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A Centennial Review of the North Island Main Trunk Railway: Geology of the West-Central North Island and its Influence on Transport Development

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SUMMARY: *This paper is an account of how the geology of the west-central North Island has affected the difficulty of finding the most favourable route for and the building of the North Island Main Trunk Railway. Some subsequent deviations have also been necessitated to some extent by continuing geological processes. Soft sedimentary rocks uplifted from the sea in the past 2 million years have poor competence as engineering materials. Combine this with the original dense forest cover on these rocks and the topography, the whole presented major riddles to builders of transport routes. Apparently easier routes on volcanic deposits to the east of this area proved to be even less attractive to route-finders.*

Implications of geological issues for the Railway are explored. In combination with the "long depression" of the 1880s, they caused progress to be slow until after 1900. Completion of the North Island Main Trunk Line forced the Railways' management to reconsider its objectives, a necessary move towards integrating New Zealand's several regional economies into one national economy.

1. IN THE BEGINNING

The concept of the North Island Main Trunk Railway (NIMT) goes back to Julius Vogel and his immigration and public works policy, first enunciated in late 1869. Inspiration for this came from the principles behind the successful completion of the Union Pacific Railroad that year, the first trans-continental railway across the USA. Vogel travelled it very soon after its opening. Vogel's plan was to bring in migrants who would build public works, primarily railways and roads to open up and provide access to land in the interior. Once those transport links were built, the migrants could then settle on the land and begin to develop it, creating the traffic that would pay for operation and capital loans used for building the links. A network of railways linking the country overland that included an Auckland-Wellington link was central to all this.

New Zealand's North Island at that time had a vast, mostly rough and heavily forested interior largely devoid of Europeans. Isolated European settlements were mostly coastal, though linked by overland telegraph lines and regular coastal mail steamer services. A major complication was the unresolved land wars of the 1860s that left varying levels of Maori disaffection with the Crown across a broad swath from the Bay of Plenty to the New Plymouth and Wanganui hinterland.

Railway construction in the North Island got off to a slow start and progressed slowly. By 1880, Auckland was linked to Te Awamutu, just north of the Puniu River, northern boundary of Te Rohe Potae, "the rim of the hat", more widely known as the King Country, an area forbidden to Europeans 1872-83 by King Tawhiao's aukati that was included in the immediate settlement of the Land Wars. In the east, in 1883, the Wellington-Napier railway was under construction southward to Makutuku in Hawkes Bay and from Masterton to Mauriceville. Three years later the rail route between Wellington and New Plymouth via the Wellington & Manawatu Railway and the Railways Department lines north of Longburn was completed.

In the west and middle of the Island there was Te Rohe Potae, one of the most rugged and difficult to travel through parts of New Zealand. Dense forests added greatly to the difficulty of moving through this area.

2. GEOLOGY OF THE WEST-CENTRAL NORTH ISLAND

See Figure 1. The rocks of this western part of the North Island have some remarkably intractable engineering properties. Oldest, in the north, are of ages varying back to Eocene times up to 56 million years ago (MYA), though these last may be overlaid by younger rocks. They range from limestones through sandstones to siltstones and mudstones that are generally known as "papa", the Maori word for "earth". All were laid down in shallow seas and are cemented with lime.

