

SUBDIVISIONS IN THE GREATER AUCKLAND AREA

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ABSTRACT: Residential, industrial and rural subdivisions straddle a diverse range of geologic settings in the greater Auckland area. Typically, Geotechnical reports address slope stability, bearing capacity and settlement, but depending on local geology, often more unusual features require investigation. These can include piping pumiceous silts, elevated groundwater levels, highly variable volcanic deposits and uncontrolled filling. In addition, topography, vegetation cover and location can often present substantial challenges for fieldwork. Occasionally, despite the best efforts of the investigation team, problems are only revealed once earthworks are underway.

1.1 Geology

Residential, Industrial and Rural subdivisions straddle a diverse range of geologic settings in the greater Auckland area. These include deeply weathered, highly fractured and jointed Mesozoic Age 'hard rock' Greywacke, 'soft rock' Miocene Age Waitemata Group sandstones and siltstones, overlain and interfingered with highly weathered Waitakere Group andesitic/basaltic lava flows, volcanic debris sandstones and breccia conglomerates, together with a series of relatively thin, Pliocene to Holocene Age alluvial, marine and estuarine terrace deposits, incorporating considerable thicknesses of organic silts and peats, as well as areas of both welded and reworked, loose pumiceous silts and sands.

In addition, basaltic volcanism over the last 150,000 years from some 48 volcanic centres has blanketed much of central and southern Auckland with volcanic ash and lapilli, extensive areas of lithic tuff, as well as some 75 km² of lava fields.

2.1 Geotechnical Considerations

Geotechnical considerations in subdivisional development around Auckland fall into three main categories, these being:

1. Slope stability (generally on steeper sites, cliff top sections or adjacent to banks and gullies).
2. Adequate bearing capacity and settlement potential for foundation loads.
3. Other, more site specific or localised problems such as piping pumiceous silts or collapsible basalt caverns, etc.

2.2 Slope Stability

Slope stability (or more correctly, instability) features encountered in the region range from the classic 'circular' style failures in highly weathered overburden and alluvial terrace deposits, block/wedge/planar type failures on cliff sites, subtle (and very difficult to investigate) features controlled by tectonic flexural slip clay seams, through to localised failures caused by elevated groundwater pressures in pumiceous silt beds or similar.

In very general terms the slope instability features as related to geology are summarized in table 1.

2.3 Bearing Capacity

Problems with adequate bearing capacity and settlement are generally restricted to terrace deposits, usually where extensive deposits of organic silts and peats are present. Some problems may occur on deeply weathered ash deposits, or where benching operations expose bands of soft weathered silt within Waitemata Group soils, but otherwise these soils and the residual Greywacke soils generally have at least 100 kPa safe bearing capacity.

Pumiceous silts, organic soils and peat present more challenging subdivisional problems and where possible 1.5 to 2 metres cover of naturally occurring clays and silts are left or Engineered filling put in place to ensure that an adequate raft of suitable overlying soil is available. Where this is not possible, lots are tagged for specific foundation investigation and design, the general solutions being either pile foundations, (driven timber or drilled and concreted) or alternatively stiffened raft designs. Driven timber piles have also been used beneath concrete strip and pad foundations.

Settlement problems can occur where marked lateral and vertical variations are present in underlying soils, natural soils exhibit marked seasonal moisture change characteristics, or where buildings are constructed partly on natural soils and partly on fill.

Solutions include adequate detailing for building movement (especially with brittle wall claddings), deeper footings or piled foundations.

2.4 Other Geotechnical Problems

Several problems additional to the above encountered on recent subdivisional investigations have included the following:

1. Highly erodible piping silts, both in pumiceous soils and weathered Waitemata Group soils (major design implications for underfill and buttress drain construction, generally controlled with geotextiles).

2. Extremely soft, saturated infill gully deposits (colluvium and slump debris). (Typical problems have included thoroughly bogged drilling rigs and excavators, as well as general earthworks difficulties such as installation of underfill drainage and trafficability).

