct cm thick bedding; very poorly sorted; clasts subangular to subrounded, outsize clasts rounded; common black and grey lithic clasts; common pale grey decitic pumice; occasional Tertiary pebbles.
				Distinct contact
•	•	0.8	10.3	Clast-supported, cross-bedded, well sorted gravel; normally graded; abundant pale grey decitic pumice.
				Distinct contact
•	•	0.1	10.4	Very pale grey silty sand.
				Distinct contact
Whangaehu Formation	•	3	13.4	Coarse sandy matrix-supported gravel; ungraded; very poorly sorted; clasts angular to rounded; few to common black, grey and red scoriated lithic clasts; abundant pale grey pumice; especially in upper 1 m of unit, where a gradation into cross-bedded sands is observed; discontinuous patches of strong iron staining and iron pan; deposit is very hard.
				Distinct contact
•	•	0.15	13.55	Yellow-brown silty sands, with some clay; common black and white fine sand scattered throughout; strong discontinuous orange red iron staining at base; stong yellow-brown mottles throughout.
				Distinct contact
Whangaehu Formation	•	0.9	14.45	Clast-supported gravels; ungraded; massive; very poorly sorted; common grey and black and few red lithic clasts; upper portion of unit contains abundant pale grey decitic pumice blocks and lapilli; hard.
•	•	0.3	14.75	Pale grey-brown fine sands and silts; contains pods of coarse sand and granules; stongly iron stained at top with very hard continuous concretions; few to common white and black fine sand scatterd throughout.
				Distinct contact
•	•	3	17.75	Clast-supported well rounded gravels; very poorly sorted.

WF5 S21/177806

Reference section

Coverbeds overlying the Whangaehu Formation are exposed in a disused metal pit perched on the edge of high bluffs cut into the Formation on the east bank of the Whangaehu River, *c.* 600 m from the left (River) side of the Whangaehu Valley Road.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.13	0.13	Sandy silt loam (10YR 3/3, dark brown) friable; non-sticky; non-plastic; well developed fine nut and granule structure; abundant very fine roots; few scattered rhyolite lapilli (up to 6mm); v. porous.
				Gradational contact
•	•	0.22	0.35	Sandy silt loam (7.5YR 3/2, dark brown); very friable; non-sticky; non-plastic; strong fine nut and granule structure; many v. fine roots; few rhyolite fine pumice lapilli (up to 10mm), stained orange; very porous.
				Gradational wavy contact
•	•	0.15	0.50	Slighty gritty fine sandy silt loam (7.5YR 4/4, brown); friable; non-sticky; plastic; strong; very fine nut structure; many very fine roots; few rhyolitic fine lapilli; few grey and reddish brown very fine andesitic lapilli; very low bulk density; many fine tubular pores.
				Very gradational boundary
•	•	0.16	0.66	Gritty sandy silt loam (7.5YR 5/6-4/6, strong brown); very friable; non-sticky; plastic; strong coarse crumb and fine nut structure; common fine grey soft lapilli; very low bulk density; many fine tubular pores.
				Transitional boundary
•	•	0.23	0.89	Gritty sandy silt loam (10.5YR 5/8, yellowish brown); firm; non sticky; slightly plastic; weak coarse crumb and fine block structure; low bulk density; few very fine roots; few very fine dark grey soft lapilli; few fine tubular pores, few with organic coatings.
				Gradational boundary
•	•	0.27	1.16	Gritty sandy silt loam (10YR 5/8, yellowish brown); firm; non sticky; slightly plastic; weak coarse crumb and fine block structure; few very fine roots; few thin clay and organic coatings on peds; common fine tubular pores; few dark grey very fine soft lapilli; scattered white lapilli.
				Gradational contact
•	•	0.31	1.47	Gritty sandy silt loam (10YR 5/6, yellowish brown); very firm; slighty sticky; slightly plastic; weak medium and very fine block; no live roots; few tubular pores; few dark grey soft very fine lapilli, coarsening slightly to centre; scattered white soft lapilli becoming common to base; more sandy to base.
				Graded contact
Kawakawa Tephra	•	0.07	1.54	Medium sandy ash with scattered very fine white pumice lapilli (10YR 6/6, brownish yellow).
				Sharp distinct contact
Kawakawa Tephra	•	0.04	1.58	Fine silty ash (10YR 5/4-7.5YR 7/2, yellowish brown to pinkish grey); abundant challazoidites (3-10 mm); some with concentric structure; orange coating on some challazoids.
				Sharp wavy contact
Kawakawa Tephra	•	0.03	1.61	Speckled grey to pale yellow coarse ash and fine lapilli.
				Sharp wavy contact

WF6 621/177806

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Kawakawa Tephra	*	0.01	1.62	Pale yellow coarse sand and fine lapilli.
				Sharp contact
Kawakawa Tephra	*	0.01	1.63	Fine sandy ash (10YR 8/3, very pale brown); burrowed base.
				Distinct contact
*	*	0.27	1.90	Fine sandy loam (10YR 5/6, yellowsih brown); very firm; slightly sticky; slightly plastic; strong coarse to medium block structure; no live roots; few fine tubular pores lined with organic matter; few fine grey lapilli; few white fine lapilli.
				Gradational contact
*	*	0.28	2.18	Slighty gritty fine sandy loam (10YR 5/6, yellowsih brown); friable; slightly sticky; slightly plastic; strong coarse to medium block; no live roots; common fine tubular pores with rusty coloured coatings; few dark grey fine lapilli; few soft fine orange and pale yellow lapilli.
				Gradational contact
Kaitieke tephra	*	0.18	2.36	Grey andesitic ash (10YR 5/4, yellowish brown); fine sandy loam; very firm; non sticky; non plastic; massive; no roots; few fine tubular pores; common dark grey and orange fine lapilli; few orange medium lapilli (soft and angular); few fine white and pale yellow lapilli.
				Gradational contact
*	*	0.44	2.80	Slightly gritty fine sandy loam (10YR 5/6, yellowish brown); very firm; slightly sticky; plastic; weak coarse block; common fine tubular pores; pores lined with very dark grey (7.5YR 3/0); few dark grey very fine lapilli; common fine white very soft lapilli.
				Gradational contact
*	*	0.15	2.95	Slightly gritty sandy loam (10YR 5/6, yellowish brown); very firm; slightly sticky; plastic; weak coarse block structure; few fine tubular pores, lined as above; common dark grey & red soft fine lapilli; few white & pale yellow soft coarse ash.
				Gradational contact
*	*	0.25	3.20	Gritty sandy loam (10YR 5/6-5/4, yellowish brown, speckled); very firm; non sticky; plastic; massive; few fine tubular pores, lined as above; common dark grey & pale grey soft fine lapilli; few orange soft fine lapilli; common white and pale yellow soft coarse ash.
				Gradational contact
Mangawherawhera tephra		0.08	3.28	Lapilli-rich andesitic tephra (10YR 4/6, dark yellowish brown, speckled); non sticky; non plastic; massive; firm but brittle, breaks easily; very low bulk density; pores between lapilli; abundant grey fine to medium lapilli, commonly stained orange; few red fine to medium lapilli; few lapilli with clayey coatings.
				Gradational contact
*	*	0.06	3.34	Slightly gritty sandy clay loam (10YR 5/6, yellowish brown); firm; slightly sticky; slightly plastic; massive; common fine tubular pores stained black (10YR 2/1); abundant dark grey soft fine lapilli; few white & pale yellow fine lapilli.
				Sharp contact

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.34	3.88	Silty clay loam (10YR 3/6, dark yellowish brown); slightly sticky; slightly plastic; firm; moderately very coarse blocky structure; common fine tubular pores, stained black to very dark brown (10YR 2/1-2/2); few fine white soft lapilli; few dark grey soft fine lapilli.
				Gradational contact
•	•	0.56	4.24	Silty clay loam (10YR 5/4-5/8, yellowish brown); firm; sticky; plastic; strong coarse blocky structure; prismatic in face; common fine tubular pores lined as above; common white fine soft lapilli size feldspar ghosts; few fine soft dark grey lapilli.
				Gradational contact
•	•	0.50	4.74	Silty clay loam (10YR 5/8, yellowish brown); firm; slightly sticky; plastic; moderately developed coarse nut; common fine tubular pores; common thin dark reddish coatings on peds and on cracks; few white fine to medium lapilli; few dark grey very fine lapilli.
				Gradational contact
•	•	0.28	5.02	Clay loam (10YR 5/8, yellowish brown); firm; slightly sticky; plastic; strong fine block and crumb structure; common very fine tubular pores stained black (10YR 2/1); common clay and iron coatings on peds; few fine dark grey lapilli.
				Gradational contact
•	•	0.15	5.17	Clay loam (10YR 6/8, brownish yellow); firm; sticky; plastic; weak coarse blocky structure; common very fine tubular pores lined as above; few light grey (10YR 7/2) fine mottles; few fine dark grey and orange lapilli.
				Gradational contact
•	•	0.18	5.35	Mottled sandy clay loam (7.5YR 6/8-10YR 7/2, reddish yellow to light grey); firm; slightly sticky; plastic; weak nut and crumb structure; common fine pores with pale brown clay coatings; common dark grey soft fine lapilli; common rounded pale grey fine lapilli.
				Distinct contact
Rangiwhaia tephra	•	0.12	5.47	Sandy clay loam (7.5YR 7/8-6/8, reddish yellow); friable; slightly sticky; slightly plastic; massive; common med to fine pores coated black; abundant pale grey and orange soft fine lapilli; few dark grey fine lapilli.
				Sharp contact
•	•	0.08	5.55	Oxidized peat (7.5YR 6/8-5/8, redish brown to strong brown); mottled; clay loam; firm and friable; sticky; plastic; massive; few fine tubular pores coated black; upper 1cm dark reddish brown 5YR 4/8; few dark grey soft lapilli.
				Sharp contact
•	•	0.14	5.69	Silty clay loam (10YR 7/4-6/8, very pale brown to brownish yellow); firm; sticky; plastic; massive; common fine tubular pores coated black; few fine dark grey lapilli; common orange soft fine lapilli; few fine rounded mudstone pebbles.
				Distinct contact

WF6 621/177806

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
*	*	0.10	6.81	Matrix-supported gravel; common orange, grey, and purple soft weathered andesite pebbles and cobbles; abundant soft rounded mudstone pebbles; poorly sorted; matrix contains abundant black fine lapilli. Gradational contact
Whangaehu Formation	veneer	0.81	8.82	Matrix-supported common grey red and purple andesite pebbles, cobbles and boulders; very poorly sorted; ungraded; occasional bombs; clasts commonly subangular; clasts commonly soft; matrix colour orange grey (7.5YR 6/8-10YR 8/4, strong brown to light yellowish brown); black staining and coatings on cracks. Distinct contact
Whangaehu Formation	veneer	0.62	7.14	Matrix-supported common grey, black, and red subrounded pebbles; very poorly sorted; weakly inversely graded; matrix colour yellowish brown (10YR 5/4-5/6). Distinct contact
Whangaehu Formation	veneer	*	*	Matrix-supported gravel; abundant grey scoriaceous pebbles and cobbles; matrix appears grey; sandy and indurated; porous; dominant relief in face. Distinct contact
Whangaehu Formation	veneer	3.50	10.64	Matrix-supported gravel; common orange, pale yellow, red, black soft subrounded pebbles and cobbles; very poorly sorted; ungraded; few dark grey and black hard scoriaceous pebbles and cobbles; common angular pale yellow lapilli to block size pumice clasts; few grey bombs; matrix speckled grey, orange and pale orange.

ON WHANGAEHU FORMATION MARGINAL LITHOFACIES

WF6 521 194825

Reference section

The Whangaehu Formation is exposed beside a track on the west bank of the Whangaehu River. This track has been cut through veneer and marginal-A lithofacies of the Formation, and overlying tephra and loess. The section is *c.* south of the end of Old Fields Track, and just above the confluence of the Kaitieke Stream with the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Kaitieke tephra	•	0.19	0.19	Mottled dark greyish brown to yellowish brown tephra (10YR 4/2-5/4); gritty, sandy clay loam; very firm; slightly sticky; slightly plastic; massive; very few fine pores; common fine dark grey lapilli; orange and brown staining around pores.
				Distinct sharp contact
•	•	0.12	0.31	Slightly gritty sandy clay loam (10YR 5/6, yellowish brown); friable; sticky; plastic; weak medium block breaking to crumbs; common fine pores; few dark brown stains on pores; common fine dark grey and pale grey lapilli and coarse ash; few scattered white coarse ash and lapilli.
				Gradational contact
Mangawharawhara tephra		0.14	0.45	Lapilli rich grey tephra (10YR 5/2-5/8); sandy clay loam; non sticky; slightly plastic; few fine pores; abundant dark grey coarse ash and fine lapilli, few red fine lapilli; common white coarse ash; dominant in relief.
				Distinct contact
•	•	0.47	0.92	Sandy clay loam (10YR 4/6, dark yellowish brown); firm; sticky; plastic; medium coarse blocky structure; abundant fine pores with dark grey linings; abundant white coarse ash; few fine orange lapilli; common dark grey fine lapilli.
				Gradational contact
•	•	0.14	1.06	Silty clay loam (10YR 5/6, yellowish brown); sticky; plastic; weak coarse blocky structure; few fine pores with dark grey linings; common pale grey firm lapilli; common white coarse ash.
				Gradational contact
Rangiahu tephra	•	0.16	1.22	Speckled lapilli rich tephra (10YR 5/8, yellowish brown); gritty loamy sand; firm; non sticky; non plastic; brittle; massive; few fine pores, stained dark purplish grey; abundant red and grey fine lapilli; common orange and white fine lapilli.
				Gradational contact
•	•	0.50	1.72	Sandy clay loam (10YR 4/6, dark yellowish brown); firm; sticky; plastic; weak coarse blocky structure; slight purplish pink coatings on peds; abundant fine pores with purplish stains and coatings; common dark grey and white lapilli.
				Gradational contact
•	•	0.19	1.99	Slightly gritty sandy clay loam (10YR 5/6, yellowish brown); slightly sticky; slightly plastic; firm; moderately blocky; common fines pores with dark brown and black coatings; common pale grey fine lapilli; common white coarse ash.
				Gradational contact
•	•	0.49	2.48	Sandy silty clay loam (10YR 5/8, yellowish brown); firm; sticky; plastic; weak coarse blocky structure8; dark purple coatings on peds; abundant fine pores with dark purple (7.5YR 3/4, dark brown) coatings; common dark grey and white coarse ash; few orange fine lapilli.
				Gradational contact

WFS S21/194825

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
*	*	0.40	2.88	Last interglacial paleosol; sandy clay loam (10YR 5/6-5/8, yellowish brown); firm; sticky; plastic; strong medium to coarse blocky structure; purple in face with dominant relief; abundant fine root channels with very dark brown (10YR 2/2-2/1) coatings; common white and dark grey coarse ash; few pale grey fine lapilli; few orange coarse ash.
				Gradational contact
*	*	0.21	3.09	Slightly gritty sandy clay loam (10YR 4/6, dark yellowish brown); friable; sticky; plastic; moderate medium blocky structure; comon fine pores with very dark grey (7.5YR 3/0) coatings; common orange, white and pale grey coarse ash; few pale grey pebbles with orange coatings.
				Gradational contact
*	*	0.17	3.26	Silty clay loam (10YR 6/8, brownish yellow, speckled); slightly gritty; friable; slightly sticky, plastic; weak coarse blocky structure; few fine pores stained dark purplish; common grey and orange coarse ash and fine lapilli; common dark grey coarse ash; few white coarse ash.
				Gradational contact
Rangiwhaia tephra	*	0.18	3.44	Gritty sandy clay loam (10YR 4/6, dark yellowish brown); very sticky; plastic; friable; moderate medium blocky structure; firm ped strength; thick dark brown coatings on many peds; few fine pores; few soft orange, grey and pale yellow lapilli; common pale grey coarse ash and fine lapilli; common white feldspar ghosts.
				Gradational contact
*	*	0.59	4.03	Sandy silt loam (10YR 7/8, yellow); slightly sticky; slightly plastic; firm; weak coarse blocky structure breaking to coarse nut and crumb; common fine pores with black (10YR 2/1) coatings; few pale and dark grey pebbles with orange coatings: common orange, white and pale grey coarse ash.
				Distinct sharp contact
Whangaehu Formation	veneer	0.49	4.52	Matrix-supported gravel; ungraded; very poorly sorted; largest clast pebble-sized; common red, purple, orange and grey pebbles; matrix dominantly gritty sandy clay loam (10YR 7/8, yellow, speckled); slightly sticky, slightly plastic; massive breaking to coarse block; few pores, stained dark reddish brown (5YR 2.5/2); few pods of unweathered grey matrix.
				Distinct contact
*	*	0.20	4.72	Sandy clay loam (10YR 6/8, brownish yellow); very slightly gritty; sticky; plastic; strong medium block structure; common fine pores stained black (5YR 2.5/1); common pale grey, orange and white coarse ash and fine lapilli; white streaks through unit.
				Distinct contact
Whangaehu Formation	veneer	1.40	6.12	Matrix-supported gravel; ungraded; largest clast pebble-sized; common grey, red, orange and purple pebbles; matrix dominantly gritty sandy loam (10YR 8/2, white); non sticky; non plastic; massive; firm; common pods of unweathered grey matrix.
				Distinct contact

WF6 S21/194826

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
*	*	0.18	6.30	Sandy loam (7.5YR 8/2, pinkish white, with orange and grey mottles); non sticky non plastic; friable; strong fine block structure; few grey; red, orange and pale yellow pebbles; common light grey coarse sand.
				Gradational contact
Whangaehu Formation	veneer	0.58	6.88	Matrix-supported gravel; ungraded; largest clast ebble-sized; grey, red and purple pebbles; matrix dominantly gritty sandy loam (7.5YR 8/0, white, speckled); weak coarse blocky structure grading downwards to massive.
				Distinct contact
Whangaehu Formation	veneer	0.26	7.14	Matrix-supported gravel; ungrdeed; grey, red and purple pebbles; matrix dominantly slightly gritty sandy loam; firm; non sticky; non plastic; weak blocky structure; iron stained in upper 0.1 m.

ON WHANGAEHU FORMATION

WF7 S21/188825

Reference section

Coverbeds overlying the Whangaehu Formation are exposed in a cutting on the right side of Old Fields Track, on the west bank of the Whangaehu River, about 1km downstream of the confluence of the Mangawherawhera Stream with the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.40	0.40	Sandy clay loam (10YR 5/6), distinct lumpy profile; well developed; little loose material; medium coarse to fine nut structure; some fine crumb; dom fine nut; prominent root channels; dark reddish brown.
				Gradational contact
•	•	0.45	0.85	Sandy clay loam to sandy loam (10YR 5/6, yellowish brown); distinct lumpy profile; well developed; medium to fine nut and crumb structure.
				Gradational contact
Kawakawa tephra	•	0.20	1.05	Very fine sandy loam (10.5YR 5/6, yellowish brown); moderately developed fine nut and crumb; numerous root channels stained red brown; common scattered very fine white pumice lapilli; few fine white ash cream cakes (2.5Y 7/4, pale yellow).
				Gradational contact.
•	•	0.20	1.25	Very fine sandy loam (10.5YR 5/6, yellowish brown); well developed fine and medium nut structure; numerous root channels.
				Gradational contact
•	•	0.11	1.36	Gritty sandy clay loam; well developed medium and fine nut; common root channels stained purple brown.
				Gradational unit
•	•	0.23	1.59	Very fine sandy clay loam (10YR 5/6, yellowish brown); well developed medium and fine nut; coarser structure and heavier than before; fine white ash scattered throughout; root channels stained orange/yellow brown; porous; non greasy.
				Gradational contact
Kartieke tephra	•	0.30	1.89	Sandy loam (2.5Y 7/4-10YR 4/2, pale yellow to dark greyish brown); prominent relief in section; very firm; weakly developed medium and fine nut; numerous root channels stained brown; fine white ash scattered throughout.
				Gradational contact
•	•	0.18	2.07	Fine sandy clay loam (10YR 4/4-5/4, dark yellowish brown to yellowish brown); well developed medium and fine nut; numerous root channels stained dark brown; fine ash scattered throughout; distinct reddish tone; very prominent cracking.
				Distinct contact
Mangawherawhera tephra		0.55	2.62	Very gritty sandy clay loam (10YR 5/6 yellowish brown); abundant grey very fine to coarse lapilli (2.5YR 6/0 grey); numerous root channels with brown coating; firm; bulgy relief; cracked exterior.
				Gradational contact.
•	•	0.30	2.92	Sandy clay loam (10YR 5/6 yellowish brown); moderately well developed fine and medium nut; numerous root channels; very fine white ash scattered throughout; dark brown root channels; non greasy; abundant scattered cobbles and med pebbles at the base of this unit.

ON WHANGAEHU FORMATION VENEER LITHOFACIES

MA1 S22/063429

Reference section

Mangatipona pumice sand and Ratan fluvial gravels are exposed in the undercut banks of the Mangatipona Stream *c.* 20 m above its confluence with the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	1	1	Massively bedded fine and medium quartzofeldspathic sands.
				Graded contact
•	•	0.2	1.2	Finely laminated silts.
				Distinct contact
•	•	4.5	5.7	Alternating beds of silty sands and pale grey loess.
				Distinct contact
Mangatipona pumice sand		1	6.7	Clast-supported granules and sands; ungraded; massive; abundant pale grey dacitic pumice clasts; common flecks and few pieces of charcoal, dated (Wk-2681) at 37,030 ± 730 years B.P.
				Distinct contact
•	•	0.6	7.3	Finely laminated silty sand.
				Graded contact
•	•	0.4	7.7	Massively bedded sands.
				Distinct contact
•	•	0.75	8.55	Clast-supported, well rounded, well sorted andesitic gravels.

AP1 S21/190781

Reference section

Apitian lahars are exposed in a cutting beside a track which provides access from the high Whangaehu Formation surface down to low terraces on the east bank of the Whangaehu River, *c.* 600 m north of the confluence between the Maketu Stream and the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.1	0.1	Dark brown; topsoil
				Graded contact
•	•	0.2	0.3	Yellow brown gritty sandy clay loam; non sticky; non plastic; greasy; common scatterd andesitic sands; fine nut and crumb structure.
				Graded contact
•	•	0.35	0.65	Very fine clast-supported cross-bedded sands.
				Distinct contact
•	•	0.15	0.8	Pale yellowish brown sandy loam; non sticky; non plastic; non greasy; moderately firm; blocky structure breaks to medium nut with some crumb.
				Graded contact
Bullot Formation	Ngamatea lapilli -2	0.05	0.85	Common scattered orange and grey fine to coarse lapilli.
				Graded contact
•	•	0.30	1.15	Pale yellowish brown sandy silt loam; non plsartic; non sticky; non greasy; firm; blocky structure breaking to medium nut and some crumb.
				Graded contact
Bullot Formation	Ngamatea lapilli -1	0.1	1.25	Common scattered yellow and grey fine to coarse lapilli
				Graded contact
•	•	0.2	1.45	Pale yellowish brown sandy silt loam; slightly sticky; non plastic; non greasy; blocky structure breaking to medium nut and crumb.
				Graded contact
Kewakewa Tephra	•	0.15	1.60	0.005 m thick white ash cream cakes at base, grading upwards into 0.04 m of fine to medium lapilli, grading upwards into 0.1 m of chellazoidites.
				Distinct contact
•	•	0.3	1.9	Pale yellowish brown silty loam; non sticky; non plastic; non greasy; firm blocky structure.
				Graded contact
•	•	0.3	2.2	Reddish brown gritty sandy clay loam; slightly sticky; slightly plastic; well developed fine nut and crumb structure; friable; very cracked in face; common black and white very coarse sand scattered.
				Graded contact
Apitian lahars	•	0.95	3.15	Clast-supported sand and granules with few pebbles; ungraded; massive.
				Distinct contact
•	•	0.2	3.35	Brownish grey sandy loam; slightly sticky; very slightly plastic; non greasy; medium nut and crumb structure.
				Graded contact
Apitian lahars	•	1.1	4.45	Clast-supported sands and granules; ungraded; massive.

SECTION OBSCURED BELOW THIS UNIT, BUT OVERLIES WHANGAEHU FORMATION.

AP2 822/058412

Reference section

Apitian lahars are exposed in terrace coverbeds beside the Whangaehu Valley Road, *c.* 4 km downstream of Wyley's Bridge.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
*	*	0.1	0.1	Dark brown topsoil
				Graded contact
*	*	1.9	2	Pale greyish brown silty clay loam; firm blocky structure; Kawakawa Tephra located approximately 0.6 m from the base of this loess.
				Distinct contact
Apitian lahars	*	1.5	3.5	Clast-supported sands and gravel; inversely graded base grades upwards to middle of unit then into normally graded upper portion; very poorly sorted; massive; coarser gravelly clasts concentrated in middle and upper of unit; clasts subangular to subrounded, larger clasts commonly rounded; largest clast 0.08 m; common black and grey and few red lithic clasts; common grey and yellow pumice clasts; pumice clasts commonly stained yellowish brown.
				Distinct contact
Apitian lahars	*	0.8	4.3	Clast-supported sands and granules; normally graded; massive; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; common grey and occasional red lithic clasts; common grey and yellow pumice clasts; pumice clasts commonly stained yellowish brown.