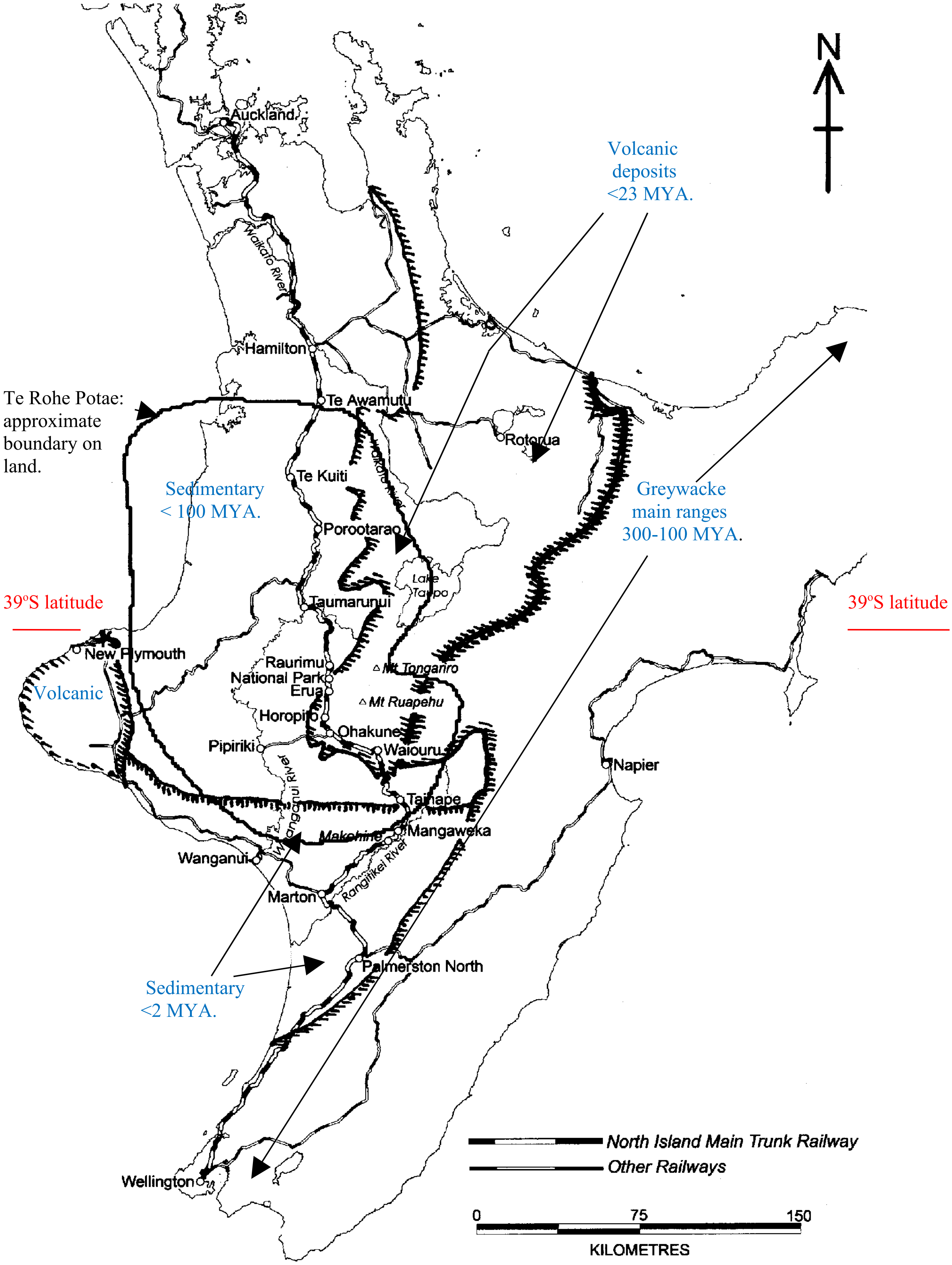

Figure 1: *The North Island of New Zealand, showing the route of the North Island Main Trunk Railway and indicative ages of geological formations.*

Most of these rocks weather rapidly as the lime is leached out or as expansive volcanic clays contained within them change volume with changing moisture content. For many years derivative clay soils barred all progress to horse or wheeled vehicle in wet weather. Durable gravels suitable for use as road metal or railway ballast were only found in the Rangitikei and Whanganui Rivers. Those in the Rangitikei River are greywackes derived from the Kaimanawa and Ruahine Ranges. The upper Whanganui River carries gravels derived from the andesites of the Mts Tongariro and Ruapehu area.