3. Discovery of 5 skeletons in a lava cave on a 14 unit development site (potential for major contractual delays; averted through consultation with local Maori, leaving them undisturbed and sealing off mouth of cave with several metres of concrete, reinforcing steel and rock).

4. Extremely soft, marine silt deposits on a coastal subdivisional development (too soft to register any friction on cone penetrometer (CPT) cone; major design implications for bearing capacity and settlement - estimated 550mm over 8 metres thickness for 55 kPa surcharge).

5. Loose to very loose, uncompacted refuse fill on proposed industrial subdivision (seismic velocities <300 m/sec; potential for up to 2 metres of settlement; landfill gas problems, difficult piling conditions due to hardfill and inorganic refuse as well as elevated sulphate levels and generally aggressive soil conditions).

6. Environmentally 'impaired' sites including sites with imported, dirty fill through to development on former industrial sites such as timber treatment yards, etc.

7. Steep, hilly sites requiring development of extensive bulldozer tracks prior to investigation with bulldozer winches used to pull rigs into place or at worst use of heliportable rigs.

3.1 Investigation Methods

General investigation methods used during subdivision investigations can include any or all of the following:

1. Extensive field mapping and walkover surveys, coupled with aerial photographic interpretation; very useful as a planning tool for investigations, as well as slope stability assessments.

2. Hand auger boreholes; 50mm diameter to depths of up to 6 metres, in conjunction with field shear vanes and scala penetrometer tests.

3. Machine boreholes; both conventional open barrel and triple tube drilling, as well as HQ and NQ wireline have been used to depths of up to 30 metres, together with SPT testing, recovery of 100mm and 65mm diameter tube samples and bulk core samples for effective stress, consolidation and compaction testing. Hollow stem, 150mm and 300mm flight augers have also been used in conjunction with SPT and field vane testing.

4. Excavator pits: 12 to 20 tonne machines with reaches of up to 7 metres. Very useful tool for assessing infill gully deposits and general soil characteristics for earthworks.

5. CPT's in soft alluvial ground and marine terraces; useful stratigraphic mapping tool, relatively cheap costs for wide coverage.

6. Percussion boreholes, especially on basalt and scoriaceous sites for soakage and groundwater investigations.

7. Seismic methods, including refraction, gravity, resistivity and ground penetrating radar. Often used in conjunction with environmental investigations.

4.1 Case Studies

Two contrasting sites will be described in the following section, these being:

1. An 83 lot subdivision at Murrays Bay, on the North Shore, currently under construction on steep, dissected Waitemata Group sandstones and siltstones.

2. The Tamaki Farms Estate, involving both industrial and residential development at East Tamaki, on a mixture of volcanic, marine terrace and Waitemata Group soils capped in places with basalt rock.

4.2 Hauraki Heights Subdivision, Murrays Bay

The Hauraki Heights Subdivision is currently under construction (as at December 1993). Eighty three lots are planned, which, together with roading, accessways and reserves, will cover an area of approximately 12.7 hectares. The site has been the subject of several geotechnical investigations and proposed subdivisional schemes, the current development proceeding only after an extensive series of Town Planning Hearings.

The terrain comprises hill and valley topography, covered with regenerating bush, scrub and pine trees. One main ridge runs north-west/south-east between the top of Bellbird Rise and the Pinehill Reservoir, with a series of sub-parallel flanking ridges lying between the main ridge and East Coast Road to the west (fig. 1).

Total earthworks volumes are in the order of 70,000m³, with cuts and fills of up to 10 and 15 metres respectively aimed at levelling off the ridges and filling in the flanking gullies.

The site was investigated by ourselves in December 1992 as a follow-up to earlier work undertaken in 1982, 1985 and work completed in the mid-1970's by another Consultancy.

The latest investigation involved a detailed walkover field survey and review of aerial photographs, coupled with a relatively intensive machine and hand auger borehole programme as well as laboratory testing and extensive slope stability analyses.