AP3 520/203909

Reference section

Apitian lahars are exposed in a cutting beside Ohutu-Mangahouhou Road, in the Mangawherawhera catchment.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.6	0.6	Slightly gritty sandy clay loam (10YR 7/6, yellow); slightly sticky; slightly plastic; greasy; blocky structure breaking to fine nut and crumb; common fine pore stained pale orange grey; commmon live roots; common scattered grey and orange soft fine and medium sands.
				Graded conatct
•	•	0.4	1	Gritty sandy silt loam (2.5Y 7/4-10YR 7/4, pale yellow to very pale brown); non sticky; non plastsic; blocky structure breaking to fine nut and crumb; cracked in face; common fine pores stained pale yellowish orange; common scattered black, grey and white fine to medium sand.
				Graded contact
Kawakawa Tephra	•	0.15	1.15	Slightly gritty sandy silt; dominantly white glassy ash (2.5Y 8/0-8/2, white), with common challazoidites at base; grades upwards into sandy silt loam (2.5Y 7/4, pale yellow).
				Distinct contact
•	•	0.75	1.9	Very slightly gritty sandy silt loam (10YR 7/4-7/6, very pale brown to yellow); slightly sticky; slightly plastic; blocky structure breaking to fine nut and crumb; common fine pores satined orange and black; common black and orenge fine and medium sands scattered.
				Distinct contact
Apitian lahars	•	0.3	2.2	Clast-supported sands; ungraded; poorly sorted; largest clast 0.005 m; clasts angular to subangular; common black and grey lithic clasts; common grey and yellow pumice clasts.
				Distinct contact
•	•	0.05	2.25	Gritty sandy clay loam (10YR 7/6, yellow); abundant black, orange and yellow soft fine and medium sands; andesitic lapilli?
				Graded contact
Apitian lahars	•	0.05	2.3	Clast-supported sands; ungraded; poorly sorted; largest clast 0.005 m; common black and grey lithic clasts; common grey pumice clasts.
				Distinct contact
•	•	0.05	2.35	Gritty sandy loam (10YR 6/6, brownish yellow); non sticky; non plastic; slightly greasy.
				Distinct contact
Apitian lahars	•	1.5	3.85	Clast-supported sands and gravel; normally graded; very poorly sorted; largest clast 0.16 m; clasts subangular to subrounded; common black and grey and few red and purple lithic clasts; common grey and yellow pumice clasts.
				Distinct contact
Apitian lahars	•	0.3	4.15	Clast-supported sned with some gravel; normally graded; very poorly sorted; largets clast 0.03 m; clasts angular to subangular; common black and grey and few red and purple lithic clasts; common grey and yellow pumice clasts; common pumice clasts with yellow brown stains.
				Distinct contact

AP3 S20/203909

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.05	4.2	Sandy clay loam (2.5Y 7/4, pale yellow); slightly sticky; slightly plastic; slightly greasy; common fine pores stained orange; few orange and grey fine and medium sands scattered.
				Graded contact
Apitian lahars	•	0.2	4.45	Clast-supported sands with occasional gravel; thin inversely graded base grades upwards into normally graded upper portion of unit; very poorly sorted; clasts subrounded to rounded; abundant grey pumice clasts; few grey, black, red and purple lithic clasts; one grey lithic cobble observed in midddle of unit.
				Distinct contact
•	•	0.1	4.55	Very gritty sandy clay loam (10YR 5/3, brown); sticky; plastic; greasy; common grey, red and orange fine and medium sands scattered; few fine pores stained orange yellow.
				Graded contact
Apitian lahars	•	0.9	5.45	Clast-supported sand and granules; thick inversely graded base grades upwards into normally graded upper portion; largest clast 0.02 m; clasts subrounded to rounded; poorly sorted; few to common grey and black and few red lithic clasts; common grey and yellow pumice clasts; pumice commonly stained orange brown.
				Distinct contact
Apitian lahars	•	0.35	5.9	Sandy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.7 m; clasts subangular to subrounded; few black, grey and red lithic clasts; common grey and yellow pumice clasts; pumice clasts commonly stained yellowish brown and strongly weathered.

TE1 820/256902

Reference section

Te Heuheu Formation is exposed in a cutting beside the Whangaehu Valley Road 100 m below the junction of this road with State Highway 49.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
"	"	0.2	0.1	Dark brown topsoil, with scattered Taupo Ignimbrite sands.
				Graded contact
"	"	0.6	0.8	Sandy clay loam (10YR 6/8, brownish yellow); slightly sticky; slightly plastic; greasy; fine nut and crumb structure; few fine and medium roots; common grey and few purple and orange scattered fine sands; few medium pores stained purplish brown.
				Graded contact
"	"	0.4	1.2	Gritty sandy clay loam (10YR 6/6, brownish yellow); slightly sticky; slightly plastic; very greasy; firm blocky structure breaking to coarse nut and few crumbs; porous; few medium pores stained purplish brown; few live roots; few grey sands scattered.
				Graded contact
Bullot Formation	Ngamatea lapilli -2	0.02	1.22	Very gritty sandy clay loam (10YR 5/8, yellowish brown); sticky; non plastic; very greasy; common grey and yellow ash to medium lapilli scattered; lapilli commonly stained orange brown; slightly porous.
				Distinct contact
"	"	0.42	1.64	Gritty sandy clay loam; sticky; slightly plastic; greasy; blocky structure breaking to medium nut with few crumbs; porous; few fine to medium pores, stained yellowish brown; common grey and yellow and few red and purple sands scattered.
				Graded contact
Bullot Formation	Ngamatea lapilli -1	0.1	1.74	Very gritty sandy clay loam (7.5YR 6/8-10YR 6/8, reddish yellow to brownish yellow); common soft and pumiceous grey, orange and pale yellow and occasional red medium lapilli, scattered.
				Distinct contact
"	"	0.36	1.10	Very slightly gritty sandy clay loam; plastic; sticky; greasy; firm blocky structure breaks to fine nut and crumb; few medium pores stained purplish brown; common orange mottles; few to common grey sand scattered; occasional lithic gravels in base.

ON TE HEUHEU FORMATION

TE2 S20/285916

Reference section

Te Heuheu Formation and overlying coverbeds are exposed in a cutting on the north side of the North Island Main Trunk Line, *c.* 20 m above its bridging point over the Tokiahuru River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
"	"	0.2	0.2	Dark brown topsoil
				Graded contact
"	"	0.7	0.9	Very gritty sandy clay loam (2.5Y 5/6, light olive brown); non sticky; non plastic; greasy; moderately developed fine nut and crumb structure; friable; few grey and red sands scattered throughout; common pale cream glassy Taupo Ignimbrite pumice sands in upper 0.4 m; common roots.
				Graded contact
"	"	0.1	1	Sandy clay loam (10YR 7/8, yellow); non sticky; non plastic; slightly greasy; weak blocky structure breaking to medium nut with some crumb.
				Graded contact
Bullot Formation	Ngamatea lapilli -2	0.2	1.2	Very gritty sandy clay loam (10YR 4/6-6/8, dark yellowish brown); non sticky; non plastic; very greasy; blocky structure breaks to weak medium nut and crumb; very porous; pores stained purplish brown; common to abundant pale yellow medium and coarse lapilli scattered throught.
				Distinct contact
"	"	0.2	1.4	Gritty sandy clay loam; slghtly sticky; slightly plastic; greasy; moderately developed coarse nut with some crumb; few medium pores stained purplish brown; slightly porous; common ngrey and few orange and yellow sands scattered.
				Graded contact
Bullot Formation	Ngamatea lapilli -1	0.3	1.7	Gritty sandy clay loam; slightly sticky (2.5YR 5/4-5/6, reddish brown to red); non plastic; very greasy; blocky structure breaks to fine nut and crumb; few medium pores, stained brown; common orange, yellow, black and grey sacttered medium and coarse lapilli.
				Distinct contact
"	"	0.4	2.1	Slightly gritty sandy clay loam (2.5YR 4/4, reddish brown); slightly sticky; non plastic; greasy; blocky structure breaks to weakly developed coarse nut and some crumb; common pores stained brown; common black, orange and grey fine sand scattered throughout.
				Graded contact
"	"	0.2	2.3	Gritty sandy clay loam (10YR 4/6, dark yellowish brown); non sticky; non plastic; greasy; common scattered sandfs and gravels and occasional cobbbles and boulders; colluvium.
				Distinct contact
"	"	0.5	2.8	Very gritty sandy clay loam (10YR 6/8-5/8, brownish yellow to yellowish brown); non sticky; non plastic; very greasy; abundant clast-supported, steeply bedded, well sorted orange and common grey fine to medium lapilli; strong black manganese staining.
				Distinct contact
Te Heuheu Formation	"	1	3.8	Clast-supported sand and gravel; inversely graded; weakly bedded; very poorly sorted; largest clast 1.1 m; clasts anguler to rounded, commonly subangular; common grey and orange and few red and purple lithic clasts.
				Distinct contact

TE2 820/285915

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.35	4.15	Very slightly gritty sandy clay (7.5YR 6/8-10YR 6/8, reddish yellow to brownish yellow); non sticky; non plastic; very greasy; fine nut and some crumb; abundant orange and few grey strongly weathered medium to coarse lapilli.
				Distinct contact
•	•	0.05	4.2	Slightly gritty sandy clay loam; blocky structure; few black, grey, orange and white fine lapilli.
				Graded contact
•	•	0.1	4.3	Gritty sandy clay loam; non sticky; non plastic; very greasy; abundant soft weathered orange medium and coarse lapilli.
				Distinct contact
•	•	0.45	4.75	Very slightly gritty sandy clay loam; slightly sticky; non plastic; very greasy; few black and white sands scattered; common fine pores stained yellowish orange.

TG1 821/209877

Reference section

Tree stumps in growth position are exposed in the undercut banks of a tributary of the Mangawherawhera Stream on the left side of Oruakukuru Road, *c.* 1.6 km northeast of the junction of this road with Old Fields Track.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.6	0.6	Silty sand (10YR 3/3, dark brown); non sticky; non plastic; slightly greasy; few orange sands scattered; common live roots; few manganese and iron nodules.
				Graded contact
•	•	0.1	0.7	Bedded silty diatomaceous sediment (10YR 4/3, brown), with few glassy fine lapilli and ash; few yellowish brown mottles.
				Distinct contact
•	•	0.5	1.2	Gritty sandy clay loam (10YR 3/2, very dark greyish brown); slightly sticky; slightly plastic; greasy; firm blocky structure; common twigs, roots, bits of wood and tree stumps, dated (Wk-1773) at 7,800 ± 70 years B.P., in growth position.
				Graded contact
•	•	0.3	1.5	Gritty silty sand (10YR 3/2, very dark greyish brown); massive; firm; non sticky; non plastic.

TQ3 S21/287872

Reference section

Onetapu and Tangatu Formation are exposed in bluffs on the east bank of the Whangaehu River, *c.* 1.5 km downstream of the bridging point of Strachans Road over the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.4	0.4	Sandy matrix-supported gravel; inversely graded to middle then normally graded; very poorly sorted; largest clast 0.09 m; clasts subangular to subrounded; abundant black and common grey and few red and soft white and orange lithic clasts; matrix colour 2.5Y 4/2, dark greyish brown.
				Distinct non-erosional contact
"	"	0.11	0.51	Fine sandy loam (10YR 5/4- 2.5Y 5/4, yellowish brown to light olive brown); non sticky; non plastic; weakly developed fine crumb; occasional sandy olive grey hard andesitic pumice clasts; occasional reworked Taupo Ignimbrite pumice granules and pieces of charcoal.
				Graded contact
Onetapu Formation	Ong	1.8	2.31	Clast-supported sands (2.5Y 5/2-4/2, greyish brown to dark greyish brown); distinct mm thick grade upwards into cm thick beds; normally graded; poorly sorted; largest clast 0.02 m; clasts subangular to rounded; common black and few grey, red and purple lithic clasts; abundant grey pumice clasts; few stained orange and soft; few scattered reworked Taupo Ignimbrite clasts.
				Distinct contact
"	"	0.09	2.4	Gritty sandy silt loam (2.5Y 5/4,light olive brown); friable; non sticky; slightly plastic; sticky; weakly developed fine nut and crumb; common sandy andesitic and reworked Taupo ignimbrite clasts; common live roots.
				Graded contact
Onetapu Formation	Ong	1.1	3.5	Clast-supported sands and granules (2.5YR 4/2 dark greyish brown, appears mottled olive and grey); normally graded; poorly sorted; largest clast 0.005 m; massively bedded grades into upper 0.1 m with faint laminae; clasts subangular to subrounded; common black and few red and grey lithic clasts; common grey pumice clasts, commonly stained orange; few well rounded Taupo Ignimbrite granule-sized pumice clasts; few live roots.
				Distinct contact
"	"	0.5	4	Sandy loam (2.5Y 5/4, light olive brown), with few scattered gravel-sized lithic clasts; weakly developed block breaking to fine crumb; common roots.
				Graded contact
Onetapu Formation	Onf	0.15	4.15	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; 2.5Y 4/2, dark greyish brown with 7.5YR 5/6, strong brown, mottles; abundant grey and common black and few red and few white (soft and commonly stained orange) lithic clasts; clasts commonly stained orange.
				Distinct contact
"	"	0.9	5.05	Slightly gritty sandy silt loam (10YR 6/8-5/6, brownish yellow); non sticky; non plastic; common medium pores stained dark purplish brown; common creamy Taupo Ignimbrite pumice granules in upper 0.15 m; few orange fine to medium lapilli scattered.
				Graded contact

TG3 S21/287872

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Tangatu Formation	"	1	6.05	Clast-supported sands; 10YR 5/3, brown; massive; laminae; ungraded; largest clast 0.2 m; clasts subrounded to rounded; poorly sorted; common black and few red lithic clasts; abundant grey hardvesicular pumice clasts.
				Distinct contact
"	"	0.5	6.55	Slightly gritty sandy loam (10YR 6/4, light yellowish brown); non sticky; non plastic; weakly developed coarse nut and crumb; fine to medium grey pumice sands scattered; common pores stained black; common fine roots.
				Distinct contact
Tangatu Formation	"	2.5	9.05	Clast-supported sands and granules; massive; distinct cm thick beds; moderately sorted.
				Distinct contact
Tangatu Formation	"	0.4	9.45	Clast-supported gravel; poorly sorted; ungraded; common black lithic clasts; common grey pumice clasts.
				Distinct contact
Tangatu Formation	"	7	16.45	Clast-supported gravel (10YR 3/2, very dark greyish brown, speckled); normally graded; distinct cm thick beds; largest clast 0.2 m; clasts subangular to rounded; very poorly sorted; common black and few red and occasional soft white lithic clasts; common grey pumice; occasional Tertiary siltstone pebbles.
				Distinct contact
Tangatu Formation	"	20	36.45	Clast-supported sand and gravel; distinct cm thick beds, which follow the channel configuration; ungraded; largest clast 0.05 m; clasts subangular to rounded; very poorly sorted; common black and grey and few red lithic clasts; occasional grey pumice clasts; occasional Tertiary siltstone pebbles.
				Distinct erosional contact
Tangatu Formation	"	2.8	39.25	Clast-supported sand and granules (10YR 3/3, dark brown, speckled); distinct cm thick beds; ungraded; largest clast 0.01 m; clasts subrounded to rounded; abundant grey pumice; common black and grey and few red lithic clasts.
				Graded contact
"	"	0.75	40	Pale orange sandy loam.
				Graded contact
Tangatu Formation	"	5.	45	Clast-supported sand and gravel (10YR 3/2, very dark greyish brown); ungraded; distinct cm thick beds; largest clast 0.02 m; clasts subangular to rounded; poorly sorted; common black and grey and few red lithic clasts; abundant grey pumice.
				Distinct contact
Tangatu Formation	"	1.	53.	Clast-supported sands and gravels (10YR 6/2, light brownish grey); distinct cm thick beds; inversely graded; largest clast 0.015 m; clasts subrounded to rounded; abundant grey pumice clasts; common black, grey and few red lithic clasts.
				Distinct contact

TQ3 821/287872

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Tengatu Formation	**	1.	64.	Clast supported sands (10YR 6/2-6/3, light brownish grey to pale brown); ungraded; laminae; poorly sorted largest clast 0.005 m; clasts subrounded to rounded; common black and few red and grey lithic clasts; abundant grey pumice.

TG4 S21/280887

Reference section

Tangatu Formation is exposed in a metal pit on the west bank of the Whangaehu River, on the left side of Strachans Road.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
"	"	0.65	0.65	Gritty sandy clay loam (10YR 5/8, yellowish brown); slightly sticky; slightly plastic; slightly greasy; blocky structure breaking to weakly developed fine nut and crumb; common fine roots; scattered Taupo ignimbrite lapilli in top 0.1 m; common scattered black and grey and orange sands.
				Graded contact
Tangatu Formation	"	0.22	0.87	Clast-supported sands; inversely graded; distinct mm thick laminae; poorly sorted; largest clast 0.3 m; clasts rounded; common grey and black and few red lithic clasts; few dacitic pumice blocks.
				Distinct contact
"	"	0.43	1.3	Gritty sandy clay loam (10YR 5/6, yellowish brown); non sticky; non plastic; greasy; blocky structure breaks to moderately dveloped fine nut and crumb; common grey and black and few red sands scattered; few orange mottles and stains on clasts.
				Graded contact
Tangatu Formation	"	0.18	1.48	Clast-supported sands; ungraded; distinct mm thick laminae; largets clast < 0.005 m; clasts sunangular to subrounded; abundant black and common grey lithic clasts; few to common grey pumice clasts.
				Graded contact
"	"	0.25	1.73	Gritty sandy loam (2.5YR 4/6-10YR 4/6, red to dark yellowish brown); non sticky; non plastic; firm blocky structure ; common pores stained black; common black and faw yellow sands scattered.
				Graded contact
Tangatu Formation	"	1.2	2.93	Clast-supported sand and granules; ungraded; massive; very poorly sorted.
				Distinct contact
"	"	0.4	3.33	Clast-supported, well sorted, wall rounded dacitic pumice gravel.
				Distinct contact
Tangatu Formation	"	1.7	5.03	Clast-supported gravel; weakly inversely graded; distinct cm thick bedding; very poorly sorted; largest clast 0.03 m; clasts angualr to subrounded; common blacks nd grey and few red lithic clasts; common grey pumice clasts, becoming abundant in upper 0.5 m of unit.
				Distinct contact
"	"	0.1	5.13	Sandy loam; non sticky; non plastic; firm blocky structure; few to common grey, black and white sands scattered throughout.
Tangatu Formation	"	0.6	5.73	Clast-supported sands and granules; ungraded; distinct cm thick bedding; abundant black and few red lithic clasts; common grey pumice clasts.
				Distinct contact
"	"	0.1	5.83	Sandy loam (2.5YR 4/2, weak red); non sticky; non plastic; common grey and black sands scattered throughout.
				Graded contact

TG4 521/280887

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Tangatu Formation	•	1.6	7.33	Clast-supported sand and granules; normally graded; distinct cm thick bedding; very poorly sorted; largest clast 0.02 m; clasts subangular to subrounded; common black and few red lithic clasts; abundant grey pumice clasts; occasional Tertiary siltstone pebbles.
				Distinct contact
Tangatu Formation	•	12	19.73	Clast-supported gravel; normally graded; very poorly sorted; distinct cm thick bedding throughout unit; bedding dominantly horizontal and continuous over at least 1 m, although at margins to unit bedding is steeply inclined, and groups of beds separated by lenses of silt; In basal 6 m discontinuous zones of sand and granule matrix-supported gravel; largest clast 1.6 m; clasts subangualr to rounded; commonly subangular; few Tertiary siltstone rip-up clasts; common black and red lithic clasts; common grey pumice clasts.
				Distinct contact
Tangatu Formation	•	4	23.93	Clast-supported gravel; thin inversely graded base grades upwards into normally graded main upper portion to unit; very poorly sorted; distinct cm thick laminae throughout unit; largest clast 0.07 m; clasts subangualr to rounded, commonly subrounded; common black and grey and few red lithic clasts; common grey pumice clasts.
				Distinct contact
•	•	0.17	24.1	Gritty sandy silt loam (10YR 3/3, dark brown); structureless; discontinuous.
				Distinct contact
Tangatu Formation	•	1.2	25.3	Clast-supported sand and granules; ungraded; distinct cm thick bedding; poorly sorted; largest clast 0.016 m; clasts subangular to rounded; ; common black, grey and red lithic clasts; common grey pumice clasts; occasional Tertiary siltstone pebbles.
				Distinct contact
Tangatu Formation	•	1.6	26.8	Clast-supported sands and granules; ungraded; distinct cm thick bedding; poorly sorted; largest clast 0.01 m; clasts subangular to rounded; common black and few red and white lithic clasts; abundant grey pumice clasts.

TG6 521/278888

Reference section

Tangatu Formation is exposed in a pit on the west bank of the Whangaehu River, on the right side of Strachans Road, facing North.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.3	0.3	Gritty sandy clay loam; non sticky; non plastic; slightly greasy; fine crumb structure; common orange, black and grey sands scattered; occasional gravel; common fine roots; appears cracked in face.
				Graded contact
Tangatu Formation	•	0.15	0.45	Discontinuous lenses of clast-supported, poorly sorted, subangular and subrounded sands.
				Graded contact
•	•	0.3	0.75	Very gritty sandy clay loam (10YR 5/6, yellowish brown); non sticky; non plastic; slightly greasy; common orange and black sands scattered.
				Graded contact
Tangatu Formation	•	0.2	0.95	Clast-supported sands; ungraded; mm thin laminae; poorly sorted; largest clast 0.01 m; clasts subrounded and rounded; abundant grey pumice clasts.
				Distinct contact
Bullot Formation	Ngamatea lapilli -2	0.05	1	Very gritty sandy clay loam; abundant orange and common black,gray and yellow medium and coarse lapilli.
				Distinct contact
•	•	0.1	1.1	Very gritty sandy clay loam (10YR 5/6, yellowish brown); non plastic; non sticky; very greasy; blocky structure; common orange, black and cream sands scattered.
				Graded contact
Tangatu Formation	•	0.12	1.22	Clast-supported sands; ungraded; poorly sorted; distinct mm thick laminae; largest clast 0.01 m; clasts angular to subrounded, commonly subrounded.
				Distinct contact
Bullot Formation	Ngamatea lapilli -1	0.1	1.32	Very gritty sandy clay loam; abundant orange and common black grey and few yellow medium and coarse lapilli.
				Graded contact
•	•	0.25	1.57	Gritty sandy clay loam (10YR 5/6, yellowish brown); slightly sticky; very slightly plastic; very greasy; blocky structure breaks to fine nut and crumb; common orange and black and few white sands scattered.

ON TE HEUHEU FORMATION

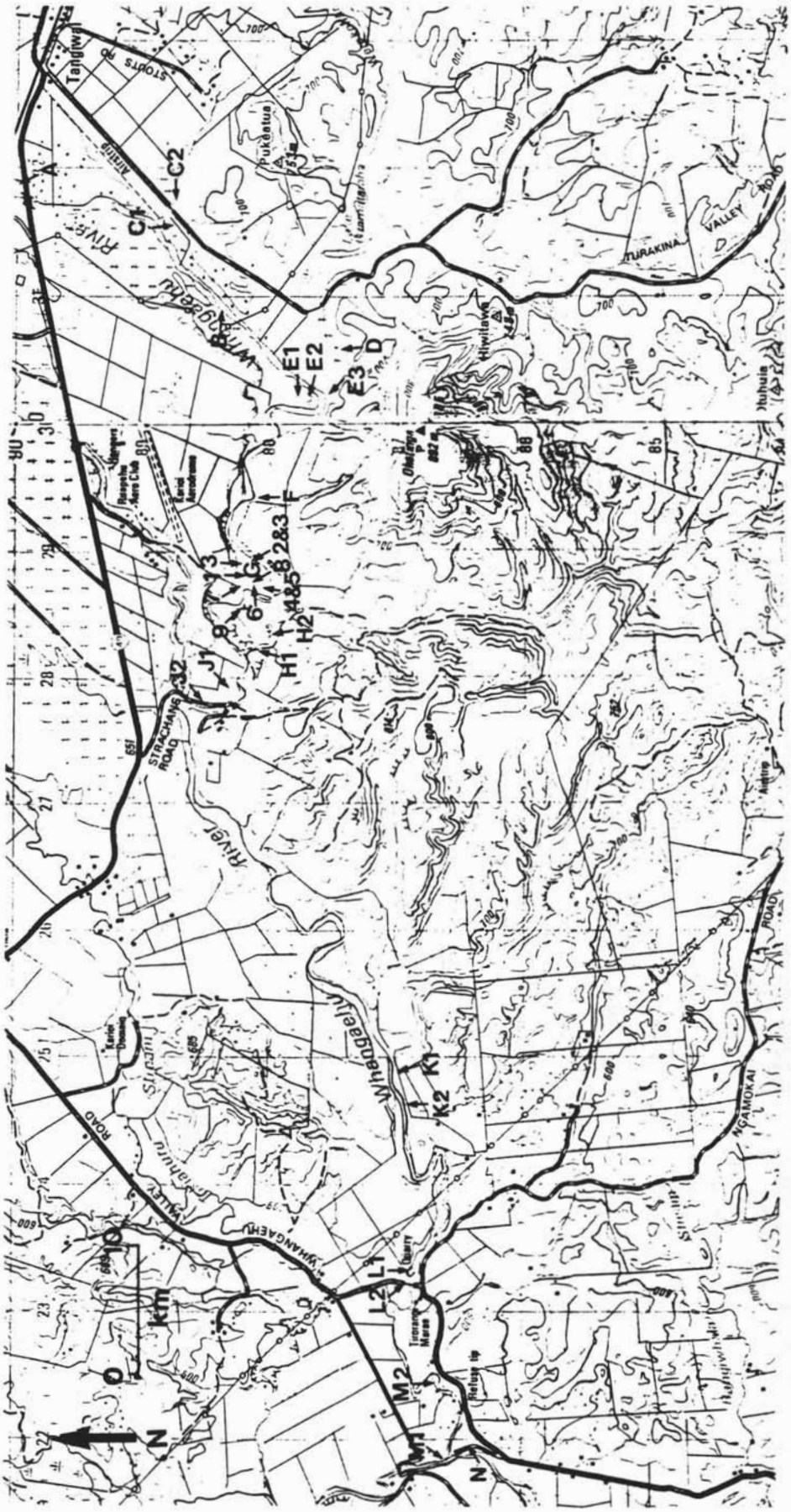

Figure A.1 Map showing localities of sections A - N on the southern edge of the Mount Ruapehu ring plain.

A T20/318901

Reference section

Onetapu Formation deposits are exposed in a low terrace on the east bank of the Whangaehu River, on the north side of State Highway 49,between Tangiwai road and rail bridges.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
				Dark brown topsoil
				Graded contact
Onetapu Formation	Onk	0.35	0.35	Sandy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.8 m; clasts angular to rounded, commonly subangular; common black and grey lithic clasts.
				Distinct non-erosional contact
Onetapu Formation	Oni	0.30	0.65	Sandy matrix-supported very coarse sand and gravel; slightly normal graded; very poorly sorted; largest clast 0.07 m; clasts angular to subangular; common black and grey and few white lithic casts.
				Distinct non-erosional contact
Onetapu Formation	Onh	1.10	1.75	Sandy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.6 m; casts subrounded to rounded; common grey and black and few red lithic clasts, commonly pitted on surface; occasional orange stains on casts; matrix colour 10YR 5/2, greyish brown.
				Distinct non-erosional contact
Onetapu Formation	Ong3	0.1	1.85	Clast-supported fine to medium sand; medium to poorly sorted; ungraded; faint mm thick laminae; largest clast < 0.005 m; common black and grey lithic casts; common roots.
				Distinct non-erosional contact
Onetapu Formation	Ong2	0.45	2.3	Clast-supported sands and few gravel; occasional cobbles and boulders; normally graded; poorly sorted; largest clast 0.5 m; clasts subangular to rounded; very faint mm thick laminae; common orange stains on casts; common grey and few red lithic casts; few to common pumice; upper 0.1 m weakly developed (2.5YR 5/6, dark red) gritty, friable, non sticky non plastic silty sand with common roots.
				Graded contact
Onetapu Formation	Ong1	0.7	3	Clast-supported very coarse sand and gravel, grading upwards into clast-supported sands which are faintly laminated; normally graded; very poorly sorted; largest clast 0.4 m; clasts subangular to rounded, commonly subangular; common grey and black and few red and purple, occasional hard white lithic clasts; few pale grey pumice clasts.
				Distinct no-erosional contact
Onetapu Formation	Onf	0.8	3.8	Muddy matrix-supported gravel; ungraded, although boulders are concentrated near to the top; very poorly sorted; largest clast 0.90 m; clasts angular to rounded, commonly subangular; cobble and boulder-sized clasts commonly subrounded to rounded; common grey black and red and occasional white lithic clasts; common orange red stains on clasts; matrix colour 10YR 4/4, dark yellowish brown.
				Distinct non-erosional contact
Onetapu Formation	Ona	0.3	4.1	Muddy matrix-supported gravels; clast-rich; ungraded; very poorly sorted; largest clast 0.02 m; clasts subangular to rounded, commonly subrounded; common black and grey and few red lithic clasts; common red and orange stains on clasts; matrix colour 10YR 6/8-7.5YR 5/8, brownish yellow to strong brown, mottled olive grey-orange.

B T21/310881

Reference section

Onetapu Formation deposits are exposed in a low terrace on the west bank of the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.12	0.12	Sandy matrix-supported sand and gravel; ungraded; very poorly sorted; contains few clasts of reworked well rounded Taupo Ignimbrite near to its base.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.12	0.24	Clast-supported medium to very coarse sand; ungraded; massive.
				Distinct non-erosional contact
Onetapu Formation	Onf	0.4	0.64	Muddy matrix-supported gravel; ungraded; very poorly sorted; matrix colour 10YR 5/1, gray.
				Distinct non-erosional contact
Onetapu Formation	Ond	0.15	0.79	Particle supported sands; ungraded; massive.
				Distinct non-erosional contact
Taupo Ignimbrite	*	0.6	1.39	Dominantly glassy fine ash and lapilli, overlain by *c.* 0.05 m of well rounded,well sorted white pumice gravels.

C1 T21/316887

Reference section

Onetapu Formation deposits are exposed in the east bank of the Waitangi Stream, 500 m above its confluence with the Whangaehu River, and below the bridging point of the Turakina Valley Road over the Waitangi stream.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onv	0.15	0.15	Clast-supported sands; ungraded; massive.
				Distinct non-erosional contact
Onetapu Formation	Onh	0.65	0.8	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clasts 0.15 m; clasts subangular to subrounded.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.30	1.1	Clast-supported sands; ungraded; poorly sorted; largest clast < 0.005 m.
				Distinct non-erosional contact
Onetapu Formation	Onf	1.1	2.2	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.05 m; clasts subangular to rounded, commonly subrounded.

C2 T21/317888

Reference section

Onetapu Formation deposits are exposed in the east bank of the Waitangi Stream, 600 m upstream of its confluence with the Whangaehu River, and above the bridging point of the Turakina Valley Road over the Waitangi stream.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.6	0.6	Sandy matrix-supported gravels; normally graded; very poorly sorted; largest clast 0.03 m; clasts angular to subrounded, commonly subangular; common black and grey and few red and occasional orange and white lithic clasts; occasional reworked Taupo Ignimbrite clasts; matrix colour 2.5YR 4/4-10YR 4/4, reddish brown to dark yellowish brown.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.30	0.9	Clast-supported sands; normally graded; faint mm laminae; largest clast < 0.005 m; clasts subangular to subrounded; overall colour 10YR 3/4, dark yellowish brown; common fine roots.
				Distinct non-erosional contact
Onetapu Formation	Onf	1.3	2.2	Muddy matrix-supported gravel; normally graded, with clast-rich base; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; common black and grey and few red, orange and white clasts; matrix colour 10YR 4/4-4/2, dark yellowish brown to dark greyish brown, with orange mottles.

D T21/305876

Reference section

Onetapu Formation deposits are exposed in a channel cut into Taupo Ignimbrite on the west bank of a stream which drains Lake Otamatereha.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onk	0.6	0.6	Clast-supported sands; ungraded; poorly sorted; massive; few to common black, grey and red lithic clasts; common grey pumice clasts.
				Distinct non-erosional contact
Onetapu Formation	Onj	0.6	1.2	Muddy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.1 m; clasts angular to rounded, commonly subangular; abundant grey glassy lithic clasts; channel filling lenticular deposit.
				Distinct non-erosional contact
Onetapu Formation	Onh	0.4	1.6	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.04 m; clasts angular to rounded, commonly subrounded; common grey and few red lithic clasts; channel filling lenticular deposit.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.4	2	Clast-supported sands; ungraded; poorly sorted; massive; common grey pumice clasts; channel filling lenticular deposit.
				Distinct erosional contact
Taupo Ignimbrite	*	1.5	3.5	Dominantly glassy fine ash and lapilli, with pieces of charcoal.

E1 T21/303877

Reference section

Onetapu Formation deposits are exposed in the northernmost section in a metal pit on a meander bend on the west bank of the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Oni	0.4	0.4	Clast-supported sands; ungraded; mm thick laminae; poorly sorted; largest clast 10 mm; clasts subangular to subrounded.
				Graded contact
Onetapu Formation	Onh	1.5	1.9	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 1 m; clasts subangular to rounded, commonly subrounded; larger clasts commonly rounded; common grey, black, purple and red lithic clasts; orange stains common on clasts; thick channel filling deposit grades laterally away from main flow channel to thinner tabular beds.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.7	2.6	Clast-supported sands; ungraded; poorly sorted; largest clast 0.01 m; clasts subangular to rounded, commonly subangular; common black, grey purple and red lithic clasts; common brown grey pumice.
				Distinct non-erosional contact
"	"	0.1	2.7	Gritty sandy clay loam (10YR 3/4, dark yellowish brown); weak fine crumb; common fine roots; gravel scattered throughout.
				Graded contact
Onetapu Formation	Onf	0.75	3.45	Muddy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.15 m; clasts angular to rounded, commonly subrounded to rounded; common grey, black and few red lithic clasts; clasts stained orange red; occasional soft altered clast; matrix colour 10YR 3/1, very dark grey, with orange red mottles.
				Distinct non-erosional contact
"	"	0.06	3.51	Very gritty sandy clay loam (10YR 3/2, very dark greyish brown); very weak crumb structure; few roots; sandy.
				Graded contact
Onetapu Formation	One	0.9	3.6	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.2 m; clasts angular to rounded, commonly subrounded to rounded; common black, grey and few red lithics clasts; clasts commonly stained orange red; matrix colour 10YR 3/2, very dark greyish brown.
				Contact obscured
Taupo Ignimbrite				Dominantly glassy fine white ash and lapilli; pinkish red hue to ash; few charcoal logs.

E2 T21/302876

Reference section

Onetapu Formation deposits are exposed in the southernmost section in a metal pit on the west bank of the Whangaehu River. Younger members Onh, Oni, Onj and Onk fill a channel cut into underlying Ong.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onk	1	1	Clast-supported gravel; normally graded to middle then inversely graded; very poorly sorted, with poorly sorted middle; clasts subangular to subrounded; largest clast 0.65 m; common black and grey and few red lithic clasts.
				Distinct non-erosional contact
Onetapu Formation	Onj	0.5	1.5	Muddy matrix-supported gravel; ungraded; very poorly sorted; clasts subangular to subrounded; largest clast 0.15 m; abundant grey glassy, common black and few red lithic clasts; common orange stains on clasts; matrix colour 10YR 3/1, very dark grey, with olive-orange mottles.
				Distinct non-erosional contact
Onetapu Formation	Oni	0.45	1.95	Clast-supported sands; ungraded; massive; poorly sorted; largest clast 0.06 m; clasts subangular to subrounded; coarsens to inversely graded matrix-supported gravel east towards main flow channel.
				Distinct non-erosional contact
Onetapu Formation	Onh	0.95	2.9	Sandy matrix-supported gravel; inversely graded base grades to normally graded main portion; very poorly sorted; largest clast 0.7 m; clasts subangular to rounded, commonly subangular; common black grey and few red lithic clasts; few clasts stained orange.
				Distinct non-erosional contact
Onetapu Formation	Ong	1.5	4.4	Clast-supported sands, with some gravel; ungraded; weak cm thick beds; very poorly sorted; largest clast 0.06 m; clasts angular to rounded, commonly subangular; common black, grey and few red and purple and white lithic clasts; common grey brown pumice; overall colour 10YR 3/4, dark yellowish brown.
				Distinct non-erosional contact
Onetapu Formation	Onf	0.7	5.1	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.3 m; clasts subrounded to rounded; common black and grey and few red and white lithic clasts; clasts commonly stained orange red; matrix colour 10R 4/2-4/3, dark greyish brown to dark brown, with orange-red mottles.

E3 T21/303876

Reference section

Onetapu Formation deposits are exposed in a track cutting through a terrace on the east bank of the Whangeshu River, immediately opposite E1 & E2.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.2	0.2	Dark brown top soil
				Graded contact
Onetapu Formation	Onj	0.2	0.4	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; abundant dark grey glassy lithic clasts; matrix colour 10YR 5/2, greyish brown; clasts commonly stained orange.
				Distinct non-erosional contact
Onetapu Formation	Onh	0.8	1.2	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.12 m; clasts angular to rounded, commonly subrounded; common black and grey with few red and occasional white lithic clasts; matrix colour 10YR 3/3, dark brown.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.45	1.65	Clast-supported sands; ungraded; poorly sorted; cm thick beds; largest clast < 0.005 m; clast angular to subrounded, commonly subangular; common black and grey lithic clasts; deposit infills a small channel cut into Taupo Ignimbrite.
				Distinct erosional contact
•	•	0.3	1.95	Gritty sandy clay loam (10YR 3/4, dark yellowish brown); moderately developed fine nut and crumb; non sticky; non plastic; non greasy; common Taupo Ignimbrite clasts scattered throughout.
Taupo Ignimbrite	•	7.5	8.45	Fine glassy ash to medium lapilli; massive; ungraded; creamy pink colour; common pieces of charcoal.

F 821/284882

Reference section

Onetapu Formation, Taupo Ignimbrite, Mangaio Formation and Tangatu Formation are exposed on the outside of a meander bend on the outside of a meander bend on the east bank of the Whangaehu River. Below this section is a hyperconcentrated flow deposit containing anthropogenic debris, and probably deposited by the 1953 lahar.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onj	0.6	0.6	Muddy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; common glassy gray and few black and occasional white lithic clasts; matrix colour 10YR 4/2, dark greyish brown, appears grey with olive mottles.
				Distinct non-erosional contact
"	"	0.05	0.66	Very gritty sandy loam (10YR 5/4, yellowish brown); non sticky; non plastic; non greasy; common fine roots; scattered sand throughout.
				Graded contact
Onetapu Formation	Onh	1.5	2.15	Sandy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.25 m; clasts subangular to rounded, commonly subrounded; common black and gray and few red lithics clasts; few clasts with orange staining; matrix colour 10YR 4/2, dark greyish brown, appears brown.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.8	1.95	Clast-supported sands; ungraded; cm thick beds; poorly sorted; clasts angular to subrounded; common black and grey and few red lithic clasts; few to common grey pumice; unit pinches out away from river.
				Contact obscured
Taupo Ignimbrite	"	1.5	3.45	Taupo Ignimbrite; massive glassy fine ash and lapilli; ungraded; creamy coloured.
				Distinct contact

ON MANGAIO FORMATION AND TANGATU FORMATION.

Q1 S21/288882

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.18	0.18	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.04 m; clasts subangular to subrounded; common black, grey and red lithic clasts; clasts commonly stained orange-red (2.5YR 4/8, red); matrix colour 10YR 5/2, greyish brown, appears mottled grey and olive brown; lenses of grey (10YR 5/1, grey) with
				Distinct non-erosional contact
"	"	0.17	0.35	Clast-supported, well sorted, well rounded Taupo Ignimbrite gravel clasts; thin very fine silty sand matrix; orange stained.
				Distinct wavy erosional contact
Onetapu Formation	Onf	0.5	0.85	Muddy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.03 m; clasts subangular to rounded, commonly subrounded; common black red and grey and few orange and white lithic clasts; occasional soft altered orange and white clasts; matrix colour 10YR 5/4-5/6, yellowish brown.
				Distinct contact
"	"	0.05	0.9	Clast-supported, well sorted well rounded reworked Taupo Ignimbrite gravel clasts; thin muddy matrix, colour 10YR 7/8, yellow, mottled strong orange; blocks of charcoal.
				Graded contact
Onetapu Formation	Ona	0.12	1.02	Clast-supported sands; ungraded; poorly sorted; thin matrix, colour 10YR 7/2-7/6, light grey to yellow, appears mottled orange, grey and olive grey; largest clast < 0.002 m; few flecks charcoal.
				Distinct erosional contact
"	"	0.2	1.22	Clast-supported, well sorted, well rounded Taupo Ignimbrite gravel clasts; thin muddy matrix, colour 10YR 8/8-10YR 8/2, yellow to white, appears mottled grey and orange; common pieces of charcoal.
				Graded contact
Taupo Ignimbrite	"	0.25	1.47	Fine ash and fine to medium lapilli; glassy; 10YR 8/4, very pale brown, appears mottled brown-cream; slightly reverse graded; massive.
				Graded contact
Taupo Ignimbrite	"	0.90 m +	2.37 m +	Fine ash and few fine to coarse lapilli; 10YR 8/3 appears pale creamy brown; massive; glassy; ungraded.

G2 S21/288882

Reference section

Formation	Member	Unit thickness	Cumulative thickness (m)	Description
Onetapu Formation	Onl	0.11	0.11	Clast-supported sand and gravel; inversely graded; cm thick beds; well sorted; largest clast 0.01 m; clasts subrounded to subangular; abundant black common grey, and few red, orange and white lithic clasts; few pale grey pumice clasts.
				Distinct contact
Onetapu Formation	Onk	0.12	0.23	Clast supported sands; 10YR 4/4, dark yellowish brown, speckled; ungraded; weak cm and mm thick laminae and beds; moderately sorted; largest clast 0.005 m; clasts subangular to subrounded; common black and white grey and few red lithic clasts.
				Graded contact
Onetapu Formation	Onj	0.2	0.83	Muddy matrix-supported gravel; lower 0.05 m inversely graded grades into upper normally graded portion; very poorly sorted; largest clast 0.3 m; clasts subangular to subrounded; abundant grey and common black and few red white and orange lithic clasts; matrix colour 10YR 5/2, greyish brown, appears mottled orange-olive; very fine sandy top; common roots.
				Graded contact
"	"	0.07	0.87	Sandy loam (10YR 5/6, yellowish brown); occasional lenses of dark greyish brown andesitic medium to coarse lapilli scattered; few live roots; iron pan at top.
				Graded contact
Onetapu Formation	Onh	0.6	1.37	Sandy matrix-supported gravel; grades vertically upwards from normally graded base through an ungraded central portion into a normally graded upper portion; in profile grading is undulose; very poorly sorted; largest clast 0.1 m; clasts angular to rounded; abundant black and grey with few red purple and white (occasionally soft) lithic clasts; common clasts stained orange; matrix colour 10YR 4/3-5/2, dark brown to greyish brown, appears mottled grey (10YR 8/1, grey) and orange (10YR 5/6-5/8, yellowish brown).
				Distinct contact
"	"	0.10	1.82	Sandy silty loam (10YR 5/6, yellowish brown, appears olive brown); weakly developed fine to medium nut and crumb; non sticky; non plastic; sandy base; common live roots.
				Graded contact
Onetapu Formation	Ong3	0.60	2.72	Clast-supported sands; 10YR 4/4-3/4, dark yellowish brown, speckled; weak normal grading; weak mm thick laminae; largest clast 0.005 m; clasts subangular to subrounded; moderately poorly sorted; common black grey red and purple and few orange and cream (occasionally soft) lithic clasts.
				Graded contact
Onetapu Formation	Ong2	0.35	3.07	Clast-supported sands; massive; poorly sorted; largest clast < 0.002 m; slight coarsening in top 0.1 m; common black grey and red lithic clasts; few Taupo ignimbrite medium to coarse lapilli; appears 10YR 4/3, dark brown, appears mottled orange and grey.
				Distinct contact

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Ong1	0.05	3.12	Clast-supported granules; ungraded; largest clast 0.005 m; clast subangular to subrounded; poorly sorted; common black and with few orange and white lithic clasts.
				Distinct contact
Onetapu Formation	Onf	2.00	5.12	Muddy matrix-supported gravel; normally graded; very poorly sorted; clasts rounded; largest clast 0.28 m; common black and grey and few red and white lithic clasts; few Tertiary siltstone clasts; matrix colour 2.5Y 4/4, olive brown;
				Distinct contact
Onetapu Formation	Onc	0.60	5.72	Clast-supported sands; massive; ungraded; poorly sorted; clasts subangular to angular; common black and grey and few red, orange, and white lithic clasts; overall colour mostly 2.5Y 4/4, olive brown; with 10YR 3/2, very dark greyish brown mottles; lithified in discontinuous patches associated with thin (< 0.01 m) reddish brown iron pans.
				Non distinct contact
Onetapu Formation	Onb	0.35	6.07	Clast-supported sands; ungraded; poorly sorted; massive; common black and grey and few red and white lithic clasts; overall colour 2.5Y 4/4, olive brown; discontinuous line of reworked Taupo Ignimbrite 0.02 m from base.
				Distinct contact
Onetapu Formation	Ona	0.37	6.44	Muddy matrix-supported gravel; inversely to normally graded; very poorly sorted; clasts subrounded to rounded; common grey and few black and red lithic clasts; few to common clasts with strong brown mottles; few Taupo Ignimbrite creamy pumice clasts with long vesicles; matrix colour 10YR 6/1, grey, with 7.5YR 5/8-5YR 4/8, strong brown mottles.
				Distinct contact
Taupo Ignimbrite	*	0.28	7.72	Clast-supported, well sorted well rounded reworked Taupo Ignimbrite gravelly clasts.
				Graded contact
Taupo Ignimbrite	*	2.00 +	9.72 +	Pale grey fine glassy ash; massive; ungraded.

G3 621/280882

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onk	0.22	0.22	Clast-supported sands; 10YR4/4; ungraded; weak cm and mm thick laminae; moderately well sorted; largest clast 0.005 m; clasts subangular to subrounded; common black and grey and few white intrude lithic clasts.
				Graded contact
Onetapu Formation	Onj	0.6	0.88	Muddy matrix-supported gravel; inversely graded basal 0.05 m grades into upper normally graded main portion; very poorly sorted; largest clast 0.3 m; clasts subangular to subrounded; abundant grey and common black and few red and white lithic clasts; few clasts with orange staining; matrix colour 10YR 5/2, greyish brown; with olive brown mottles.
				Distinct contact
"	"	0.02	0.9	Sandy loam (10YR 5/6, yellowish brown); few live roots; iron pan at top.
				Graded contact
Onetapu Formation	Onh	0.5	1.4	Sandy matrix-supported gravel; grades vertically upwards from normally graded base through an ungraded central portion into a normally graded upper portion; in profile grading is undulose;very poorly sorted; largest clast 0.1 m; clasts angular too rounded; abundant black and grey and few red and purple and white lithic clasts; clasts commonly stained orange; matrix colour 10YR 4/3, dark brown.
				Distinct contact
"	"	0.45	1.85	Sandy silt loam (10YR 5/6, yellowish brown); weakly 2developed fine to medium nut and crumb; non sticky; non plastic; common live roots.
				Graded contact
Onetapu Formation	Ong2?	0.9	2.75	Clast-supported sands; 10YR 4/5-3/4, yellowish brown to dark yellowish brown; weak normal grading; weak mm thick laminae; largest clast 0.005 m; clasts subangular to subrounded; poorly sorted; common black, red and grey and few purple and white lithic clasts; few clasts stained orange.
				Graded contact
"	"	0.35	3.1	Sandy clay loam (10YR 4/2, dark greyish brown, with 7.5YR 4/6-5YR 5/8, strong brown to yellowish red, staining); coarsens to sand in upper 0.1 m; common black, grey and few red sands scattered; few reworked Taupo Ignimbrite clasts scattered.
Onetapu Formation	Ong1?	0.05	3.15	Clast-supported sands; ungraded; largest clast 0.005 m; clasts subangular to subrounded; poorly sorted; common black and grey and few white and red lithic clasts; common clasts with orange stains; matrix colour 10YR 5/3, brown.

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onn	0.20	0.20	Clast-supported sands with some gravel; massive; normally graded; largest clast 0.08 m; clasts subangular to rounded; poorly sorted; common grey and black lithic clasts; abundant live roots and twigs.
				Distinct contact
Onetapu Formation	Onm	0.10	0.30	Clast-supported sands; 7.5YR 3/2- 4/2, dark brown; ungraded; faint laminae; largest clast < 0.002 m; very well sorted; common live roots and twigs, and one pine cone, concentreted at the top.
				Distinct contact
Onetapu Formation	Onl	0.26	0.56	Clast-supported sands; 10YR 6/1, grey; ungraded; weak laminae; well sorted; largest clast < 0.002 m; few twigs.
				Distinct contact
"	"	0.02	0.57	Fine sandy silt (10YR 4/2, dark greyish brown); very well sorted; abundant live roots.
				Graded contact
		0.13	0.70	Weakly developed sandy silt loam (10YR 3/2, very dark greyish brown); no structure; scattered grey pumice medium lapilli; abundant twigs.
				Distinct contact
Onetapu Formation	Onh	1.30	2.00	Clast-supported sands and gravel (10YR 4/2-4/3, dark greyish brown to dark brown); weak angled mm thick laminae; largest clast 0.3 m; clasts subangular to rounded; very poorly sorted; abundant black and common red and grey lithic clasts; occasional cobbles and pebbles of Tertiary siltstone; orange staining on few clasts; common pitting on surface of clasts.
				Distinct contact
		0.11	2.11	Clast-supported sands (7.5YR 3/2-10YR 3/2, dark brown to very dark greyish brown); ungraded; massive; largest clast < 0.02 m; very well sorted; abundant black and grey and few red and white lithic clasts; common live roots.
				Distinct contact
"	"	0.004	2.11	Thin layer of clay (10YR 5/4, yellowish brown); discontinuous.
				Distinct contact
"	"	0.15	2.26	Grey silty sand (10YR 3/2, very dark greyish brown); loose; massive; largest clast < 0.002 m; very well sorted; common black red and grey lithic clasts; few live roots.
				Graded contact
"	"	0.10	2.36	Olive grey silty sand (10YR 4/4, dark yellowish brown); fine nut and crumb structure; firm; common black red and grey fine to medium sand scattered; common reworked Taupo Ignimbrite sand-sized clasts; few live roots.
				Graded contact
		0.14	2.50	Dark grey sands (10YR 3/2, very dark greyish brown); massive; normally graded; loose; largest clast < 0.002 m; very well sorted; common black grey and red lithic clasts; few reworked Taupo Ignimbrite sand and granule-sized clasts; 0.08 m from base thin lens clay; few live roots.
				Distinct contact

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.05	2.55	Clast-supported, well sorted, well rounded creamy glassy Taupo ignimbrite clasts;thin sandy silt loam matrix (10YR 3/4, dark brown); common live roots.
				Graded contact
•	•	0.3	2.85	Sandy loam (10Yr 3/2, very dark greyish brown); loose; common black, grey and red lithic clasts; occasional fine to medium reworked Taupo ignimbrite sands; common twigs and live roots.
				Distinct contact
•	•	0.09	2.94	Sands (10YR 4/2, dark greyish brown); firm; massive; well sorted; abundant grey and common black lithic clasts;few live roots.
				Distinct contact
•	•	0.29	3.23	Sands with occasional granules (10YR 3/2-3/8, vey dark greyish brown to dark yellowish brown); vey well sorted; few live roots.
				Distinct contact
Onetapu Member	Onf	0.15	3.38	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; common black and grey and few red lithic clasts; common clasts with orange-red stains; matrix colour 10YR 3/8-3/2, dark yellowish brown to very dark greyish brown.