Briefly, problems identified were extensive slope movement and soil creep on the slopes flanking the main gullies, coupled with areas of elevated groundwater and a distinct range of lithology. The heavily vegetated site made field operations quite difficult. Apart from installing bulldozer tracks to allow machine rig access, several hand auger borehole sites needed to be cleared with a chainsaw prior to drilling.

In summary, the main ridges were considered to be 'intact ground' with the dominant slope features being relatively shallow movements down into the flanking gullies. Deep seated instability was not ruled out, but no conclusive field evidence was seen.

Following site clearance however, it became apparent that the front of the central ridge area consisted of an old, relatively thick (5 to 10 metre) landslide mass sliding over bedrock. It appeared that this slide had travelled somewhat laterally across the front of the ridge, starting from an area to the north of the temporary silt detention dam, and moving south-west with most of the slide debris underlying an adjacent council reserve.

The slide is currently being successfully buttressed through infilling the detention dam gully, coupled with the installation of extensive, geotextile wrapped AP7 scoria buttress and underfill drains dug down and keyed into the underlying bedrock. All slump debris was excavated from the gully and replaced with engineered filling to ensure that the gully fill was benched onto competent sandstone.

In addition, some 750 metres of geotextile wrapped, 50mm diameter PVC screen is currently being installed in 6 horizontal drainage lines to maintain long term control over groundwater levels across the lower half of the site. Current water flows have ranged from an initial (and impressive) 6,000 litres per hour, on a 130 metre long line, stabilising to a constant 2,600 litres per hour over a week to more typical flows of between 100 and 200 litres per hour. Total flows from the 6 lines are currently running at 3,600 litres/hour, or around 86,000 litres/day.

Due to the fact that the lowest point of the landslide is situated in the adjacent reserve amongst well developed native bush at least 100 years old, the North Shore City Council requested that equipment and material were flown in and out using a helicopter, with full removal of drill cuttings and all drilling operations planned to have minimal impact on the environment.

Some 20 loads were flown in, including diesel, drilling rods, casing, slotted screen, power packs, drilling rig and pumps, as well as 30 bales of hay to provide silt control.

Piezometers installed prior to the horizontal works have shown marked changes as the lines are drilled, indicating that the drains are performing as intended.

The bulk earthworks for the site are scheduled for completion in February 1994.

The main point to note on this subdivision is that an ancient landslide moved sideways relative to present day topography, with subsequent downcutting through the slump debris by streams and extensive vegetation cover completely masking its presence. However, close site supervision detected the problem as soon as it became apparent and the works described have ensured that the development will be successful.

3.4 Tamaki Farms Estate, East Tamaki

The Tamaki Farms Estate, adjacent to the Tamaki Estuary in East Auckland, has been developed in several stages since 1986. Currently Stage 4 residential and Stage 2B Industrial are under construction, with earthworks due for completion early in 1994.

Briefly, the site consists of an old marine terrace, partly cut into underlying Waitemata Group soils, with relatively extensive deposits of overlying, loose, reworked pumiceous silt, several areas of organic silts and minor peat deposits, as well as typical inorganic, moderately plastic clayey silts and silty clays. Some of the site is covered by up to a metre of airfall volcanic ash, with the central third of the site capped with a basalt lava field up to 10 metres thick.

Investigations have involved both hand auger and conventional machine boreholes, excavator pits and field mapping, as well as percussion rock drilling to define areas of basalt (initially for a proposed quarry, but later used for location of service lines).

Earthworks operations have generally been confined to levelling off the site, mucking outsoft pockets of soil in and between lava flows and backfilling with compacted spoil, as well as placing up to a metre of filling over the basalt to allow conventional residential construction.

Apart from the usual problems of bearing capacity and differential settlement on the more organic soils (generally fixed using over-length driven timber poles and control joints on brick veneer walls), more unusual problems have been localised instability on esplanade reserve slopes caused by elevated groundwater levels in confined pumiceous silt layers (generally concentrated in old, buried stream channels), the extreme erodability of these materials under concentrated water flows, often complete loss of trafficability in these soils on haul roads (a sort of liquefaction failure effect), difficulties in achieving adequate compaction with some of the volcanic ash soils, and in monitoring and certifying fill areas using excavated basalt rock.

5.0 Summary

In conclusion, we have found that a detailed knowledge of local geological conditions and their problems has been useful in assessing subdivisional sites, especially where budgetary and time constraints dictate a relatively modest investigation. However, there is always the potential for unusual, or unexpected problems to appear once site works commence.

Acknowledgments.

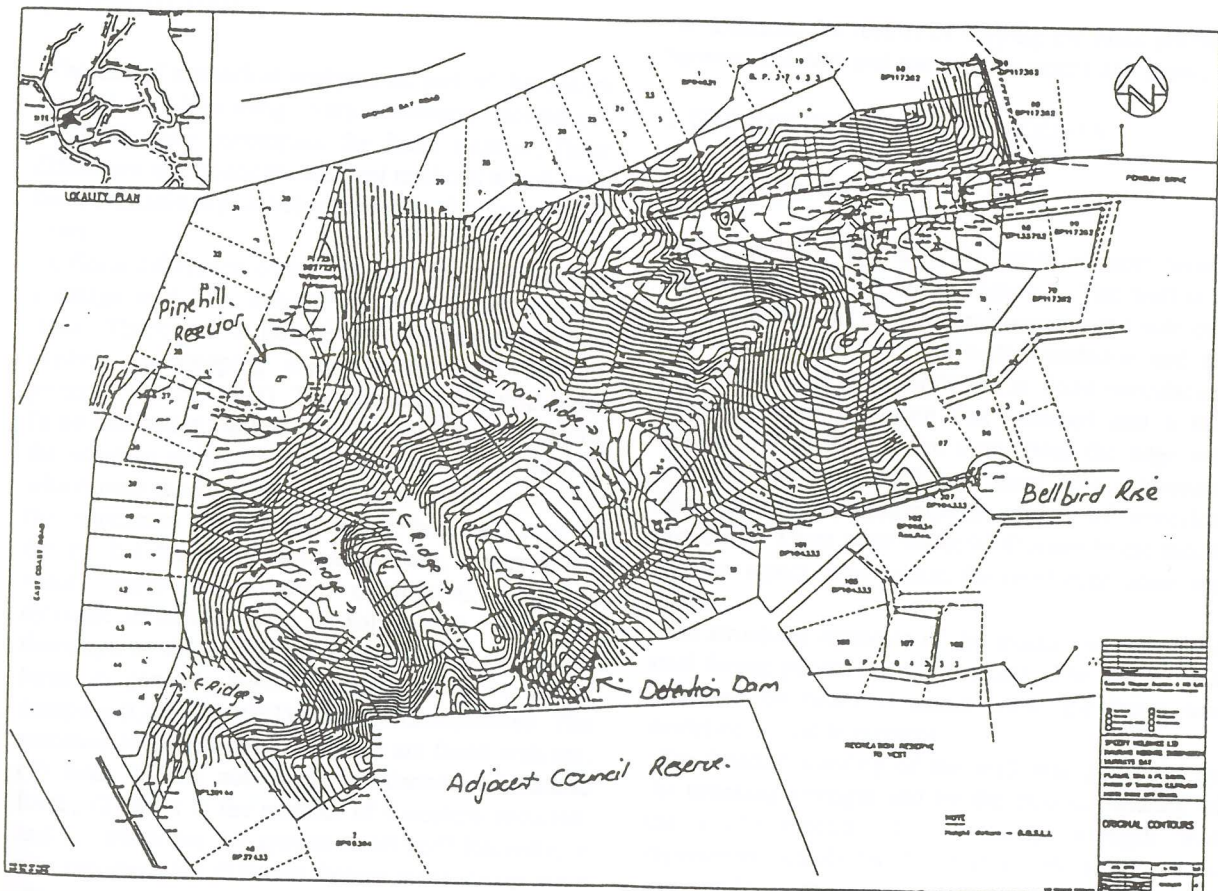
The writer would like to thank Speedy Holdings Limited and Neil Construction Limited for permission to publish details on Hauraki Heights and Tamaki Farms Estate Subdivisions respectively. Also, grateful thanks to Elaine Appleton for typing this paper.