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onn	0.2	0.2	Clast supported sand with few gravel; poorly sorted; grades from basal laminated zone upwards into ungraded and massive upper portion; largest clast 0.016 m; clasts angular to rounded; common black red and grey, and few orange and white lithic clasts; common organic matter (roots, twigs etc.).
				Distinct contact
"	"	0.06	0.26	Fine silt and fine sand; very well sorted; abundant live roots.
				Graded contact
Onetapu Formation	Onm	0.28	0.53	Clast-supported sand with some gravel; ungraded; distinct mm thick laminae and cross bedding; well sorted; largest clast 0.02 m; clasts subangular to subrounded; abundant black and common red lithic clasts; common organic matter (especially in top 0.06 m).
				Distinct contact
"	"	0.12	0.65	Grey brown fine sand and silt (10YR 3/3, dark brown); few coarse sand and granules; largest clast 0.01 m; clasts subrounded; well sorted; abundant live roots.
				Graded contact
Onetapu Formation	Onh	1.5	2.15	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 1.02 m; clasts subangular to subrounded, abundant black and common red and grey lithic clasts; orange staining on few clasts; matrix colour 10YR 4/2, dark greyish brown.

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Ono	0.8	0.8	Matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts angular to rounded; common black, grey and few red and white (soft) lithic clasts.
				Graded contact
Onetapu Formation	Onn	0.32	1.12	Clast-supported sands; inversely graded; weak cm and mm thick laminae; largest clast 0.01 m; clasts subangular to subrounded; poorly sorted; common grey and black lithic clasts; common grey pumice clasts.
				Distinct contact
*	*	0.03	1.16	Fine to medium sand (10YR 4/2, dark greyish brown); ebundant live roots.
				Graded contact
Onetapu Formation	Onm	1.2	2.36	Clast-supported sands with occasional gravel; mm thick laminae grades vertically into steeply inclined cross-bedding; poorly sorted; largest clast 0.03 m; clasts subangular to subrounded; common red, black and grey lithic clasts; common grey pumice clasts; common organic matter - twigs, pieces of wood and roots, wood dated (Wk-2097) at Post modern.
				Distinct contact
Onetapu Formation	Onh	0.70	3.06	Clast-supported sand and gravel; alternate bands sand and gravel; poorly sorted; clasts subangular to subrounded; largest clast 0.08 m; common red, black, and grey lithic clasts; common clasts with orange staining; common organic matter- live roots pieces of wood and twigs.
				Distinct contact
Onetapu Formation	Ong	2	5.06	Clast-supported sands and granules with occasional gravel; inversely graded; cm thick beds; poorly sorted; clasts sub-angular to rounded; largest clast 0.16 m; common grey and black and few red lithic clasts; common grey and orange hard pumice clasts; few live roots.
				Distinct contact
Onetapu Formation	Onf	2	7.06	Muddy matrix-supported gravel; weakly inversely graded; very poorly sorted; clasts angular to sub-rounded; common black and grey and few orange, white and red lithic clasts; clasts commonly stained orange-red; matrix colour 10YR 5/6, yellowish brown, with common orange-olive mottles.

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Ong3	2.5	2.5	Clast supported sands and granules (10YR 3/4, dark yellowish brown), with few gravel clasts; inversely graded lower portion grades upwards into upper normally graded portion; distinct cm thick beds; poorly sorted; largest clast 0.8 m; clasts subangular to rounded; common black and grey and few red and purple and white (soft with orange stains) lithic clasts; common grey pumice clasts; occasional Tertiary siltstone cobbles and boulders.
				Distinct contact
"	"	0.06	2.56	Silty clay loam (10YR 6/3, pale brown); sticky; plastic; common fine live roots.
				Graded contact
Onetapu Formation	Ong2	1.5	4.06	Clast-supported sands and granules; normal grading; well sorted; 10YR 3/3 dark brown; distinct cm thick beds; largest clast 0.01 m; clasts subangular to subrounded; abundant black and grey lithic clasts; few to common grey pumice clasts.
				Distinct contact
"	"	0.1	4.16	Silty loam (10YR 3/3, dark brown) supporting common well rounded, well sorted Taupo Ignimbrite granule-sized clasts; sticky; non plastic; blocky; common fine live roots.
				Graded contact
Onetapu Formation	Ong3	1.5	5.66	Clast-supported sands and granules (2.5Y 4/2, dark greyish brown); normally graded; weak laminae; poorly sorted; largest clast 0.01 m; clasts subangular to subrounded; common black and few red lithic clasts; medium common grey pumice clasts.
				Distinct contact
Onetapu Formation	Onf	2.40	8.06	Muddy matrix-supported gravel; 2.5Y 4/0,dark grey, appears mottled grey and orange (10YR 5/8, yellowish brown); normally graded; very poorly sorted; largest clast 0.6 m; clasts subangular to rounded; abundant black and grey and few white (soft and occasionally stained orange) lithic clasts; common clasts stained orange-red.

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	1.3	1.3	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.1 m; clasts angular to rounded, commonly subrounded; common black and grey and few red and white ithic clasts; occasional grey pumice clasts; clast-rich deposit; slightly horizontally bedded in basal finer-grained portion.
				Distinct non-erosional contact
•	•	0.16	1.46	Sandy silt (10YR 4/1-2.5YR 5/4, brownish grey to dark greyish brown); occasional granules; massively bedded; few fine to coarse lapilliat the base of the unit.
				Graded contact
•	•	0.1	1.56	Sandy silt (2.5YR 4/4); slightly platy; appears grey with olive/orange mottles; few fine roots; firm.
				Graded contact
•	•	0.09	1.65	Silty clay; appears grey (10YR 4/2) with orange/olive/red mottles; cracked in face; few fine roots; firm.
				Graded contact
•	•	0.09	1.74	Fine and medium sand; grey (10YR 3/3) with yellowish orange mottles; occasional medium and coarse reworked Taupo Ignimbrite clasts scattered; firm.
				Distinct contact
Onetapu Formation	Onf	1.2	2.94	Muddy matrix-supported gravel; matrix poor; inversely graded; very poorly sorted; largest clast 0.5 m; clasts angular to rounded, commonly subrounded; common black and grey and few red, white and purple lithic clasts; common clasts with orange-red stains; matrix colour grey (10YR 3/3) with orange red mottles.

G9 521/287872

Reference section

Onetapu Formation drape the edge of cliffs comprising Tangatu Formation deposits on the east bank of the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.4	0.4	Sandy matrix-supported gravel; inversely graded to middle then normally graded; very poorly sorted; largest clast 0.09 m; clasts subangular to subrounded; abundant black and common grey and few red and soft white and orange lithic clasts; matrix colour 2.5Y 4/2, dark greyish brown.
				Distinct non-erosional contact
"	"	0.11	0.51	Fine sandy loam (10YR 5/4- 2.5Y 5/4, yellowish brown to light olive brown); non sticky; non plastic; weakly developed fine crumb; occasional sandy olive grey hard andesitic pumice clasts; occasional reworked Taupo Ignimbrite pumice granules and pieces of charcoal.
				Graded contact
Onetapu Formation	Ong	1.8	2.31	Clast-supported sands (2.5Y 5/2-4/2, greyish brown to dark greyish brown); distinct mm thick grade upwards into cm thick beds; normally graded; poorly sorted; largest clast 0.02 m; clasts subangular to rounded; common black and few grey, red and purple lithic clasts; abundant grey pumice clasts; few stained orange and soft; few scattered reworked Taupo Ignimbrite clasts.
				Distinct contact
"	"	0.09	2.4	Gritty sandy silt loam (2.5Y 5/4,light olive brown); friable; non sticky; slightly plastic; sticky; weakly developed fine nut and crumb; common sandy andesitic and reworked Taupo Ignimbrite clasts; common live roots.
				Graded contact
Onetapu Formation	Ong	1.1	3.5	Clast-supported sands and granules (2.5YR 4/2 dark greyish brown, appears mottled olive and grey); normally graded; poorly sorted; largest clast 0.006 m; massively bedded grades into upper 0.1 m with faint laminae; clasts subangular to subrounded; common black and few red and grey lithic clasts; common grey pumice clasts, commonly stained orange; few well rounded Taupo Ignimbrite granule-sized pumice clasts; few live roots.
				Distinct contact
"	"	0.5	4	Sandy loam (2.5Y 5/4, light olive brown), with few scattered gravel-sized lithic clasts; weakly developed block breaking to fine crumb; common roots.
				Graded contact
Onetapu Formation	Onf	0.15	4.15	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; 2.5Y 4/2, dark greyish brown with 7.5YR 5/8, strong brown, mottles; abundant grey and common black and few red and few white (soft and commonly stained orange) lithic clasts; clasts commonly stained orange.
				Distinct contact
"	"	0.9	5.05	Slightly gritty sandy silt loam (10YR 6/8-5/6, brownish yellow); non sticky; non plastic; common medium pores stained dark purplish brown; common creamy Taupo Ignimbrite pumice granules in upper 0.15 m; few orange fine to medium lapilli scattered.
				Graded contact

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Tangatu Formation	"	1	6.05	Clast-supported sands; 10YR 5/3, brown; massive; laminae; ungraded; largest clast 0.2 m; clasts subrounded to rounded; poorly sorted; common black and few red lithic clasts; abundant grey hardvesicular pumice clasts.
				Distinct contact
"	"	0.5	6.55	Slightly gritty sandy loam (10YR 6/4, light yellowish brown); non sticky; non plastic; weakly developed coarse nut and crumb; fine to medium grey pumice sands scattered; common pores stained black; common fine roots.
				Distinct contact
Tangatu Formation	"	2.5	9.05	Clast-supported sands and granules; massive; distinct cm thick beds; moderately sorted.
				Distinct contact
Tangatu Formation	"	0.4	9.45	Clast-supported gravel; poorly sorted; ungraded; common black lithic clasts; common grey pumice clasts.
				Distinct contact
Tangatu Formation	"	7	16.45	Clast-supported gravel (10YR 3/2, very dark greyish brown, speckled); normally graded; distinct cm thick beds; largest clast 0.2 m; clasts subangular to rounded; very poorly sorted; common black and few red and occasional soft white lithic clasts; common grey pumice; occasional Tertiary siltstone pebbles.
				Distinct contact
"	"	20	36.45	Clast-supported sand and gravel; distinct cm thick beds, which follow the channel configuration; ungraded; largest clast 0.05 m; clasts subangular to rounded; very poorly sorted; common black and grey and few red lithic clasts; occasional grey pumice clasts; occasional Tertiary siltstone pebbles.
				Distinct erosional contact
Tangatu Formation	"	2.8	39.25	Clast-supported sand and granules (10YR 3/3, dark brown, speckled); distinct cm thick beds; ungraded; largest clast 0.01 m; clasts subrounded to rounded; abundant grey pumice; common black and grey and few red lithic clasts.
				Graded contact
"	"	0.75	40	Pale orange sandy loam.
				Graded contact
Tangatu Formation	"	5.	45	Clast-supported sand and gravel (10YR 3/2,very dark greyish brown); ungraded; distinct cm thick beds; largest clast 0.02 m; clasts subangular to rounded; poorly sorted; common black and grey and few red lithic clasts; abundant grey pumice.
				Distinct contact

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Tangatu Formation	*	1.	53.	Clast-supported sands and gravels (10YR 6/2, light brownish grey); distinct cm thick beds; inversely graded; largest clast 0.015 m; clasts subrounded to rounded; abundant grey pumice clasts; common black, grey and few red lithic clasts.
				Distinct contact
Tangatu Formation	*	1.	54.	Clast supported sands (10YR 6/2-6/3, light brownish grey to pale brown); ungraded; laminae; poorly sorted largest clast 0.005 m; clasts subrounded to rounded; common black and few red and grey lithic clasts; abundant grey pumice clasts.

H1 S21/284880

Reference section

Onetapu Formation deposits are exposed in a track cutting on the east bank of the Whangaehu River, *c.* 100 m southeast of the Rivers confluence with a small stream which drains the southern hill country.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	1.1	1.1	Sandy matrix supported gravels and pebbles; matrix colour 10YR 3/3-2.5YR 4/2, dark brown to weak red; ungraded; largest clast 0.1 m; very poorly sorted; clasts angular to rounded; abundant black, common dark grey and few red and white lithic clasts; occasional grey pumice clasts; occasional Tertiary sandstone and siltstone pebbles; clasts commonly scoriaceous and pitted.
				Distinct non-erosional contact
"	"	0.16	1.26	Sandy silt loam (10YR 3/4, dark yellowish brown); non sticky; non plastic; weak block breaking to fine crumb and nut; common scattered fine to medium creamy reworked Taupo Ignimbrite pumice sand and granules; few live roots.
				Graded contact
Onetapu Formation	Ong	1.1	2.36	Clast-supported sands; normally graded; cm thick beds grading into very shallow cross-bedding; largest clast 0.01 m; clasts subangular to subrounded; poorly sorted; loose; common pale grey pumice clasts; abundant black and common red and orange lithic clasts; matrix colour 2.5Y 4/2, dark greyish brown.
				Distinct non-erosional contact
Onetapu Formation	Onf	0.04	2.76	Muddy matrix supported gravel; ungraded; largest clast 0.2 m; very poorly sorted; clasts angular to rounded; common black grey and few red and purple; common orange lithic clasts; common clasts with orange/red staining; matrix colour 10YR 5/1-5/2, grey to greyish brown.
				Distinct undulating non-erosional contact
"	"	0.12	2.88	Slightly gritty sandy clay loam (10YR 5/6, yellowish brown); common scattered reworked Taupo Ignimbrite fine to medium sands.
				Graded contact.
"	"	0.19	3.07	Slightly gritty sandy clay loam (10YR 5/6, yellowish brown); non sticky; non plastic; blocky breaking to fine nut and crumb; abundant orange and common black and grey fine to medium sand scattered; few fine white; few tubular pores stained dark purplish grey; few pods of underlying sands; mottled orange.
				Graded contact.
Tangatu Formation	"	0.6	3.67	Clast-supported sands; ungraded; faint laminae; top broken and diseggregated; hard; largest clast 0.005 m; moderately well sorted; clasts subangular to subrounded; common black grey and few orange red and white lithic clasts; common orange and pale grey pumice clasts; 2.5Y 4/4, olive brown; strong orange staining at the top (10YR 6/8, brownish yellow).
				Distinct contact
"	"	0.10	3.77	Very gritty sandy clay loam (10YR 5/8-4/6, yellowish brown to dark yellowish brown); non sticky; non plastic; blocky breaking to fine nut and crumb; few fine pores; common black grey and red sand scattered.
				Graded contact

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Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
				Distinct contact
Tangatu Formation	*	0.95	3.71	Clast-supported sands; 10YR 3/6, dark yellowish brown; inversely graded at base then grades to normally graded upper unit; largest clast 0.01 m; poorly sorted; clasts subangular to subrounded; very hard.
*	*	0.38	4.09	Gritty sandy clay loam (10YR 5/6, yellowish brown); non sticky; non plastic; greasy; blocky breaking to moderately developed fine nut and crumb; common medium pores stained dark purplish brown; abundant orange and common grey fine to medium sand; tephric.

H2 S21/283882

Reference section

Onetapu Formation, Taupo Ignimbrite, Manutahi, Mangaio, and Tangatu Formations are exposed in a track which cuts down to the east bank of the Whangaehu River, at its confluence with a stream which drains the southern hillcountry.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.6	0.6	Sandy matrix supported gravel; inversely graded; very poorly sorted; clasts subangular to subrounded; largest clast 0.11 m; abundant black, common grey and few red and occasional orange lithic clasts; few clasts stained orange; occasional soft altered clasts; moderately hard to very hard at base; iron stained at base.
				Distinct non-erosional contact
"	"	0.1	0.7	Gritty sandy loam (2.5Y 4/2-4/4, dark greyish brown to olive brown); non sticky; non plastic; non greasy; blocky breaks to fine nut and crumb; common fine live roots.
				Graded contact
Onetapu Formation	Ong	1.4	2.1	Clast-supported sands; normally graded; moderately well sorted; clasts subangular to subrounded; largest clast 0.005 m; distinct mm thick laminae graded upwards into exaggerated dish and pillar water escape structures; common grey pumice clasts; common black and grey and few red lithics; common fine live roots.
				Distinct non-erosional contact
Onetapu Formation		0.2	2.3	Slightly gritty sandy loam (2.5Y 4/4, dark greyish brown); non sticky; non plastic; blocky breaking to fine nut and crumb; common reworked Taupo Ignimbrite sands scattered.
				Distinct non-erosional contact
Onetapu Formation	Onf	1.1	3.4	Muddy matrix-supported gravel; matrix colour 10YR 4/2, dark greyish brown with distinctive olive mottles); common pores stained deep orange red; thin fine grained gravelly base grades into thick normally graded top; very poorly sorted; clasts subangular to rounded; largest clast 0.5 m; common black and grey and few red and purple lithic clasts; finer grained base dominantly grey lithics; occasional soft white lithics; common orange-red stains on clasts; hard.
				Distinct non-erosional contact
Onetapu Formation		0.17	3.57	Clast-supported, well sorted, well rounded, reworked Taupo Ignimbrite granules; few pieces of charcoal; common live roots.
				Distinct non-erosional contact
Onetapu Formation	Ons	0.2	3.77	Muddy matrix-supported gravel; thin sand and some clay matrix; matrix colour 10YR 6/8, brownish yellow; ungraded; very poorly sorted; clasts subrounded to rounded; largest clast 0.1 m; common black and grey and few white lithic clasts; common clasts with orange staining; hard.
				Distinct non-erosional contact
"	"	0.04	3.81	Slightly gritty silty loam (10YR 8/6-7/6, yellow); loose; friable; common very fine black sand; common root channels.
				Graded contact
Taupo Ignimbrite	"	0.05	3.86	Taupo Pumice ignimbrite; fine white ash grading to fine and medium lapilli (10YR 8/3-8/4, very pale brown); inversely graded; loose.
				Distinct contact

H2 821/283882

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Manutahi Formation	Mn	0.12	4.59	Clast-supported sands; ungraded; massive; poorly sorted; largest clast 0.02 m; clast subangular to subrounded; common black and red and grey lithic clasts; appears broken in face; common live roots.
				Distinct contact
"	"	0.15	5.73	Sandy silt (2.5Y 6/4, light yellowish brown); non sticky; non plastic; weakly developed fine nut and crumb structure; abundant fine roots.
				Graded contact
Manutahi Formation	Mn	0.5	6.23	Clast-supported sands and granules; ungraded; cm thick beds; poorly sorted; largest clast 0.04 m; clast subrounded to rounded; common grey, black red and purple and few white lithic clasts; occasional Tertiary siltstone clasts.
"	"	0.1	6.33	Sandy silt loam (10YR 6/6, olive yellow); weakly developed fine nut and crumb structure; non sticky; non plastic; few scattered sandy clasts; common fine roots.
				Graded contact
Mangaio Formation	Mg	0.8	7.13	Matrix-supported gravel; clast-rich; normally graded; poorly sorted; largest clast 0.07 m; clasts subrounded to rounded; abundant grey and few black, red and purple lithic clasts; matrix colour 10YR 6/8, olive yellow, with 10YR 6/4, light yellowish brown, mottles.

ON TANGATU FORMATION

H3 S21/280883

Reference section

Onetapu Formation deposits are exposed in an offal pit excavation on the west bank of the Whangaehu River, *c.* 20 m upstream of the bridging point of Strachans Road over the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Oni	0.15	0.15	Clast-supported sands and granules; inversely graded; poorly sorted; mm thick laminae largest clast 0.01 m; clasts angular to subrounded; clasts commonly black and grey and few red and orange lithic clasts; few grey pumice clasts.
				Distinct non-erosional contact
"	"	0.1	0.25	Very gritty sandy loam (10YR 2/2, very dark brown); non sticky; non plastic; non greasy; common fine to medium sand scattered throughout; abundant fine roots.
				Graded contact
Onetapu Formation	Onh	0.6	0.85	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts angular to rounded; common grey and black and few red lithic clasts; few clasts stained orange; matrix colour 2.5Y 4/2, dark greyish brown.
				Distinct non-erosional contact
"	"	0.2	1.05	Gritty sandy loam (10YR 3/4, dark yellowish brown); non sticky; non plastic; non greasy; friable; common black and grey sand scattered throughout; common fine roots.
				Graded contact
Onetapu Formation	Ong	0.55	1.6	Clast-supported sand, granules and gravel; normally graded; very poorly sorted; cm thick beds; largest clast 0.04 m; clasts angular to rounded; common black and grey and few red lithic clasts; few to common grey pumice.
				Distinct non-erosional contact
"	"	0.15	1.75	Gritty sandy clay loam (10YR 5/4-5/6, yellowish brown); non sticky; non plastic; common fine roots; occasional reworked Taupo ignimbrite clasts scattered; common fine roots.
				Graded contact
Onetapu Formation	Onf	1.1	1.85	Muddy matrix-supported gravel; normally graded; very poorly sorted; largest clast 0.25 m; clasts angular to rounded; common grey and black and few red lithic clasts; clasts commonly stained orange red; matrix colour 10YR 5/2-5/6, greyish brown to yellowish brown.

I S21/277883

Reference section

Onetapu Formation, Taupo Ignimbrite, Mangaio and Tangatu Formations are exposed in a cutting to the east of a bridging point on the west bank of the Whangaehu River. Thick deposits of Onetapu members One and Onf dominate this exposure.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Ong2?	0.35	0.35	Clast-supported sands; ungraded; poorly sorted; distinct mm thick laminae; largest clast 0.01 m; clasts subangular to subrounded; few to common black and red lithic clasts; common grey pumice clasts; occasional reworked Taupo Ignimbrite granules; common fine roots.
				Distinct non-erosional contact
"	"	0.1	0.45	Slightly gritty sandy silt loam (10YR 4/2, dark greyish brown); non sticky; non plastic; weakly developed fine nut and crumb; abundant fine roots.
				Graded contact
Onetapu Formation	Ong1	0.3	0.75	Clast-supported sands; ungraded; poorly sorted; distinct mm thick laminae; common black and grey and few red and white lithic clasts; common grey pumice; few clasts stained orange; common fine roots.
				Distinct non-erosional contact
"	"	0.06	0.81	Gritty sandy loam (10YR 5/4-5/6, yellowish brown); non sticky; non plastic; weakly developed fine crumb; common live roots; occasional coarse sand clasts scattered.
				Graded contact
Onetapu Formation	Onf	1.2	2.01	Muddy matrix-supported gravel; thin inversely graded base, grades upwards into normally graded main upper part of unit; very poorly sorted; largest clast 0.15 m; clast subangular to rounded; abundant grey and few black and red and occasional white lithic clasts; orange-red stains on common clasts; matrix colour 10YR 5/2, greyish brown, with orange-red mottles.
				Distinct non-erosional contact
Onetapu Formation	One	1.1	2.2	Muddy matrix-supported gravel; inversely graded basal portion, grading upwards into normally graded upper portion to unit; largest clast 0.15 m; clasts subangular to rounded; abundant grey and few red and few black and occasional white lithic clasts; orange-red stains on few clasts; matrix colour 10YR 5/2-5/3, greyish brown to brown, with orange-red mottles.
				Distinct non-erosional contact
(Onetapu Formation)	(Ond)	0.4	2.6	Gritty sandy loam (10YR 5/6, yellowish brown); non sticky; non plastic; moderately developed fine nut and crumb; common scattered andesitic sands; few reworked Taupo Ignimbrite sands scattered; few tree stumps at contact with overlying unit, stump dated (Wk-2098) at 890 ± 40 years B.P; 0.1 m thick discontinuous interfingering clast-supported poorly sorted sandy unit, with distinct mm thick laminae, lies at about 0.1 below the upper contact of this soil.
				Graded contact
Onetapu Formation	Onc	0.2	2.8	Muddy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.07 m; clasts rounded; common grey and few black clasts; clasts commonly stained orange-red; matrix colour 10YR 7/6, yellow; matrix poor.
				Distinct non-erosional contact

I S21/277883

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.02	2.82	Sandy silt loam (10YR 7/6, yellow); weakly developed fine nut and crumb; non sticky; non plastic; scattered reworked Taupo Ignimbrite sands.
				Graded contact
•	•	0.11	2.93	Clast-supported, well rounded, well sorted reworked Taupo Ignimbrite granules and pebbles; thin muddy metrix (10YR 7/6, yellow); pumice clasts stained orange; common pieces of charcoal.
				Distinct non-erosional contact
Onetapu Formation	Ona	0.1	3.03	Muddy matrix-supported gravel; thin inversely graded base grades upwards into upper portion marked by cm thick beds; very poorly sorted; largest clast 0.1 m; clasts subrounded to rounded; abundant grey and few black and red lithic clasts; clasts commonly stained orange-red.
				Distinct non-erosional contact
Taupo Ignimbrite	•	0.11	3.14	Sightly gritty ash to medium lapilli (10YR 7/8, yellow); weakly developed fine crumb.
				Graded contact
Taupo Ignimbrite	•	0.13	3.27	Slightly gritty creamy fine ash to fine lapilli (10YR 8/4, very pale brown); few flecks of charcoal.
				Distinct contact
Mangaio Formation	Mg	0.90	4.17	Gritty sandy loam (10YR 6/8-5/6, brownish yellow to yellowish brown) supporting discontinuous lenses/pods of andesitic gravel; non sticky; non plastic; greasy; blocky structure; common fine live roots.
				Graded contact
Tangatu Formation	•	0.90	1.97	Clast supported sands; massive; inversely graded; largest clast 0.01 m; clasts subangular to rounded; poorly sorted; common black and grey and few red lithic clasts; few grey pumice clasts; pumice commonly stained orange.
				Distinct erosional contact
•	•	0.10	1.97	Gritty sandy loam (10YR 5/8, yellowish brown); few fine to coarse soft grey pumice sands; common fine live roots.
				Graded contact
Tangatu Formation	•	0.90	2.87	Clast-supported sands; inversely graded; weak mm thick laminae; largest clast 0.005 m; clasts subangular to subrounded; poorly sorted; common black and grey and few red lithic clasts; common grey pumice clasts; few pumice clasts stained orange; channel cut into this unit and filled with overlying sandy unit.
				Distinct non-erosional contact
Tangatu Formation	•	0.50	3.37	Clast supported sands; weak mm thick laminae; normally graded; poorly sorted; largest clast 0.01 m; clasts subangular to subrounded; common black grey and few red lithic clasts; common grey pumice.