Table 1.

Geology	Typical Instability Features	Site Settings
<p>Indurated 'hard rock' Greywacke. Weathered soils typically firm to stiff, non-plastic, red/orange brown clayey silts and sandy silts. Unweathered rock typically dense, dark-grey sandstone alternating with grey to black argillite. Hard, typically closely to moderately closely fractured.</p>	Circular and planar failures - slumps, slides, flows	Developed in highly to completely weathered overburden. Planar failures common where 'greasybacks' (soft overburden in conjunction with elevated groundwater) occur over less weathered rock.
	Wedge/block failures, rock falls, rock slides	Common in unweathered to moderately weathered rock on steep country. Failures usually controlled by joints, shear zones and fractures. Majority of gullies and valleys have developed due to some form of underlying structural control.
	Shallow soil creep	Common on steep slopes where relatively thin 'skin' of weathered overburden has developed over underlying bedrock.
<p>'Soft rock' Waitemata Group sandstones and siltstones. Weathered residual soils range from soft to stiff, non to very plastic, grey/yellow/brown/cream silts, clayey silts, sandy silts and silty clays, reflecting their depositional lithology. Often extensive soil softening around standing groundwater levels. Unweathered rock is typically alternating, weak to moderately strong sandstone, siltstone and mudstone.</p>	Circular and planar failures, soil creep	Circular failures usually restricted to completely weathered overburden, generally on slopes above about 20 degrees. Often occur in conjunction with elevated, sometimes artesian groundwater conditions. Planar failures somewhat less common, tending to develop along bedding planes coupled with thin clay seams and elevated groundwater or where 'weathering front' of overburden parallels slope and is exposed as a result of erosion. Both 'down dip' and 'cross dip' planar failures have been encountered on recent subdivisions. Often difficult to recognise in field.
	Clayseam controlled block slides	Relatively common within the more muddy or silty faces of the Waitemata Group, especially in East Tamaki/Flat Bush areas.
	Wedge/block failures - rock falls, rock slides, toppling failures	Most obvious along the extensive cliffs fronting the Waitemata and Manukau Harbours, but often present in inland, deeply incised gullies (usually well obscured). More subtle manifestations include some 'stress relaxation' features where blocks and beds of more resistant rock dilate laterally as a result of downcutting streams in adjacent gullies (often found with bedding parallel clay seams and clay filled joints. Toppling failures common where bedding dips inward on cliff sites, often in conjunction with wedging tree roots or similar. Block falls often develop where siltstone beds fret and spall faster than overlying sandstone.
<p>Alluvial/estuarine terrace deposits. Diverse range of soft to stiff, non to very plastic, normal to well over-consolidated, inorganic and organic silts, clayey silts, sandy silts, silty clays and clays often interbedded with pumiceous silts, organic peat and gravels. Commonly overlain with volcanic ash deposits.</p>	Circular and planar failures, soil flows, piping failures.	Circular failures common where areas are subject to active erosion such as in stream gullies or along estuary banks. Planar features rare, except where soil moves 'en masse' over underlying bedrock. Soil flows occur under extremely wet (usually concentrated runoff) conditions. Piping failure common in pumiceous deposits.

Volcanic materials - tuff rings, scoria cones, lava flows. Deposits typically exhibit the following: - rapid lateral and vertical variation. - emplaced over wide range of underlying sediments. - lava flows occupy former river valleys, locally cavernous.	Circular failures	Relatively common in highly weathered ash, or where volcanic detritus has been reworked into terrace deposits
	Planar failures	Occur in situations where ash or tuff is deposited onto sloping, weathered Waitemata group soils. Often potential failures not recognised on immediate site as problems usually well buried and can extend over wide areas.
	Block failures	Restricted to frontal lobes of basalt flows, or in quarry areas.

Fig. 1.



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