J1 621/278885

Reference section

Onetapu Formation deposits are exposed in a metal pit on the west bank of the Whangaehu River, on the left side of Strachans Road.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Oni	0.4	0.4	Clast-supported sands (10YR 6/2, grayish brown); normally graded; poorly well sorted; largest clast 0.01 m; clasts subrounded to rounded; distinct mm thick laminae; common pale grey pumice clasts; common black and gray and few red lithic clasts.
				Distinct non-erosional contact
		0.07	0.47	Gritty sandy loam (10YR 4/3, dark brown); non sticky; non plastic; fine crumb and nut structure; common fine roots.
				Graded contact
Onetapu Formation	Onh	0.7	1.17	Sandy matrix supported gravel; inversely graded base grades upwards into normally graded upper portion; very poorly sorted; largest clast 0.3 m; clasts angular to rounded; abundant black and few red white and grey lithic clasts; orange stains on few clasts.
				Distinct non-erosional contact
		0.1	1.27	Gritty sandy loam (2.5Y 4/4, olive brown); non sticky; non plastic; blocky breaks to fine crumb; few scattered andesite sands and granules; common live roots.
				Graded contact
		0.06	1.33	Slightly gritty sandy clay loam (2.5YR 5/4, light olive brown); with lenses of light grey (10YR 7/2) andesite granules; moderately hard and vesicular; largest clast 0.02 m; well sorted; rounded.
				Graded contact
Onetapu Formation	Ong	1.5	2.88	Clast-supported sands; normally graded; distinct cm thick beds at the base grade into dish and piller structures; largest clast 0.01 m; poorly sorted; clasts subangular to subrounded; abundant grey pumice clasts; few orange, black, grey and red lithic clasts.
				Distinct non-erosional contact
		0.14	3.02	Gritty sandy loam (2.5Y 4/4, olive brown); non sticky; non plastic; common scattered orange and white lithic sands; common live roots.
				Graded contact
		0.08	3.10	Clast-supported, well sorted, well rounded Taupo Ignimbrite pumice granules and pebbles; thin fine sandy loam (2.5Y 5/6, light olive brown) matrix; few pieces charcoal.
				Graded contact
Onetapu Formation	Onf	0.16	3.26	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.04 m; clasts subangular to subrounded; common black and grey lithic clasts; common clasts with orange-red stains.
				Distinct non-erosional contact
Onetapu Formation	Ona	0.3	3.56	Muddy matrix supported gravels; slightly inversely graded; poorly sorted; largest clast 0.07 m; clasts angular to rounded; common grey, black and orange lithic clasts; matrix appears grey with olive and orange mottles; fine white ash scattered; few live roots.
				Distinct non-erosional contact

J1 S21/278885

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.2	3.75	Very gritty sandy clay loam (10YR 5/6); non sticky; non plastic; abundant Taupo Ignimbrite pumice sands and granules coarse ash to fine lapilli scattered; few scattered black and grey lithic sands; few live roots.

J2 821/278886

Reference section

Onetapu Formation and Taupo Ignimbrite are exposed in in a cutting on the west bank of the Whangaehu River and the left side of Strachnes Road, immediately below this roads bridging point over the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Oni	0.25	0.25	Particle-supported sands; ungraded; mm thick laminae; poorly sorted; largest clast 0.005 m; clasts subangular to subrounded; common black and grey and few red lithic clasts; common fine roots; loose.
				Distinct non-erosional contact
"	"	0.09	0.34	Gritty sandy silt loam (10YR 3/4, dark yellowish brown); non sticky ; non plastic; moderately developed fine nut and crumb; common fine to medium roots; fine to coarse sand scattered throughout.
				Graded contact
Onetapu Formation	Onh	0.35	0.69	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clast angular to subrounded; common black, grey and few red, orange and white lithic clasts; few clasts with orange staining; matrix colour 10YR 3/4, dark yellowish brown.
				Distinct non-erosional contact
"	"	0.1	0.79	Fine sand grades upwards to very fine sand and silt (2.5Y 5/4-4/4, light olive brown to olive brown); common fine roots.
				Graded contact
Onetapu Formation	Ong3	4.4	5.19	Clast-supported sands and granules; ungraded; cm thick beds; poorly sorted; largest clast 0.01 m; clasts subangular to rounded; few black, grey and red lithic clasts; abundant pale grey pumice; few clasts with orange-yellow stains.
				Distinct non-erosional contact
"	"	0.17	5.36	Fine to medium sand (10YR 5/1-2.5Y 4/2, grey to dark greyish brown); common black and grey lithic clasts; few Taupo Ignimbrite clasts; common fine roots.
				Graded contact
Onetapu Formation	Ong2	1.35	6.71	Clast-supported sands; normally graded; poorly sorted; faint mm thick laminae; largest clast 0.015 m; clasts angular to subrounded; common black and occasional red and white lithic clasts; few to common grey pumice; some clasts with orange stains.
				Distinct non-erosional contact
"	"	0.11	6.82	Reworked Taupo Ignimbrite; common creamy pumice gravel clasts in dark olive grey matrix (10Yr 5/6-2.5YR 4/4, yellowish brown to olive brown); common fine roots.
				Graded contact
Onetapu Formation	Onf	0.7	6.95	Muddy matrix-supported gravels; normallygraded; very poorly sorted; largest clast 0.1 m; clasts subangular to rounded; common black and grey and few red and purple and occasional soft white and orange lithics; common orange red stains on clasts; matrix colour 10YR 5/2, greyish brown.
				Distinct non-erosional contact

J2 S21/278886

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	One	0.5	7.45	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.02 m; clasts subangular to rounded; common black and grey and few red and white lithic clasts; common red (2.5YR 4/8-7.5YR 5/8, red to strong brown) stains on clasts; occasional pods of grey 10YR 5/2, greyish brown, muddy sand; common fine roots.
				Distinct erosional contact
Taupo Ignimbrite	"	0.5	7.95	Taupo Ignimbrite; glassy creamy fine ash to fine lapilli; common flecks of charcoal; massive.

K1 S21/253873

Reference section

Onetapu Formation deposits are exposed in a disused metal pit on the east bank of the Whangaehu River, *c.* 3 km downstream of Tirorangi Marae.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.8	0.8	Sandy matrix-supported gravel; ungraded; very poorly sorted.
				Distinct contact
"	"	0.1	0.9	Reworked Taupo Ignimbrite; abundant creamy pumice clasts, with long vesicles.
				Distinct contact
Onetapu Formation	Ong3	1.2	2.1	Clast-supported sands; ungraded; poorly sorted; distinct mm thick laminae, and convolute bedding structures.
				Distinct contact
Onetapu Formation	On1	0.8	2.9	Clast-supported sand with few gravel clasts; ungraded; poorly to very poorly sorted.

K2 S21/249870

Onetapu Formation, Taupo Ignimbite, and Mangaio Formation are exposed in a track cutting on the east bank of the Whangaehu River, *c.* 2.5 km downstream of Tirorangi Marae.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.5	0.5	Sandy matrix-supported gravel; ungraded; very poorly sorted.
				Distinct contact
Onetapu Formation	Ong	1	1.5	Clast-supported sands; ungraded; distinct mm thick laminae; poorly sorted.
				Distinct contact
Onetapu Formation	Onf	0.3	1.8	Muddy matrix-supported gravel; ungraded; very poorly sorted.
				Distinct contact
"	"	0.2	2	Reworked Taupo Ignimbrite; abundant glassy creamy pumice clasts with long vesicles.
Onetapu Formation	Ona	0.2	2.2	Muddy matrix-supported gravel; normally graded; very poorly sorted.
"	"	0.2	2.4	Taupo Ignimbrite; fine glassy ash to medium lapilli with long vesicles; common pieces of charcoal.

L1 821/233869

Onetapu Formation and Tangatu Formation are exposed in a metal pit on the west bank of the Whangaehu River, immediately upstream of Tirorangi Marae.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.6	1.00	Matrix-supported gravel; very poorly sorted; ungraded; largest clast 0.20 m; massive; clasts subangular to angular; common grey and few red and black lithic clasts; matrix colour 10YR 4/3, dark brown; few pumice granules.
				Distinct non-erosional contact
"	"	0.30	1.3	Clast-supported, very well sorted, well rounded reworked Taupo ignimbrite pumice pebbles with some mud; pumice dominantly rounded and white with long vesicles; slight orange staining; contains large pieces of wood and charcoal; capped with fine silt; matrix colour 10YR 6/8, yellowish brown.
				Distinct non-erosional contact
Onetapu Formation	Ong1	3.50	4.80	Clast-supported sand and granules; normally graded; weak mm thick laminae; dish and pillar structures in upper 1.5 m, and few water escape pipes extending from top of unit to about 2 m depth; clasts subrounded to rounded; few of these pipes lead directly to a sand volcano, common black and grey and few red lithic clasts; common grey pumice clasts; overall colour 2.5Y 4/4, olive brown.
				Distinct non-erosional contact
"	"	0.05	4.85	Clast-supported very well sorted reworked Taupo ignimbrite pumice pebbles; pumice dominantly rounded and white with long vesicles.
				Graded contact
Onetapu Formation	Ong2	0.60	5.45	Clast-supported sand and granules; normally graded to centre then inversely graded; massive; poorly sorted; clasts subangular to angular; common grey, black and few red lithic clasts; common grey pumice clasts; overall colour 10YR 4/3 dark brown.
				Distinct non-erosional contact
"	"	0.03	5.48	Clast-supported very well sorted, well rounded reworked Taupo ignimbrite granules and pebbles; contains abundant white pumice clasts with long vesicles; matrix colour 10YR 4/2 dark greyish brown.
				Distinct non-erosional contact
Onetapu Formation	Ong1	1.20	6.68	Clast-supported sand and granules; faint mm thick laminae; poorly sorted; inversely graded from bottom to middle then normal graded; common black and grey and few red lithic clasts; common grey pumice clasts; few rip up clasts of Tertiary siltstone; overall colour 10YR 4/3, dark brown.
				Distinct non-erosional contact
Onetapu Formation	Onf	3.00	11.18	Muddy matrix-supported gravel; very poorly sorted; normally graded; maximum clast size 0.6 m; clasts rounded to subrounded; common grey and few red and black lithic clasts; common clasts with orange-red staining; fine-grained pebbly base; matrix colour 10YR 5/1, grey with orange-red and olive mottles.
				Distinct erosional contact
Onetapu Formation	Ond	0.30	11.48	Clast-supported sands with few granules; ungraded; mm thick laminae; poorly sorted; largest clast 0.03 m; clasts subangular to subrounded.
				Distinct erosional contact

Onetapu FormationOne		0.40	11.88	Muddy matrix-supported granules; inversely graded; very poorly sorted; largest clast 0.1 m; clasts subrounded to rounded; common grey and black and few red lithic clasts; matrix colour 10YR 5/8-2.5Y 4/4, yellowish brown to olive brown, mottled orange red and grey; contains common orange stained Taupo pumice clasts in upper 0.15 m, with charcoal. Distinct non-erosional contact
•	•	0.30	12.18	Clast-supported, well sorted, well rounded reworked Taupo ignimbrite pebbles and granules; abundant white rounded pumice clasts, with long vesicles and stained orange; thin muddy matrix. Distinct contact
•	•	0.60	12.48	Very gritty sandy clay loam (10YR 6/8); contains lenses of rounded lithic granules and pebbles; common soft white pumice with long vesicles 0.2 m from top.

L2 S21/232669

Reference section

Onetapu, Mangaio, and Tangatu Formations are exposed in a road cutting at Tirorangi Marae. Immediately above the bridging point of the Whangaehu Valley Road over the Whangaehu River, on the west bank of the River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onk	1.20	1.20	Clast-supported sands; ungraded; cm thick beds; largest clast 0.01 m; moderately to poorly sorted; common black and grey and few white lithic clasts; common grey pumice clasts; common fine roots; convoluted bedding structures.
				Distinct non-erosional contact
"	"	0.05	1.25	Gritty sandy loam (10YR 4/3, brown); very greasy; slightly sticky; humic; abundant fine roots.
				Graded contact
Onetapu Formation	Onj	0.25	1.50	Muddy matrix-supported gravel; fine grained clast-supported base; ungraded; very poorly sorted; largest clast 0.8 m; clast subangular to angular; orange red mottles; common black and grey and few red lithic clasts; clasts commonly stained orange-red; matrix colour 10YR 5/2, greyish brown.
				Distinct non-erosional undulating contact
"	"	0.10	1.60	Very gritty sandy silt (10YR 3/4, dark yellowish brown); structureless; common fine roots; common black and grey coarse sand.
				Graded contact
Onetapu Formation	Onh	0.90	2.50	Sandy matrix-supported gravel; ungraded to inversely graded; very poorly sorted; largest clast 0.2 m; clasts angular to rounded; common black and grey and few red and purple lithic clasts; few clasts with orange stains on clasts; matrix colour 10YR 4/2, dark greyish brown.
				Distinct contact
(Onetapu Formation)	(Ong3)	0.20	2.70	Very gritty sandy silt loam (10YR 3/3-4/3, dark brown); very poor structure; non sticky; non plastic; non greasy; common grey black and white sand; common fine roots; contains 0.1 m thick lense of clast-supported sands at base of soil, immediately overlying Ong2.
				Graded contact
Onetapu Formation	Ong2	0.65	3.35	Clast-supported sand and granules with lenses of pebbles; ungraded; cm thick laminae; laminae are convoluted; poorly sorted; largest clast 0.08 m; clast angular to rounded; common black and grey and few orange and white lithic clasts; few clasts with orange red stains; pinches out towards river.
				Distinct non-erosional contact
"	"	0.05	3.40	Gritty sandy loam (2.5Y 5/4, light olive brown); scattered reworked Taupo ignimbrite granule-sized pumice clasts.
				Graded contact
Onetapu Formation	Ong1	0.05	3.45	Clast-supported sands; cm thick beds; poorly sorted; largest clast 0.05 m; clasts angular to subrounded; common black and grey and few red and white lithic clasts; few to common grey pumice clasts; few clasts stained orange.
				Graded contact
"	"	0.05	3.50	Gritty sandy loam (2.5Y 5/4, light olive brown).
				Graded contact

L2 821/232889

Reference section

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	*Description*
Onetapu Formation	Onf	0.30	3.80	Muddy matrix-supported gravel; pebble-rich base; ungraded; very poorly sorted; largest clast 0.17 m; clasts subangular to rounded; common black and grey and few red and soft white and orange lithic clasts; common clasts with orange-red staining; matrix colour 10YR 5/2, greyish brown, mottled orange and red.
				Distinct contact
Onetapu Formation	Ona	0.12	3.92	Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.15 m; clasts subangular to rounded; common black and grey and few red lithic clasts; common clasts with orange-red staining.
				Distinct contact
"	"	0.45	4.37	Slightly gritty sandy clay loam (10YR 5/6-5/8, yellowish brown); tephric; fine crumb with some nut; common fine ash to medium lapilli Taupo Ignimbrite pumice scattered in upper 0.1 m; few blocks underlying sands and gravels scattered; few fine roots and pores stained 7.5YR 5/4, brown; very occasional pieces of charcoal.
				Graded contact
"	"	0.15	4.52	Clast-supported sand and gravel; ungraded; poorly sorted; largest clast 0.02 m; clasts angular to rounded; common black and grey lithic clasts; common clasts with orange-red stains.
				Distinct contact
"	"	0.50	5.02	Discontinuous pods of lithified sands supported in gritty sandy clay loam (10YR 5/6, yellowish brown); fine nut and crumb; sticky; non plastic; very greasy; common black and orange and few white scattered sands; common fine roots.

M1 S21/218866

Reference sections

Onetapu Formation deposits are exposed on a point bar on the west bank of the Whangaehu River, *c.* 600 m downstream of Tirorangi Marae.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	0.6	0.6	Dark brown topsoil
				Graded contact
Onetapu Formation	Onh	0.7	1.2	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts angular to subrounded; common black and grey and occasional red and white clasts; matrix colour 10YR 3/3, dark brown.
				Distinct non-erosional contact
Onetapu Formation	Ong	3.6	4.7	Clast-supported sands; normally graded; distinct mm thick laminae; poorly sorted; largest clast 0.02 m; clasts angular to subrounded; common black and few red lithic clasts; common grey pumice; may be two units, marked by a thin very weak paleosol at 0.6 m above the base of the unit.
				Distinct contact
Onetapu Formation	Onf	0.7	5.4	Muddy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.15 m; clasts subrounded to rounded; common black and grey and few soft white and orange clasts; clasts commonly stained orange red; matrix colour 10YR 4/2, dark greyish brown with 2.5YR 5/2, weak red mottles.
				Distinct contact
Onetapu Formation	One	0.3	5.7	Reworked Taupo Ignimbrite; abundant glassy creamy pumice clasts with long vesicles; few flecks of charcoal; gritty sandy loam (10YR 6/6) matrix.

On TANGATU FORMATION

M2 521/224867

Reference section

Onetapu and Tangatu Formation deposits are exposed in a track cutting on the west bank of the Whangeshu River at a now derelict bridging point at the River's confluence with the Mangeshueshu Stream.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.6	0.6	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.25 m; clasts angular to rounded; common black and grey and few red and occasional white lithic clasts; orange stains of few clasts; matrix colour 10YR 3/3, dark brown.
				Distinct contact
Onetapu Formation	Ong	1.2	1.8	Clast-supported sands and granules; ungraded; distinct cm thick beds; very poorly sorted; largest clast 0.03 m; clasts angular to rounded; common black and grey and few red lithic clasts; few to common grey pumice.
				Distinct contact
Onetapu Formation	Onf	0.15	1.95	Muddy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.015 m; clasts subangular to rounded; common black and grey and few red lithic clasts; common glassy creamy pumice clasts with long vesicles in upper 0.05 m; matrix colour 10YR 4/1-4/2, dark grey to dark greyish brown.
				Distinct contact
"	"	0.05	2	Sands; few fine to medium sand Taupo Ignimbrite clasts.
				Distinct erosional contact
Mangaio Formation	"	0.85	2.85	Muddy matrix-supported gravel; clast-rich; normally graded; very poorly sorted; largest clast 0.05 m; clasts rounded; common black and grey and few white clasts; clasts commonly stained orange red; matrix colour 10YR 6/8, brownish yellow, with strong orange mottles.

N S21/218863

Reference section

Onetapu and Tangatu Formation deposits are exposed in a track cutting down to the east bank of the Whangaehu River at a now derelict bridging point at the River's confluence with the Mangaehuehu Stream.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onk	0.3	0.3	Clast-supported sands; ungraded; distinct mm thick laminae; poorly sorted; largest clast 0.01 m; clasts rounded.
				Distinct contact
"	"	0.2	0.5	Very gritty sandy silt; structureless; common live roots; occasional gravel clasts scattered throughout.
				Graded contact
Onetapu Formation	Onj	0.3	0.8	Muddy matrix-supported gravel; ungraded; very poorly sorted.
				Distinct contact
Onetapu Formation	Onh	0.5	1.3	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.03 m; clasts subangular to rounded; common black and grey and few red lithic clasts.
				Distinct contact
"	"	0.25	1.55	Gritty sandy silt (10YR 4/4, dark yellowish brown); structureless; few medium to coarse sand creamy Taupo ignimbrite clasts scattered throughout.
				Graded contact
Onetapu Formation	Ong	0.25	1.8	Clast-supported sands; ungraded; faint mm thick laminae; poorly sorted; largest clast 0.015 m; clasts subrounded to rounded; common black and grey and few red clasts.
				Distinct contact
"	"	0.32	2.12	Very gritty sandy silt; structureless; few fine to medium sand Taupo ignimbrite clasts scattered throughout.
Mangaio Formation	"	0.4	2.52	Muddy matrix-supported gravel; clast-rich; normally graded; unit pinches in and out; poorly sorted; largest clast 0.03 m; clasts rounded; common black and grey and few red lithic clasts; matrix colour 10YR 5/8-7.5YR 5/8, yellowish brown to strong brown.

O 82 1/209952

Reference section

Onetapu and Tangatu Formation deposits are exposed in the west bank of the Whangeshu River,*c.* 1.6 km downstream of the Whangeshu River's confluence with the Mangeshuehu Stream.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onk	0.3	0.3	Clast-supported sands; ungraded; distinct mm thick laminae; poorly sorted; largest clast < 0.005 m; common black and grey and few red and white lithic clasts; few grey pumice.
				Distinct non-erosional contact
"	"	0.3	0.6	Gritty sandy clay loam (10YR 3/6, dark yellowish brown); slightly sticky; slightly plastic; slightly greasy; common roots.
				Graded contact
Onetapu Formation	Onh	0.5	1.1	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.08 m; clasts subangular to rounded; common black and grey and few red lithic clasts.
				Distinct non-erosional contact
"	"	0.15	1.25	Gritty sandy clay loam (10YR 3/6, dark yellowish brown); slightly sticky; slightly plastic; greasy; moderately developed fine nut and crumb structure; common fine roots.
				Graded contact
Onetapu Formation	Ong	0.3	1.55	Clast-supported sands; ungraded; distinct mm thick laminae; poorly sorted; largest clast < 0.005 m; clasts angular to rounded; common black and grey and few red and white lithic clasts; common grey pumice.
				Distinct non-erosional contact
"	"	0.3	1.85	Very gritty sandy silt with some clay; non sticky; non plastic; greasy; weakly developed fine crumb; few grey and orange sands scattered throughout; occasional Taupo Ignimbrite fine to coarse sand clasts scattered throughout.
				Graded contact
Onetapu Formation	Onf	0.25	2.1	Muddy matrix-supported gravel; inversely graded base grades upwards to normally graded upper portion; very poorly sorted; largest clast 0.05 m; clasts subangular to rounded; common grey and black and few red lithic clasts; matrix colour 10YR 5/2, greyish brown, with olive-yellow mottles.

ON TANGATU FORMATION

P S21/181732

Reference section

Onetapu Formation deposits are exposed in a metal pit on the west bank of the Whangeshu River, immediately above the bridge at Colliers junction.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onh	0.6	0.6	Sandy matrix-supported gravel; inversely graded; very poorly sorted; largest clast 0.08 m; clasts subangular to rounded; few Tertiary siltstone pebbles and cobbles scattered throughout.
				Distinct erosional contact
Onetapu Formation	Ong	1	1.6	Clast-supported sands and granules, with some gravel; ungraded; very poorly sorted; faint cm thick beds; gravelly lens in middle of unit; largest clast 0.03 m; clasts angular to rounded; few Tertiary siltstone pebbles.
				Distinct non-erosional contact
Onetapu Formation	Onf	0.7	2.2	Muddy matrix-supported gravel; normally graded, but with fine-grained base; very poorly sorted; largest clast 0.2 m; clasts subangular to rounded; common orange-red stains on clasts; few Tertiary siltstone pebbles; distinctive grey, 10YR 6/1-6/2, matrix with orange-red mottles.
				Distinct non-erosional contact
"	"	0.1	2.3	Sands; massive; well sorted; reworked Taupo Ignimbrite fine to coarse sand scattered throughout.
				Graded contact
Onetapu Formation	Ons	0.3	2.6	Muddy matrix-supported gravel; ungraded, but with fine-grained base; very poorly sorted; largest clast 0.025 m; clasts subangular to rounded; distinctive grey (10YR 5/2) matrix with olive mottles.
				Distinct non-erosional contact
"	"	1	3.6	Sands; massive; well sorted; reworked Taupo Ignimbrite sand and granules scattered throughout, concentrated at the top of the unit.

Q 21/219863

Reference section

Onetapu Formation deposits are exposed in a metal/rubbish pit on the west bank of the Whangaehu River, at Aranui.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onj	0.75	0.75	Clast-supported sands and granules with occasional pebbles; ungraded; distinct cm thick beds; poorly sorted; largest clast 0.06 m; clasts angular to rounded; common glassy grey clasts; distinct grey matrix (10YR 5/2) with olive streaky mottles.
				Distinct non-erosional contact
Onetapu Formation	Onh	0.6	1.35	Sandy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.12 m; clasts subangular to rounded; matrix colour 10YR 5/2, greyish brown.
				Distinct non-erosional contact
Onetapu Formation	Ong	0.7	2.05	Clast-supported sands; ungraded; weak mm thick laminae; moderately poorly sorted; largest clast < 5 mm; clasts angular to rounded.

R S22/139572

Reference section

Onetapu Formation depoits are exposed in a metal pit on the east bank of the Whangaehu River, at Raukiwi.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onj	1.5		Muddy matrix-supported gravel; ungraded; very poorly sorted; largest clast 0.1 m; clasts subangular to subrounded; abundant glassy grey lithic clasts; distinctive grey (10YR 5/2) matrix with olive streaks.

S2 S22/123618

Reference section

Onetapu Formation deposits are exposed in a landfill pit on the west bank of the Whangaehu River at Mangamahu, immediately above a bridging point over the River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onj	2		Muddy matrix-supported gravel; clast-rich; ungraded; very poorly sorted; largest clast 0.12 m; clasts subangular to rounded; abundant grey lithics; distinctive grey (10YR 5/2) matrix, with olive streaks.

T S22/124618

Reference section

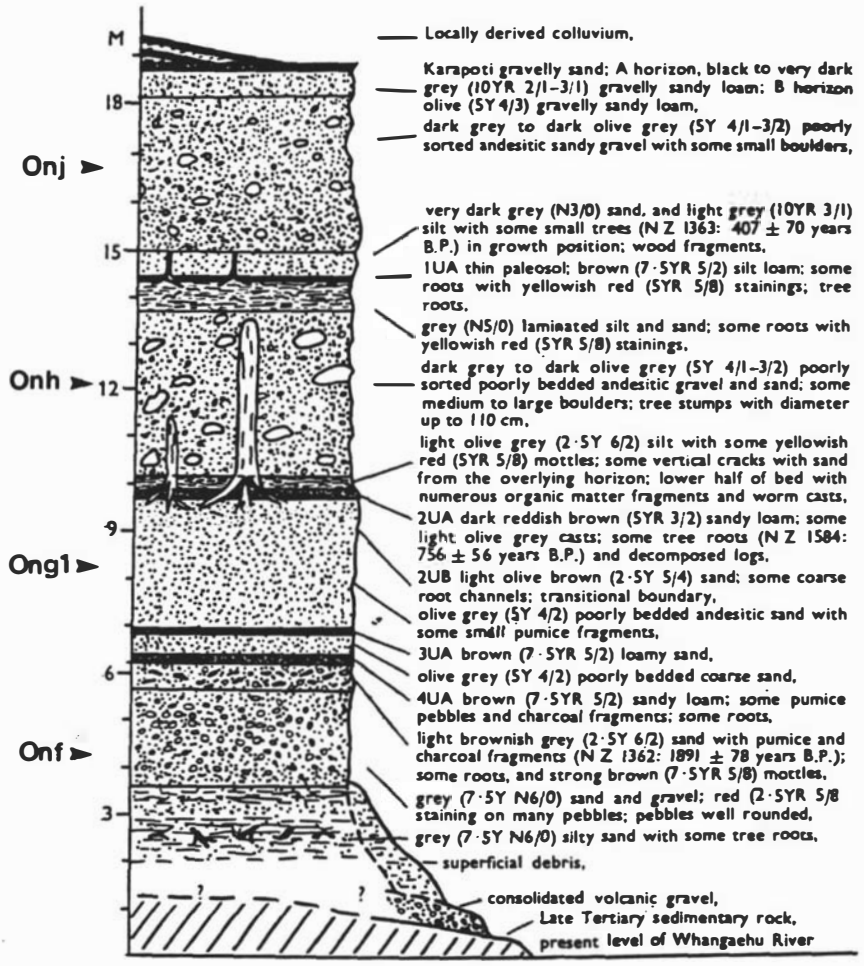
Onetapu Formation deposits are exposed in a gully on the east bank of the Whangaehu River, at the Rivers confluence with a small tributary stream, *c.* 4 km downstream of Mangamahu.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
*	*	1.5	1.5	Pale gray silty loam; common coarse roots.
				Distinct non-erosional contact
Onetapu Formation	Onj	1	2.5	Muddy matrix-supported gravel; ungraded; very poorly sorted; matrix colour distinctive grey with olive streaks.
				Distinct non-erosional contact
Onetapu Formation	Onh	3	5.5	Matrix-supported gravel; ungraded; very poorly sorted; matrix colour brownish grey.
				Distinct non-erosional contact
Onetapu Formation	Ong	1	6.5	Clast-supported sands; ungraded; weak mm thick laminae; appears orange brown.
*	*	0.5	7	Organic rich silty sand.

S1 S22/124301

Reference section

Onetapu Formation deposits described by Campbell (1973) are exposed in a metal pit *c.* 2.5 km north of Mangamahu.



U S22/124301

Reference section

Onetapu Formation deposits are exposed resting on a low lying Tertiary outcrop on the west bank of the Whangaehu River, *c.* 4 km downstream of Mangamehu..

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onf	2	2	Muddy matrix-supported sand and gravel; normally graded; very poorly sorted; largest clast 0.015 m; clasts angular to rounded; common grey and black and few white and red lithic clasts; few clasts with strong orange red stains; matrix colour distinctive grey with orange red mottles.
				Distinct non-erosional contact
"	"	0.25	2.25	Grey silty sand; few scattered sand and granule-sized clasts of reworked Taupo Ignimbrite; occasional flecks of charcoal; orange brown mottles.
				Distinct non-erosional contact
Onetapu Formation	Ona	1.5	3.75	Muddy matrix-supported gravel; inversely graded to middle then normally graded; very poorly sorted; largest clast 0.25 m; clasts angular to rounded; common grey and black and few red and purple lithic clasts; orange-red mottling on few clasts; occasional Tertiary pebbles; matrix colour grey with yellow-brown mottles.
				Distinct contact
"	"	0.2	3.95	Silty sand; common scattered sand and granule reworked Taupo Ignimbrite clasts.

ON TERTIARY SILTSTONE

V S22/198484

Reference section

Onetapu Formation deposits are exposed on the east bank of the Whangaehu River, at the edge of the Mangamehu Golf course, *c.* 2 km upstream of Manurewa.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
"	"	0.5	0.5	Silty loam
				Distinct non-erosional contact
Onetapu Formation	Onj	1.5	2	Clast-supported sands and granules; massive; ungraded; poorly sorted; abundant glassy grey scoriated lithic clasts; matrix colour grey with olive streaks.
				Distinct non-erosional contact
"	"	0.5	2.5	Pale grey silty loam.
				Distinct non-erosional contact
Onetapu Formation	Onh	1.5	4	Clast-supported sands and granules; ungraded; massive; poorly sorted; matrix colour grey brown with olive streaks.
				Distinct non-erosional contact
"	"	0.5	4.5	Silts.
				Distinct non-erosional contact
Onetapu Formation	Ong	1.5	6	Clast-supported sands and granules; ungraded; massive; poorly sorted; matrix colour grey brown with olive streaks.

W S22/095479

Reference section

Onetapu Formation deposits are exposed in the west bank of the Whangaehu River, *c.* 1. km downstream of Manurewa.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	1	1	Grey sandy silt loam.
				Distinct contact
Onetapu Formation	Onk	0.2	1.2	Clast-supported sands; ungraded; weak mm thick laminae; poorly sorted.
				Distinct non-erosional contact
•	•	0.2	1.4	Grey sandy silt loam; contains occasional bits of bark and twigs.
				Distinct non-erosional contact
Onetapu Formation	Onj	0.7	2.1	Clast-supported sands and granules; ungraded; massive; poorly to very poorly sorted.
				Distinct non-erosional contact
•	•	0.4	2.5	Grey silty loam.

X S22/093430

Reference section

Onetapu Formation deposits are exposed in a gully on the east bank of the Whangaehu River, at the Rivers confluence with a small tributary stream on the left side of Okirae Road, *c.* 2 km upstream of the confluence between the Whangaehu and Mangawhero Rivers.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
Onetapu Formation	Onj	0.5	0.5	Clast-supported sands and granules; ungraded; poorly sorted; distinct mm thick laminae; abundant scoriated grey lithic clasts.
				Distinct non-erosional contact
•	•	0.5	1	Grey silty loam; contains common pieces of wood, twigs and leaves.
				Distinct non-erosional contact
Onetapu Formation	Onh	1	2	Clast-supported sand and granules; ungraded; distinct cm thick beds; poorly sorted.

Y S22/064476

Reference section

Onetapu Formation deposits are exposed in the undercut east bank of the Mangawharo River 50 m upstream of the bridging point over this River, and 500 m above its confluence with the Whangaehu River.

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
"	"	1	1	Dark brown topsoil
"	"	1.5	2.5	Silts; massive.
"	"	1	3.5	Bedded silts.
				Graded contact
Onetapu Formation	Onj	1	4.5	Clast-supported sands and granules with some gravel; massive; ungraded; poorly sorted.
				Distinct non-erosional contact
"	"	3	7.5	Bedded silts; common pieces of wood and twigs scattered throughout.
				Graded contact
Onetapu Formation	Onh	0.5	8	Clast-supported sands; weakly developed mm thick laminae; ungraded; poorly sorted.
				Distinct non-erosional contact
"	"	0.5	8.5	Silty loam; sticky; plastic; non greasy; piece of wood found at top of this paleosol dated (Wk-2680) at 570 ± 45 years B.P.

Z 822/064433

Reference section

Onetapu Formation deposits are exposed in the undercut west bank of the Mangatipona Stream 500 m above its confluence with the Whangaehu River, and on the left side of the MAngatipona Road,immediatley below its junction with Oldrae Road (at a bridging point).

Formation	Member	Unit thickness (m)	Cumulative thickness (m)	Description
•	•	4	4	Grey silty loam, with a 0.5 m thick sandy unit (Onj) at c. 0.5 m from the top of the exposure.
				Distinct non-erosional contact
•	•	1.1	5.1	Dark grey fine sands with orange brown mottles; very well sorted.
				Distinct non-erosional contact
•	•	0.15	5.25	Pale grey loam with orange brown mottles; firm; non sticky; plastic.
				Graded contact
Onetapu Formation	Onh	0.45	5.7	Clast-supported sands; well sorted; weak mm thick laminae; distinctive grey colour with olive streaks.
				Graded contact
•	•	0.25	5.95	Grey silty loam with strong orange brown mottles; non sticky; plastic.
				Graded contact
•	•	0.5	6.45	Fine sand and silt; grey with orange brown mottles.
				Graded contact
Onetapu Formation	Ona	0.5	6.95	Muddy matrix-supported grevels; ungraded; poorly sorted; common grey lithic clasts; clasts subrounded to rounded; clasts commonly stained orange brown; few to common Tertiary siltstone pebbles; matrix colour grey with strong orange brown mottles.
				Graded contact
•	•	1.2	8.05	Very well sorted, rounded fluvial gravels.

Plate 1.1 The upper Catchment of the Whangaehu River looking towards the Southeast Mount Ruapehu ring plain showing the upper Whangaehu gorge (1), the Whangaehu Fan (2), and the Whangaehu escarpment (3, arrowed). Photograph taken looking east from the upper flanks of Mount Ruapehu by A. M. Purves.

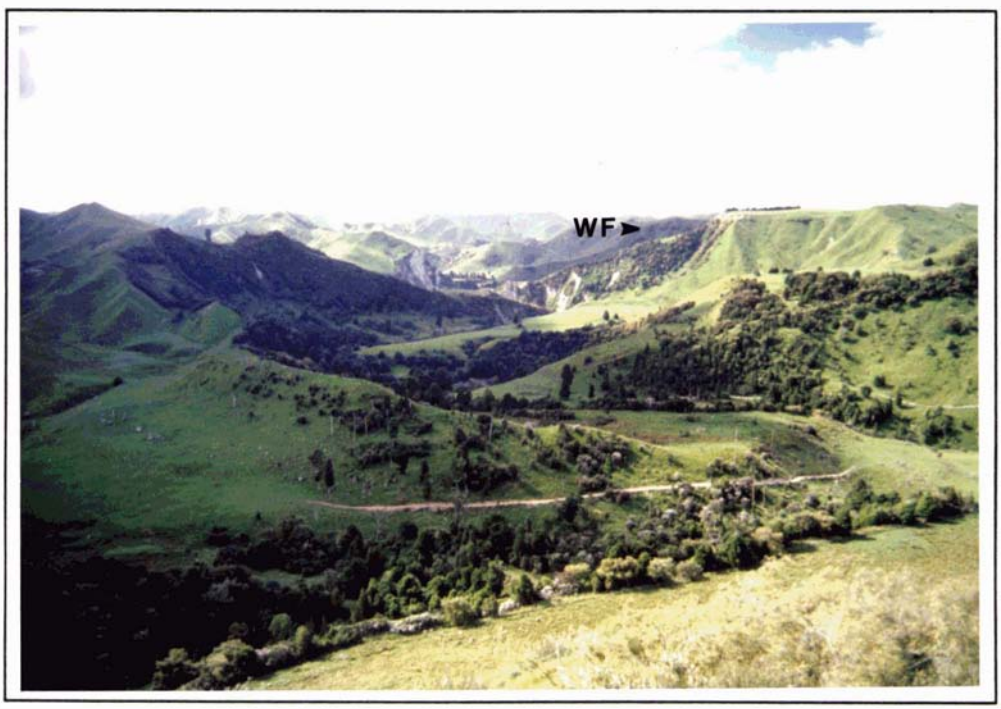


Plate 1.2 The middle Catchment of the Whangaehu River. Note the andesitic boulders lying on the low ridge in the foreground, and the exposure of Whangaehu Formation (WF) in the steep bluffs overlooking the River.
Photograph taken looking north from S21/173723.

Plate 1.3 The lower catchment of the Whangaehu River, showing Mangamahu village in the centre right of the photograph. Tangatu (TG) and Onetapu Formation lahar surfaces (ON) which form constructional terraces close to the River. Site S, arrowed, marks the locality where Campbell (1973) described post-Taupo Ignimbrite lahar deposits. In this study the velocities and discharges for Onetapu Formation members Onh and Onj have been calculated at this locality.
Photograph taken looking east from S22/106515, and courtesy of V. E. Neall, Massey University.

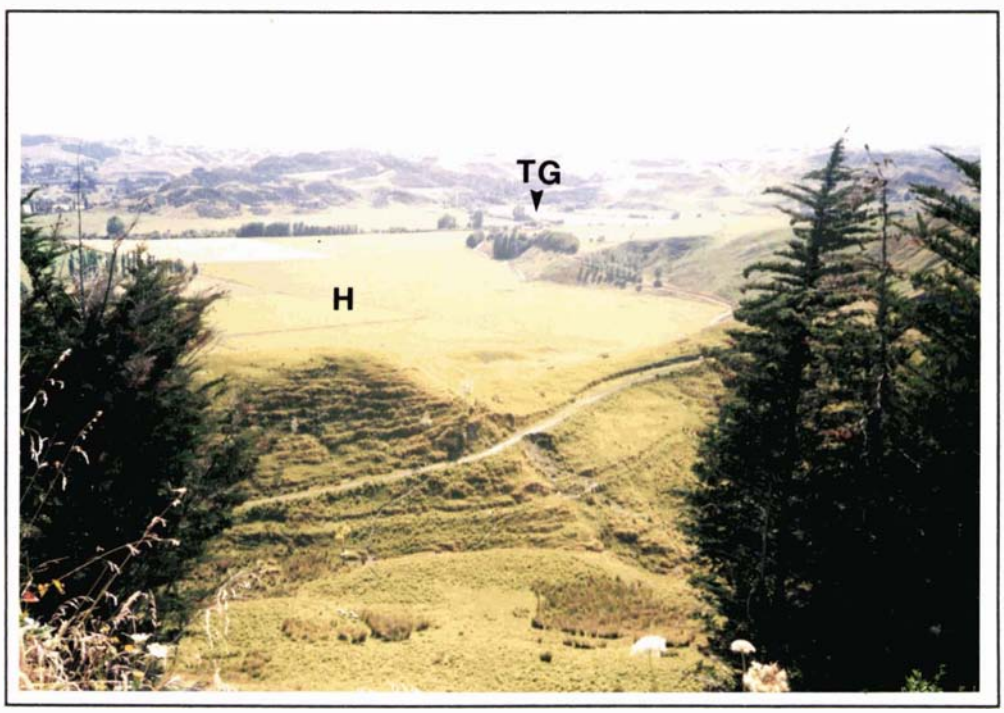


Plate 1.4 The coastal reach of the Catchment, showing Holocene river terraces (H), and the Tangatu Formation lahar surface (TG). The skyline is marked by the dissected Brunswick Formation marine-cut terrace.
Photograph taken looking east from S22/027378.

Plate 4.1 The Type Locality for the Whangaehu Formation (WF) in a north facing ridge *c.* 1.5 km west of Mangamahu (S22/106515). Note the channel cut into underlying Nukumaruan siltstones and sandstones (marked by a dashed line), which was subsequently infilled by the Whangaehu Formation.

Plate 4.2 Thick bouldery diamictites of the Whangaehu Formation from Old Fields Track. Note the sharp erosional contact and marked relief between the underlying Tertiary siltstone and overlying Whangaehu Formation (arrowed). The Formation is here overlain by yellow-brown allophanic tephric coverbeds.
Photograph taken looking east from S21/183819.

Plate 4.3 The Whangaehu Formation from Ruatangata Road (S23/965295) in the coastal reach of the Catchment, in a north facing ridge *c.* 2 km inland from State Highway 3, showing the valley-filling relationship of Whangaehu Formation (WF) with the older Ngarino terrace (NG).
Photograph courtesy of A. S. Palmer, Massey University.

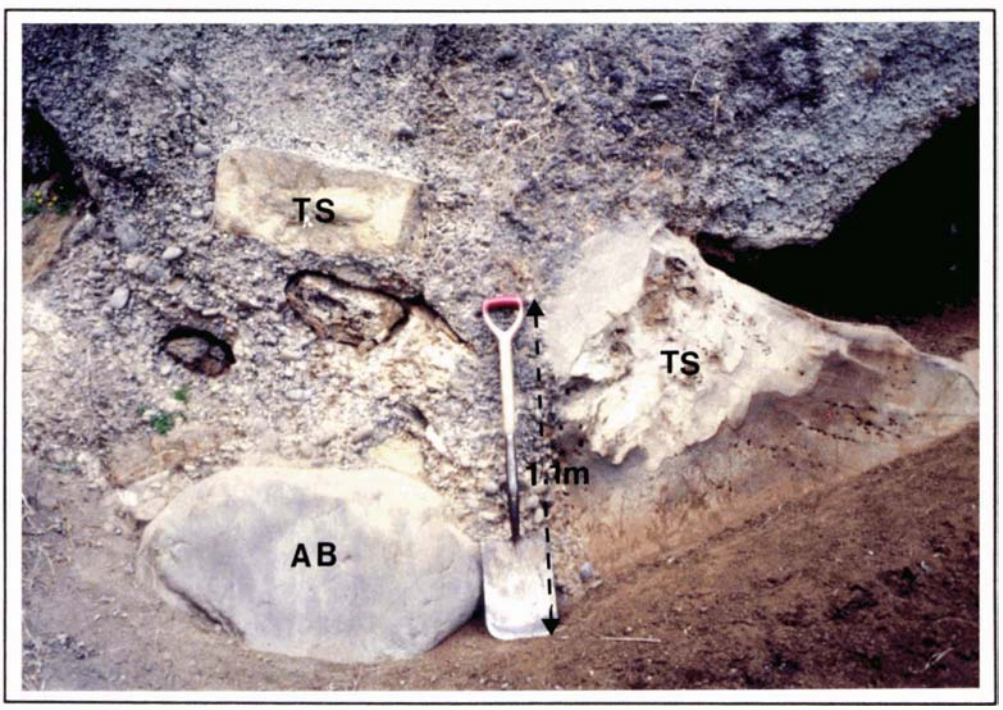


Plate 4.4 Rip-up clasts of Tertiary sandstone and siltstone (TS) at the base of the lowermost diamictite bed at the Type Locality for the Whangaehu Formation. Note the clast-supported pebbly nature of the deposit, and the rounded andesitic boulder (AB).
Photograph courtesy of V. E. Neall, Massey University.

Plate 4.5 Thick Whangaehu Formation bouldery diamictites exposed in the cliffs of the lower Whangaehu gorge (S21/204837). Note the distinct erosional contact (arrowed) between underlying Tertiary siltstone and the overlying Whangaehu Formation. Note also the gently undulating upper surface of the Formation.

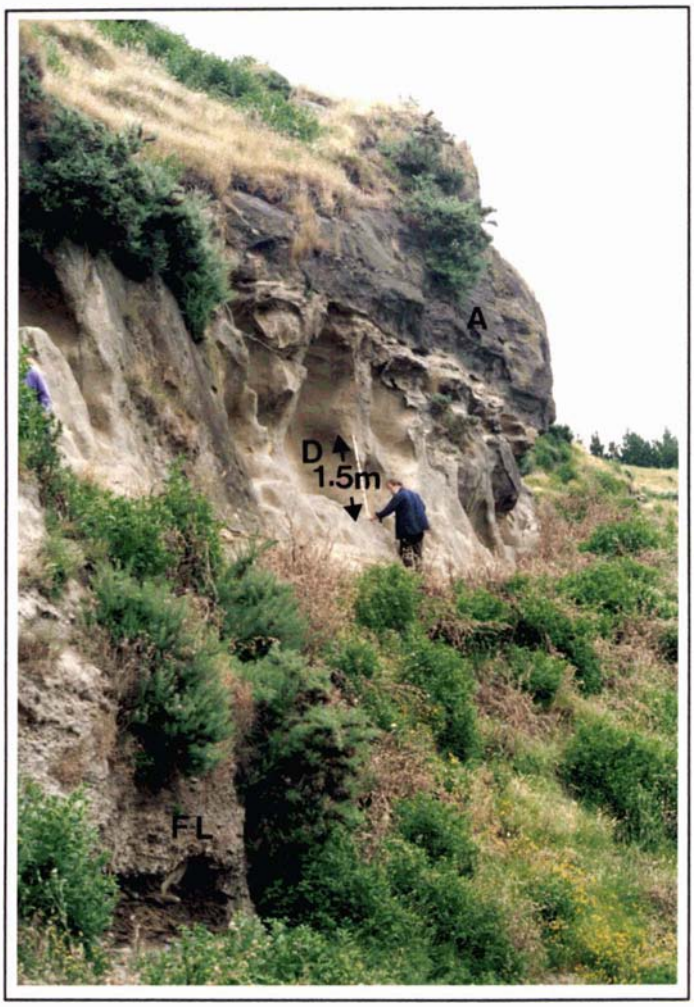


Plate 4.6 Distal lithofacies of the Whangaehu Formation, in the coastal reach of the catchment in a north facing ridge (S22/965295) *c.* 4.5 km east of Fordell, showing the contact with underlying fluvial gravels (FL), lower pale dacite pumice-rich bed (D), and upper dark andesite-rich bed (A). Note also the stratification in the upper bed.

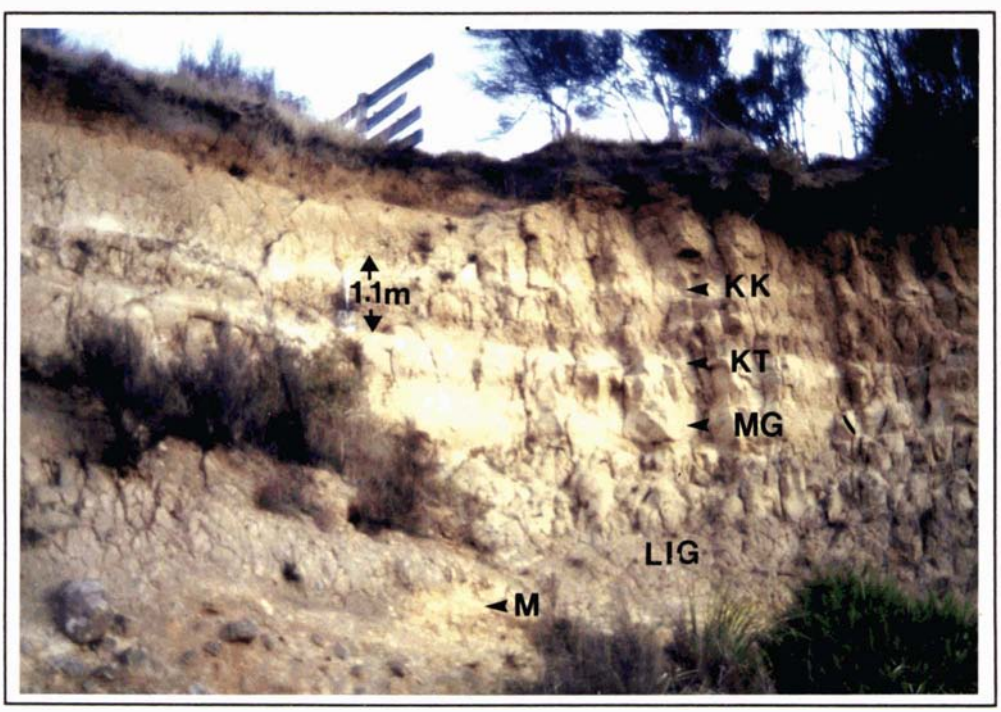


Plate 4.7 Coverbeds overlying the Whangaehu Formation at Wf5 (S21/177805). Note the position of the Kawakawa Tephra (KK), and Kaitieke (KT) and Mangawherawhera (MG) tephras, the Last Interglacial palaeosol (LIG), and underlying Marton loess (M).

Plate 4.8 Kawa kawa Tephra at WF5. Note the thin fine-grained ash base to the Tephra (arrowed). Immediately underlying is yellowish-grey Ohakean loess (OH). Fine-grained rhyolite ash, which dominates the pale coloured coverbeds overlying the base of the tephra, grades upwards into Ohakean loess at the level of the base of the Jacob Staff. Ohakean loess grades upwards into the distinctive yellow-brown Holocene allophanic soil at *c.* 0.6 m from the base of the Staff.
Both photograph 4.7 (previous page) and 4.8 courtesy of A. S. Palmer, Massey University.

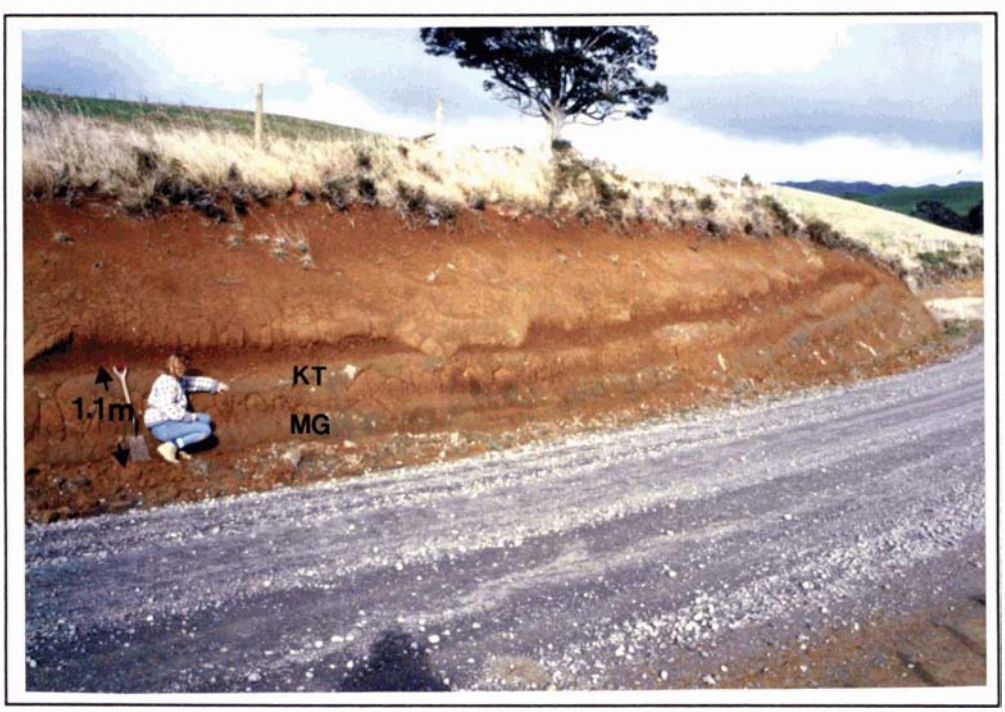


Plate 4.9 Coverbeds at WF7 (S21/188825). Note the approximate position of the Kawakawa Tephra (KK), the Kaitieke tephra (KT, marked by the author's left hand), and the Mangawherawhera tephra (MG, at the level of the author's right knee).

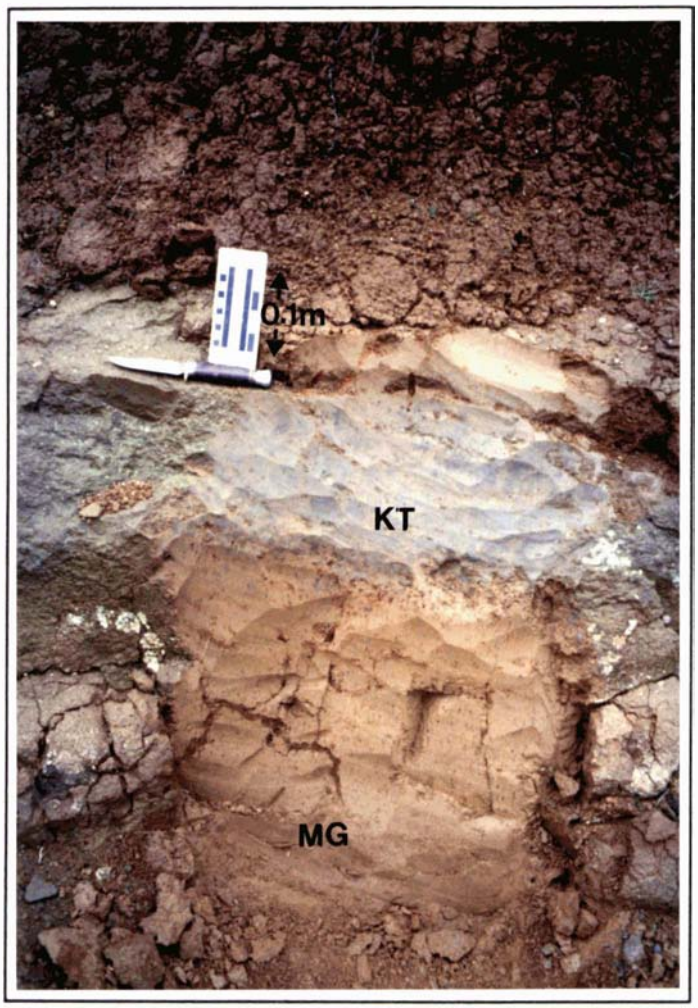


Plate 4.10 The Kaitieke (KT) and Mangawherawhera (MG) tephras at WF7. The Mangawherawhera tephra,at the bottom of the photograph, is bulgy in relief, with a distinctive cracked profile. Although not clearly visible in this photograph it is grey in colour, and comprises dominantly lapilli-sized tephra. The distinctive fine-grained grey Kaitieke tephra is in the middle of the photograph. The overlying reddish-brown coverbed is the Ratan palaeosol. Both photograph 4.9 (previous page) and 4.10 courtesy of V. E. Neall, Massey University.

Plate 4.11 Coverbeds at WF8 (S21/073877). Note the distinct bulgy profile of the Mangawherawhera tephra (MG), the strongly coloured Last Interglacial palaeosol (LIG) and Marton loess (M). WF marks lahar deposits correlated to the Whangaehu Formation.

Plate 5.1 The Mangatipona pumice sand (MA) at MA1 (S22/063429), the distinctive pumice deposit being near to the top of the Jacob Staff. Charcoal found within this deposit was dated (Wk-2681) at 37,030 ± 730 years B.P. Overlying gravels (G) are considered here to be Ratan in age.

Plate 5.2 Apitian lahars at AP3 (S20/203909), in the Mangaehuehu catchment. Note the pale pumiceous nature of the lahar deposits, and the overlying pale Ohakean loess.

Plate 6.1 Buried tree stump in growth postion (arrowed) at TG1 (S21/209877). Another piece of wood sampled at this locality was dated (Wk-1773) at 7,800±70 years B.P. Ponding at this site resulted from impeded drainage of the Mangawherawhera Stream by Tangatu Formation lahars. The thin white layer at approximately 0.5 m from the base of the Jacob Staff, and at the level of the top of the tree stump, comprises diatomaceous sediment.
Photograph courtesy of A. S. Palmer, Massey University.

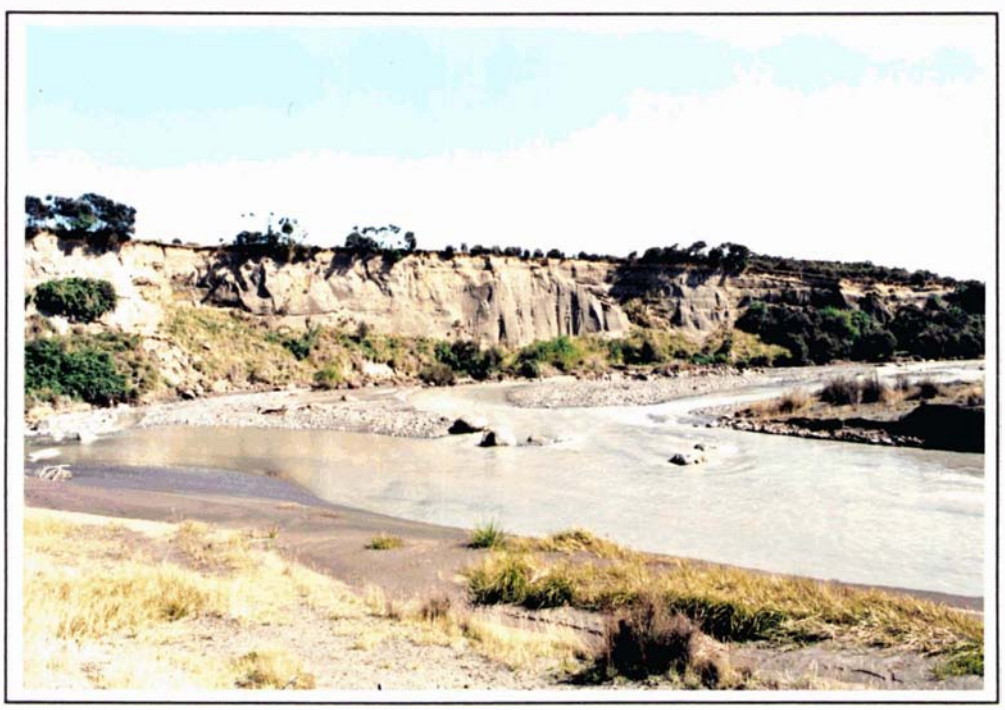


Plate 6.2 Tangatu Formation (TG) at TG3 (S21/287872), looking downstream, in the upper Catchment of the Whangaehu River on the southern edge of the Mount Ruapehu ring plain. Note the distinct erosional contacts between beds within the Formation. The unit in the centre of the photograph is *c.* 20 m thick.

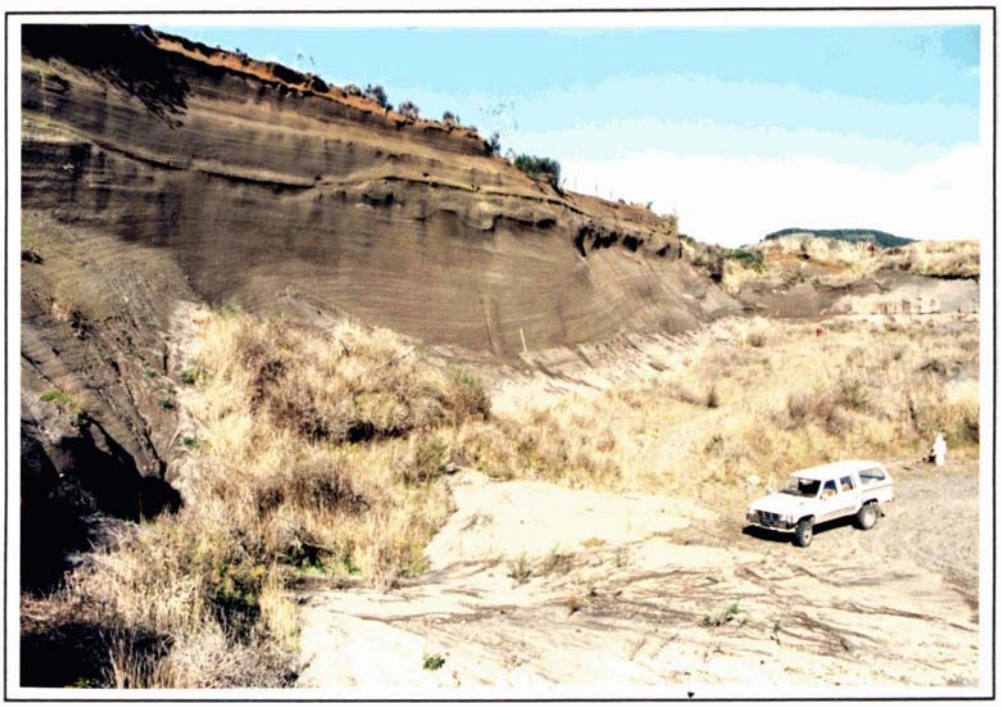


Plate 6.3 Tangatu Formation at TG4 (S21/280887). Note the horizontal and inclined centimetre thick stratifiaction within the deposits, and characteristic overlying yellow-brown loam coverbeds.

Plate 6.4 Tangatu Formation at TG8 (S21/211835). Note again the stratification, and overlying allophanic coverbeds. At this locality the Formation is *c.* 30 m above the present level of the Whangaehu River.
Photograph courtesy of V. E. Neall, Massey University.

Plate 6.5 Tangatu Formation at TG10 (S22/056448), above Wyley's Bridge in the lower catchment of the Whangaehu River. Note the sandy nature of the beds, which are massively bedded or stratified.

Plate 7.1 The remains of a tree stump at Mangamahu (S1, S22/134540) from a tree overwhelmed by Onetapu Formation lahar Onh, *c.* 600 years B.P. The lahar's deposits have been substantially mined out for road aggregates. This locality was first described by Campbell (1973), and is identified in Plate 1.3.

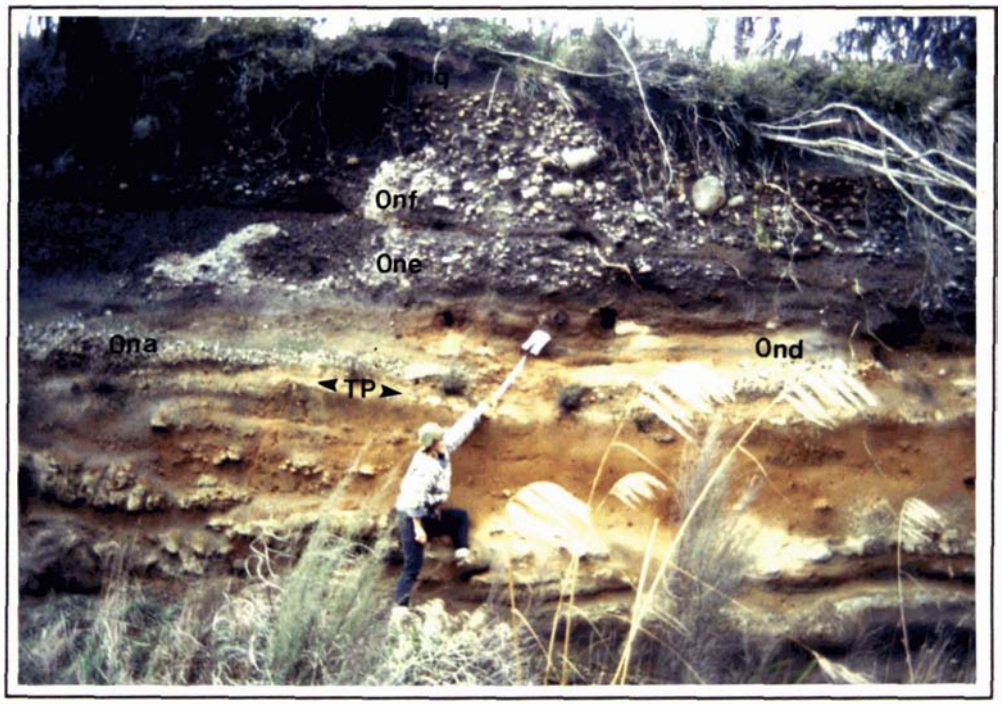


Plate 7.2 In this photograph of section *1* (S21/277883) Onetapu Formation members are underlain by Tangatu Formation (TG) and Taupo Ignimbrite (TP). A date (Wk-2098) of 890±40 years B.P. was obtained from the tree stump indicated by the blade of the spade. This provided a minimum age for underlying Onetapu members Ona and Ond, and a maximum age for the overlying members One, Onf and Ong.
Photograph courtesy of A. S. Palmer, Massey University.

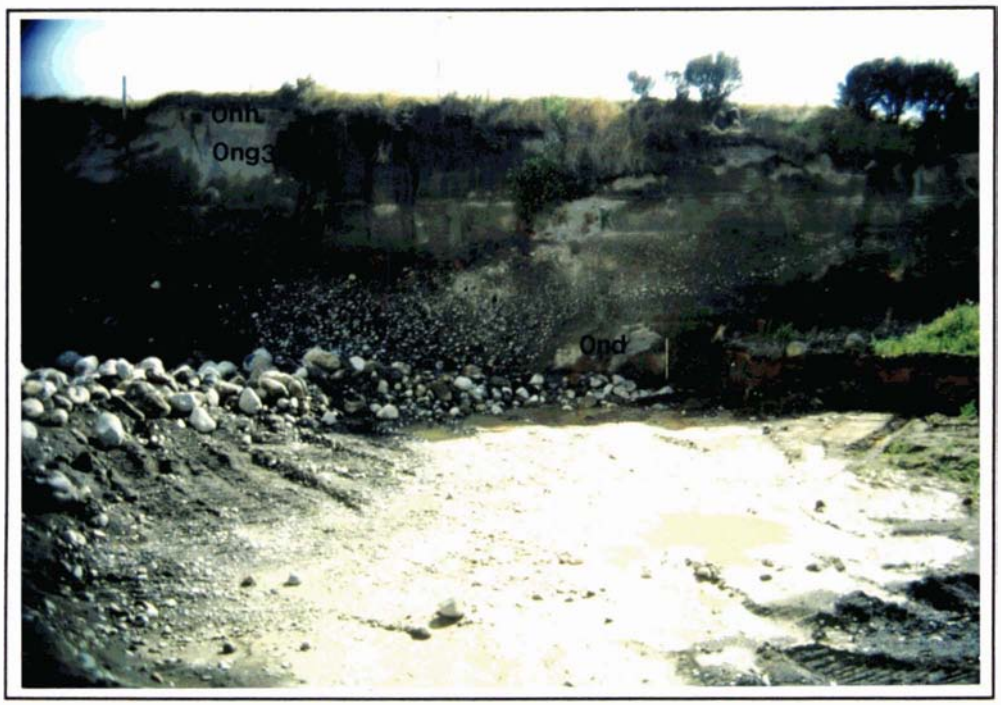


Plate 7.3 Onetapu Formation informal members Ona, Ond, Onf, Ong1, 2 & 3, and Onh are exposed at L1 (S21/233869), shown in this photograph. Note the distinct channel filling geometry and bouldery nature of Onf.
Both photographs 7.2 and 7.3, above, and 7.4 below, courtesy of A. S. Palmer, Massey University.

Plate 7.4 Onetapu Formation informal members Onm, Onn and Ono are exposed in the upper part of G6 (S21/287883), shown in this photograph. A twig collected from within this deposit was dated (Wk-2097) as Modern. These deposits are correlated to historic lahars which occurred in 1861, 1953 and 1975, respectively. 20 m to the left of the position of this photograph, and on the bank of the Whangaehu River, is the remains of a railway carriage bogey, an artifact from the Tangiwai Disaster.

Plate 7.5 An example of an undeformed hyperconcentrated flow deposit in the Manutahi Formation, Rangipo Desert. Note the horizontal stratification and coarse sandy nature of the lahar deposit.

Plate 7.6 An example showing the onset of deformation in a hyperconcentrated flow in the Manutahi Formation, Rangipo Desert. Water escaping through the sediment has entrained particles forced up into the overlying beds via a fluidization channel (arrowed). Fluidization appears to have been arrested early in the process and the sand pillar has "frozen" early in its development.

Plate 7.7 An example of deformation structures in Onetapu Formation informal member Ong at J1 (S21/278885). The movement of water and entrained particles along well-defined "escape routes" (indicated by arrows) has interrupted and upturned the laminae across which pillars have cut resulting in exaggerated dish and pillar stuctures.

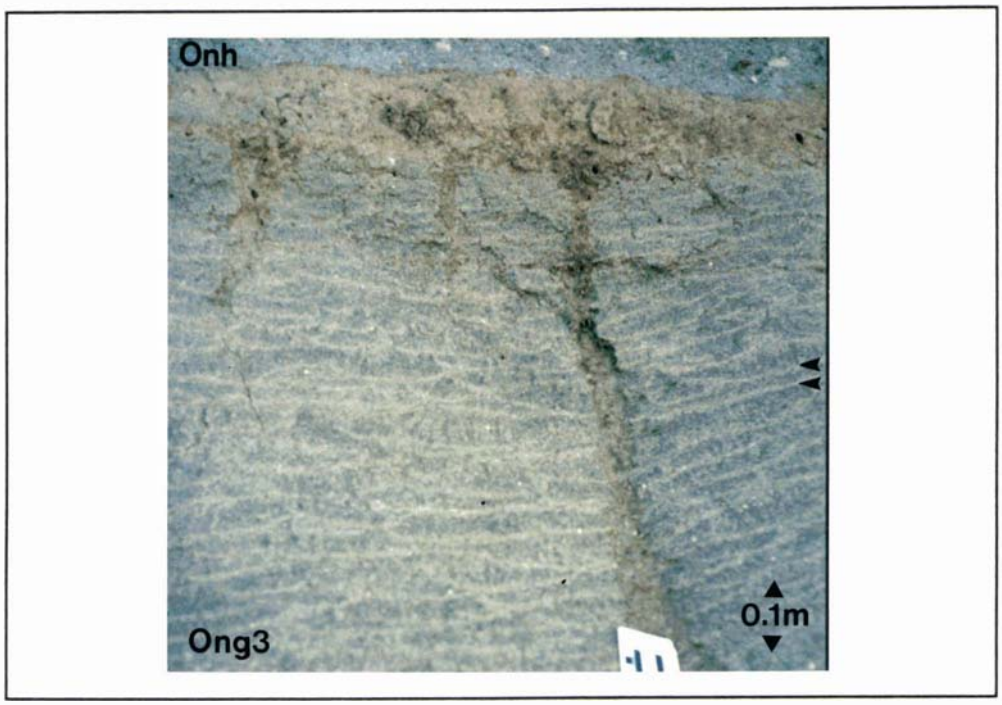


Plate 7.8 Dish and pillar structures in member Ong3 at L1. Early signs of the onset of deformation are indicated by the presence of shallow dish and pillar stuctures, depicted above. The yellowish fine-grained layers (arrowed) mark the base of the dishes.

Plate 7.9 Water escape pipes (vertical arrows) in Ong3 at L1. Accelerated water escape leads to the formation of pipes or chimneys (indicated by arrows). These are unrelated to dish and pillar structures and probably occur within zones of high permeability. In this deposit pipes have truncated and disrupted the pre-existing dish and pillar structures. In the bottom right of the photograph a 0.03 m peat layer between Ong1 & 2 is marked by an arrow.

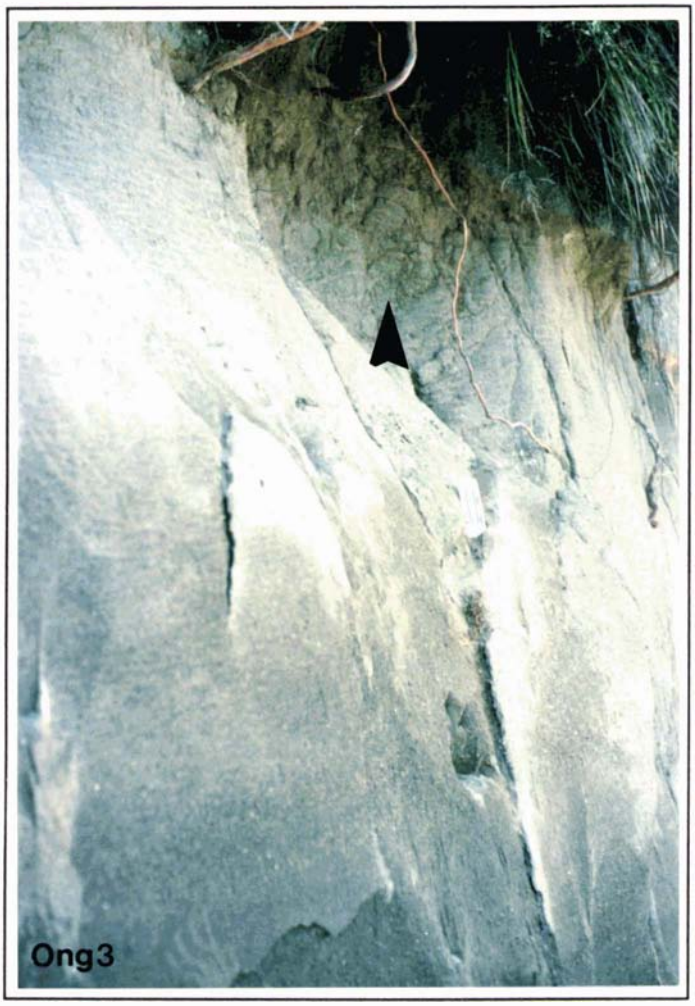


Plate 7.10 An example of a sand volcano at section L1. Water and entrained particles from underlying Ong3 have erupted into overlying Onh resulting in a sand volcano (arrowed). This violent process has disrupted the pre-existing sedimentary features which included dish and pillar structures.

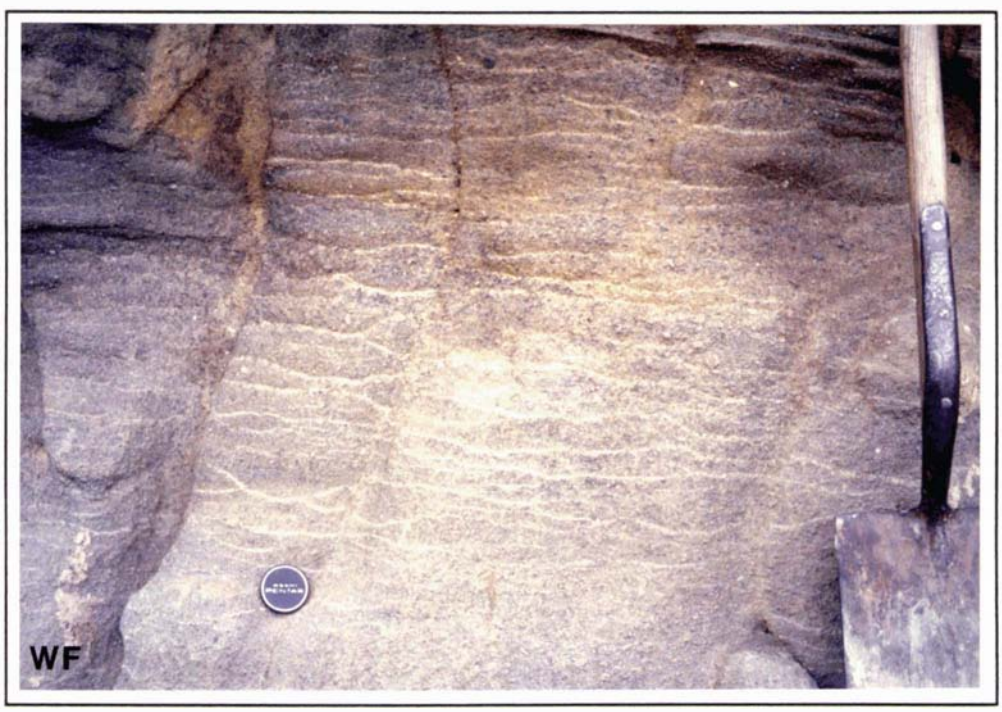


Plate 7.11 Deformation structures, including dish and pillars and possibly water escape pipes, in Whangaehu Formation hyperconcentrated flow deposit at WF3 (S22/965295). Photograph courtesy of V. E. Neall, Massey University.

Plate 7.12 Site E, where velocities and discharges are calculated for Onetapu members Ong, Onh and Onj. Sections E1 (T21/303877) and E2 (T21/302876) are in the metal pit in the forground of the photograph. Section E3 is out of shot, below the bottom right edge of the photograph. The Whangaehu (WF) and Tangatu (TG) Formation surfaces are marked. Tangatu Formation is mantled by Taupo Ignimbrite at this locality. Mount Ruapehu is in the background of this photograph. The steam rising from the forest in the middle distance marks the location of the Karioi pulp mill.

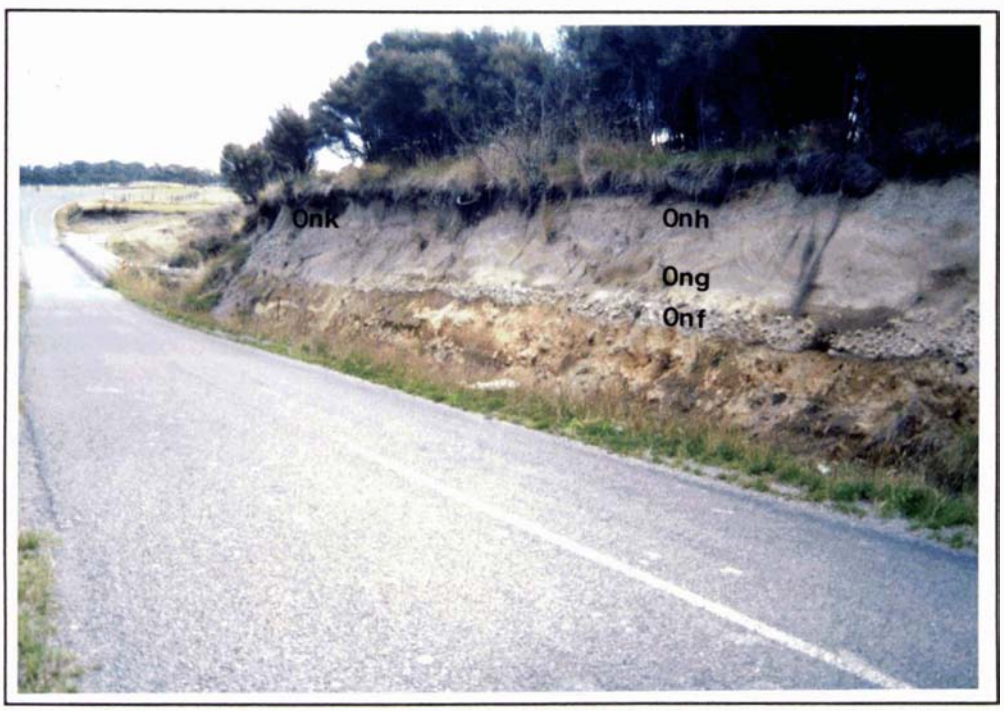


Plate 7.13 Section L2 (S21/232869), shown here, exposes Onetapu Formation lahar deposits in a road cutting on the side of the Whangaehu Valley Road where it bridges the Whangaehu River at Tirorangi Marae. Lahar deposits Onf, Ong, Onh and Onk are arrowed. Ong and Onh are also exposed in the cutting on the far bank of the River. Photographs 7.12 and 7.13, above, both courtesy of A. S. Palmer, Massey University.

Plate 8.1 Tangiwai railway bridge with Mount Ruapehu in the background, April 1990.

Plate 8.2 The scene at Tangiwai following the Christmas 1953 Tangiwai Disaster. Although the carriages in this photograph remained close to the bridge, another was carried nearly 3 km downstream by the lahar. The pile lying on the low terrace in the foreground of the photograph weighs 125 tons, and was carried 70 m downstream by the lahar.

Plate 8.3 Tangiwai, December 1953, looking upstream towards the railway bridge. The lahar swept across the terrace in the right of this photograph, and across the road bridge in the bottom of the photograph, below the rail bridge.

Plate 8.4 Crater Lake in December, 1953, following the Tangiwai Disaster. The hole in the ice and tephra barrier is marked by an arrow. Note also the top of another hole immediately to the left, which has been mostly buried by fallen ice. The lake level fell by about 9 m, releasing 1.6×10^6 m^3 of water.

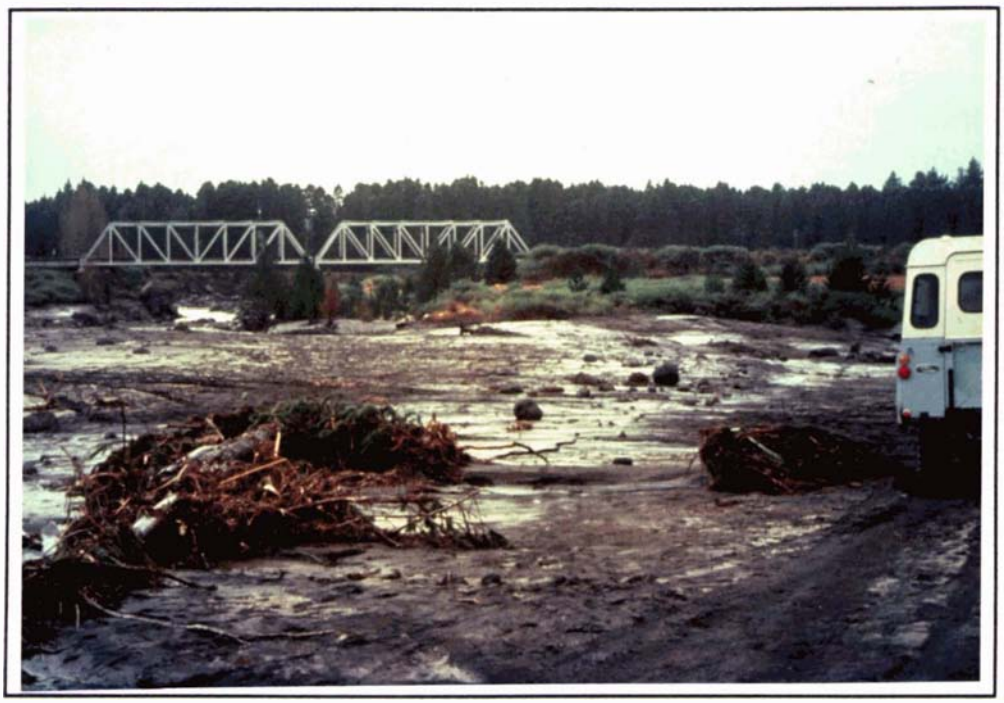


Plate 8.5 Tangiwai following the 1975 lahar, looking downstream towards the replaced railway bridge. The discharge and total volume for this event was similar to the 1953 lahar, but the new railway bridge survived.
Photograph courtesy of T. Hurst, Department of Geological and Nuclear Sciences, Wairakei.

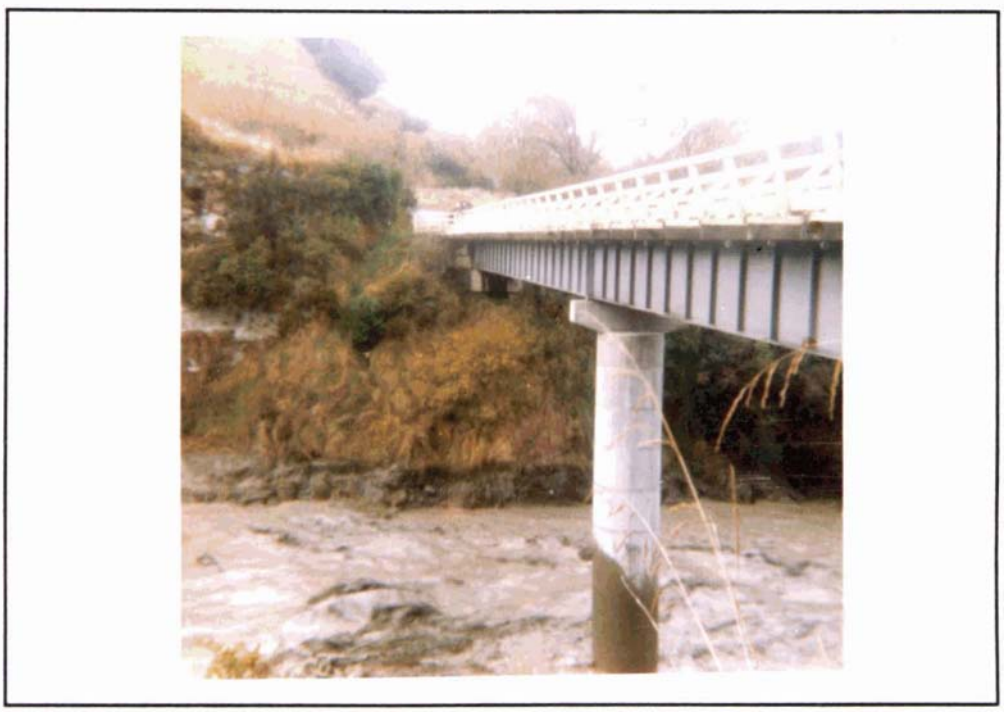


Plate 8.6 Colliers junction, in the middle catchment of the Whangaehu River, during the 1975 lahar. From the tide mark left by the lahar on the bridge pile it was estimated that the lahar reached a level 6 m above normal river level.
Photograph courtesy of Mr Merv Matthews, Waipunga, Whangaehu Valley Road.

MAP1. S20D

LEGEND TO ACCOMPANY MAP 1.

Late Quaternary volcaniclastics

- Onetapu Formation
- Onetapu Formation overlying Taupo Ignimbrite
- Taupo Ignimbrite
- Onetapu Formation overlying Tangatu Formation
- Mangaio Formation / Manutahi overlying Mangaio Formation
- Tangatu Formation
- Tangatu Formation overlying Whangaehu Formation
- Te Heuheu Formation overlying Whangaehu Formation
- Apitian lahars
- The Mangatipona pumice sand (Wk-2681 37,030±730 years B.P)
- Whangaehu Formation. ⁘ Whangaehu Formation-sourced boulders

Late Quaternary river terraces

- Holocene
- Ohakean
- Ratan
- Potewan
- Marton

PRECOMPILATION			COMPILATION							
on	base	Ckd.	Original Sheet compiled as a	Assembly of Instrument Plots by S Campbell	Field checked by	Field Check Amendments	Issued July 1982 as a	Reference to Selected Symbols used on this Sheet		
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			(i) Contour Sheet	Checked by C Kinzett	Jan 1982 Date	Date Feb 1982 1982	PHOTOGRAMMETRIC TRANSPARENCY	Exotic forest	Shelter belt	Commercial Built-up area
			(ii) Detail Sheet					Scrub	Roads	Residential Built-up area

DETAIL 7

MAP2. S21B

LEGEND TO ACCOMPANY MAP 2.

Late Quaternary volcaniclastics

- Onetapu Formation
- Onetapu Formation overlying Taupo Ignimbrite
- Taupo Ignimbrite
- Onetapu Formation overlying Tangatu Formation
- Mangaio Formation / Manutahi overlying Mangaio Formation
- Tangatu Formation
- Tangatu Formation overlying Whangaehu Formation
- Te Heuheu Formation overlying Whangaehu Formation
- Apitian lahars
- ★ The Mangatipona pumice sand (Wk-268! 37,030±730 years B.P)
- Whangaehu Formation. ⁂Whangaehu Formation-sourced boulders

Late Quaternary river terraces

- Holocene
- Ohakean
- Ratan
- Porewan
- Marton

No.	Run	Photos	Dates
04	A	15 - 20	4-2-82
	B	15 - 20	"

Geodetic Datum 1949

M.Y.

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Reference to Selected Symbols used on this Sheet: Native forest; Exotic forest; Scrub; Scattered trees; Shelter belt; Roads; Railways; Commercial Built-up area; Residential Built-up area

6 190 000 N

2 730 000 E

6 175 000 N

→ Run A

→ Run B

S21B

MAP3. S21D

LEGEND TO ACCOMPANY MAP 3.

Late Quaternary volcaniclastics

- Onetapu Formation
- Onetapu Formation overlying Taupo Ignimbrite
- Taupo Ignimbrite
- Onetapu Formation overlying Tangatu Formation
- Mangaio Formation / Manutahi overlying Mangaio Formation
- Tangatu Formation
- Tangatu Formation overlying Whangaehu Formation
- Te Heuheu Formation overlying Whangaehu formation
- Apitian lahars
- ★ The Mangapipona pumice sand (Wk-2681 37,730±730 years B.P)
- Whangaehu Formation. ⁂ Whangaehu Formation-sourced boulders

Late Quaternary river terraces

- Holocene
- Ohakean
- Ratan
- Porewan
- Marton

Metres 1000 500 0 1 2 Kilometres

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Geodetic Datum 1949

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Edited by J.K. Torok
Checked by J.A. Keats

Field B.M.

LEGEND TO ACCOMPANY MAP 4.

Late Quaternary volcaniclastics

- Onetapu Formation
- Onetapu Formation overlying Taupo Ignimbrite
- Taupo Ignimbrite
- Onetapu Formation overlying Tangatu Formation
- Mangaio Formation / Manutahi overlying Mangaio Formation
- Tangatu Formation
- Tangatu Formation overlying Whangaehu Formation
- Te Heuheu Formation overlying Whangaehu Formation
- Apitian lahars
- The Mangatipona pumice sand (Wk-2681 37,030±730 years B.P)
- Whangaehu Formation. Whangaehu Formation-sourced boulders

Late Quaternary river terraces

- Holocene
- Ohakean
- Ratan
- Porewan
- Marton

MAP4. S22A

Metres 1000 500 0 1 2 Kilometres

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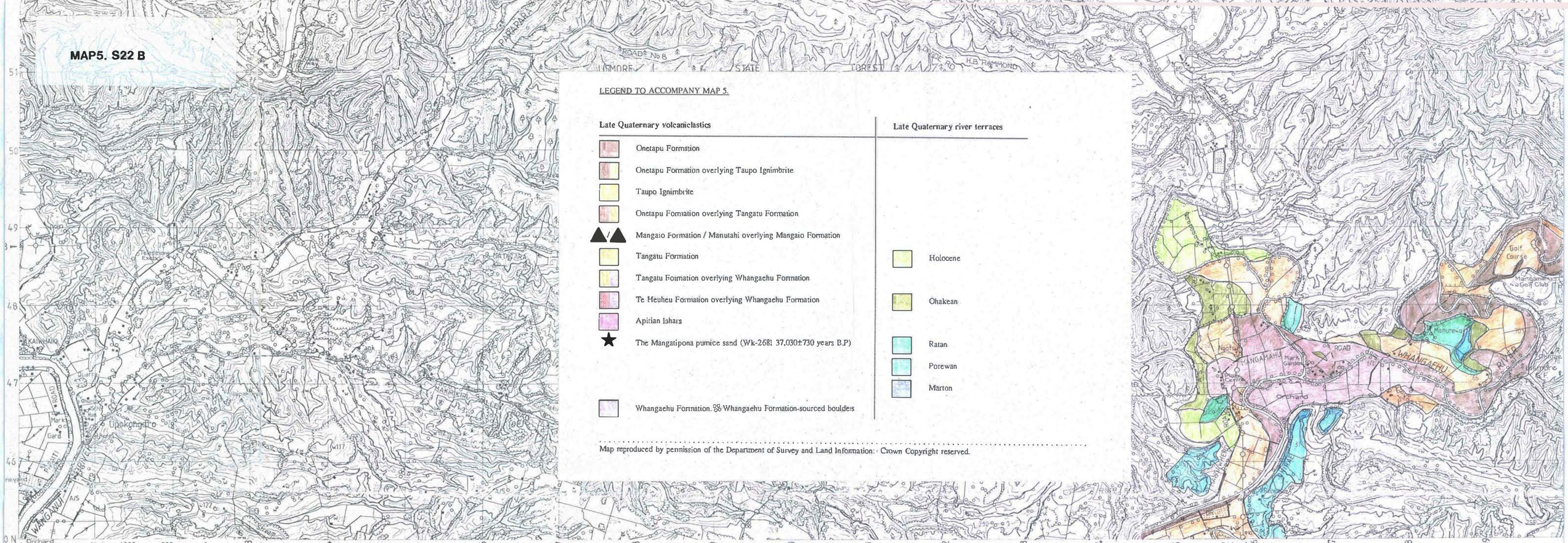
						B	11-18							

MAP5. S22 B



LEGEND TO ACCOMPANY MAP 5.

Late Quaternary volcaniclastics

- Onetapu Formation
- Onetapu Formation overlying Taupo Ignimbrite
- Taupo Ignimbrite
- Onetapu Formation overlying Tangatu Formation
- Mangaio Formation / Manutahi overlying Mangaio Formation
- Tangatu Formation
- Tangatu Formation overlying Whangaehu Formation
- Te Heuheu Formation overlying Whangaehu Formation
- Apitian lahars
- The Mangatipona pumice sand (Wk-2681 37,030±730 years B.P)
- Whangaehu Formation. ⁂ Whangaehu Formation-sourced boulders

Late Quaternary river terraces

- Holocene
- Ohakean
- Ratan
- Porewan
- Marton

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Native forest, Exotic forest, Scrub, Scattered trees, Shelter belt, Roads, Railways, Commercial Built-up area, Residential Built-up area

2690 000 E

3 000 N

MAP 6. S22C

LEGEND TO ACCOMPANY MAP 6

Late Quaternary volcaniclastics

- Onetapu Formation
- Onetapu Formation overlying Taupo Ignimbrite
- Taupo Ignimbrite
- Onetapu Formation overlying Tangatu Formation
- Mangaio Formation / Manutahi overlying Mangaio Formation
- Tangatu Formation
- Tangatu Formation overlying Whangaehu Formation
- Te Heuheu Formation overlying Whangaehu Formation
- Apitian lahars
- ★ The Mangatipona pumice sand (Wk-2681 37,030±730 years B.P)
- Whangaehu Formation. 88 Whangaehu Formation-sourced boulders

Late Quaternary river terraces

- Holocene
- Ohakean
- Ratan
- Porewan
- Marton

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Geodetic Datum 1949

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Metres 1000 500 0 1 2 Kilometres

2 690 000 E

LEGEND TO ACCOMPANY MAP 7.

Lahar hazard zones within the Whangaehu River Catchment

1. 1:10
2. 1:30
3. 1:200
4. 1:500
5. 1:14,700-5,370
6. 1:25,500-14,700
7. 1:40,000-25,500
8. 1:160,000

SCALE 1:50 000

1 0 1 2 3 4 5 6 7 8 9 10 kilometres

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Department of Survey and Land Information, Wellington, New Zealand

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Edition 1 1987

LEGEND TO ACCOMPANY MAP 8.

Lahar hazard zones within the Whangaehu River Catchment

1. 1:10
2. 1:30
3. 1:200
4. 1:500
5. 1:14,700-5,370
6. 1:25,500-14,700
7. 1:40,000-25,500
8. 1:160,000

MAP8. S22

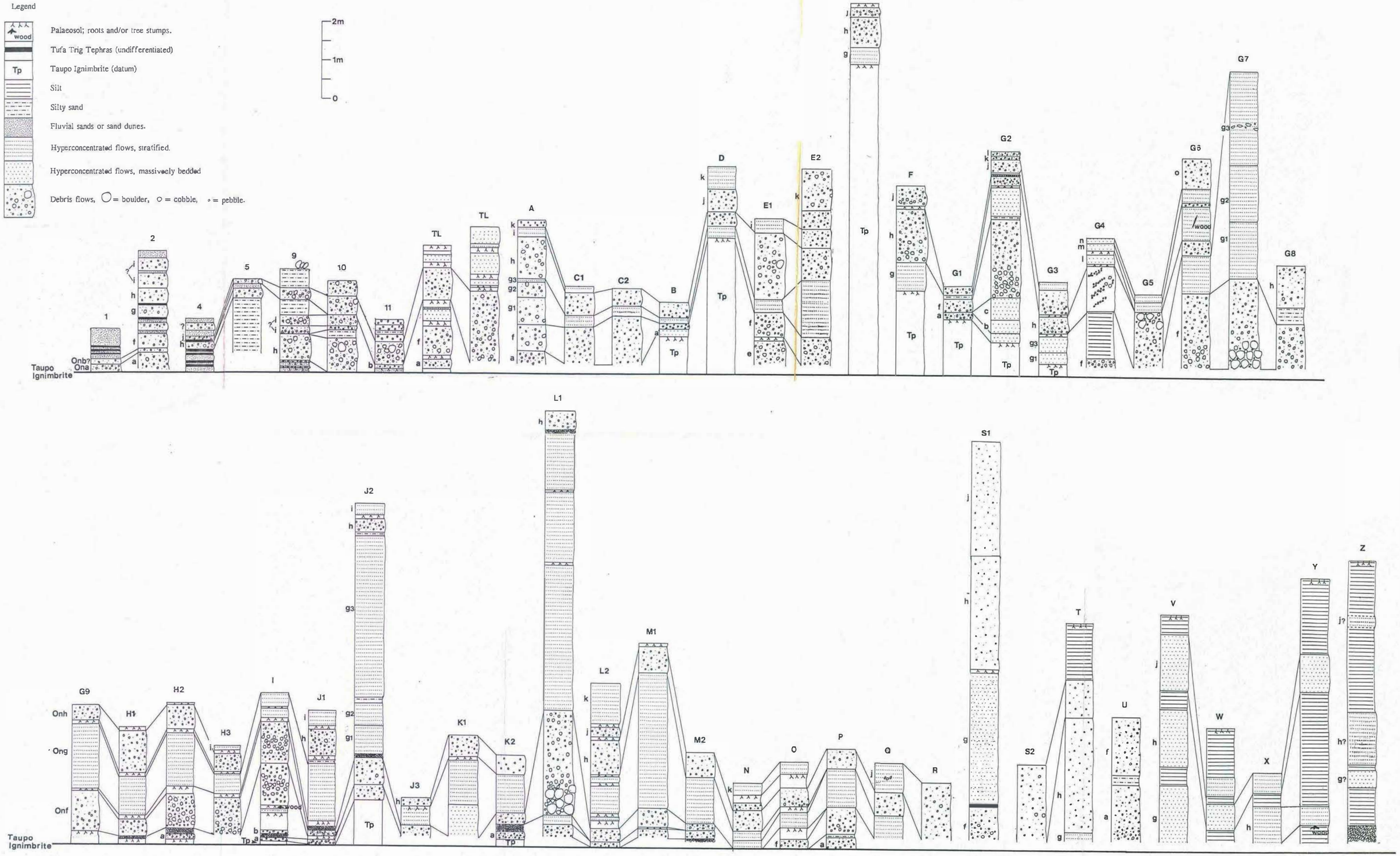
SCALE 1:50 000

1 0 1 2 3 4 5 6 7 8 9 10 kilometres

Published
Department

VR

Figure A1 Stratigraphy of Onetapu Formation members. Sections A-Z are described in the Appendix to this thesis. The Type Locality (TL) is described by Donoghue (1991) and sections 1 & 2, 4 & 5, and 9-11 on the Mount Ruapehu ring plain are described by Purves (1990). Onetapu Formation members identified by corresponding letter identifier.



L1