Structurally, the north of Te Rohe Potae is oldest. The Waikato coal measures date to Eocene times. Most of New Zealand was submerged around 20 MYA. Until about 2 MYA, the North Island south of about latitude 39^0S (a line through Waitara and Turangi) was almost entirely submerged until uplifted with the rise of the present Tararua and Ruahine Ranges. Visual evidence of this may be seen in features such as the reversal in direction of the Whanganui River at Taumarunui; the conforming directions taken by all the southward flowing rivers in this region as they followed the fall of the land as it rose; and the very prominent terraces along the valley of the Rangitikei River. Terraces are indicative of pauses in the uplift process.

Volcanism over a long period is a major feature of the North Island, with andesitic mountains such as Ruapehu and Tongariro dominating large areas. To the north and north-east of them, the volcanics of the Rotorua-Taupo series have wrought dramatic changes from about 1.7 MYA, blanketing extensive areas with ignimbrite, pumice, and derivative clays known as “brown ash”.

3. FINDING A PRACTICABLE ROUTE FOR THE NIMT RAILWAY

The geology of the west-central North Island was all significant to transportation route-finders, as it remains to those who must maintain routes through the area.

The first serious attempt to find a route for the NIMT came in 1873 when John Carruthers explored east of Te Rohe Potae, following the Waikato River from Cambridge to Taupo, then passing east of Lake Taupo and across the Rangipo Desert to about present-day Waiouru. The route was beguilingly attractive, being largely covered in scrub and fern, with generally favourable geology, topography and gradients. Almost all of this route crossed topography and soils derived from Taupo volcanic zone eruptions. Unfortunately, much of the soils crossed en route proved to be un-farmable due to bush sickness. It was only in 1936 that this fatal ailment of farm animals was traced to the deficiency of cobalt in pumice soils. The summit of this route at the Rangipo Desert was found to be some 300 metres higher than its equivalent on the western side of the volcanic plateau, further lessening its relative merits.

When negotiations between the government and leaders of Ngati Maniopoto and Ngati Tuwharetoa led to a settlement agreeing to route-finding surveys for a north-south railway at the beginning of 1883, four general routes were explored. See Figure 2.

G P Williams surveyed a Te Awamutu-Napier route up the Waikato River and along that now taken by State highway 5, the Napier -Taupo road. He concluded that this indirect route was not practicable for a railway owing to its very high summit and steep grades on the descent to Hawkes Bay.

C W Hursthouse was chosen to survey from Te Awamutu towards Stratford. After facing great difficulties with some Maori, he concluded that a railway to New Plymouth via Mokau was feasible. This route is now taken by State highway 3. A second round of exploratory surveys was then carried out in 1884 by R W Holmes and M Carkeek, examining possible routes from the north to Stratford and to Waitara. Feasible, though difficult, routes were found.

John Rochfort undertook exploration of the central route, from Marton to Te Awamutu by way of Ohakune and Taumarunui. He began on a route suggested by H C Field and explored by J F Sicely in 1882, following the Porewa, Rangitikei and Hautapu rivers to reach Ohakune. Rochfort continued this work northwards across the volcanic plateau to today’s National Park township, then down the Piopiotea and Whanganui Rivers to Taumarunui. From Karioi northward he met considerable Maori opposition and non-cooperation that was to have consequences later when the descent to Raurimu was explored in more detail by location engineers. From Taumarunui northward, Rochfort’s route continued to be that of the NIMT as built, passing up the Ongarue and Ohinemoa Rivers to Poro-o-tarao, then downhill to Te Kuiti and Te Awamutu.

In autumn 1884 the Minister of Public Works, Hon E Mitchelson, who had travelled the two most likely routes, concluded that Rochfort’s central route was the best for the NIMT. It was the most direct, the route was almost entirely through millable forests, and most of the country traversed could be farmed once the forest had been cleared.

Mr Mitchelson expressed the view that it would be difficult to find an easier route that could be built for £3,100 per kilometre. That budget level, set under the Vogel scheme some 14 years earlier, was unrealistic by 1884, especially so in view of the nature of the terrain in Te Rohe Potae. The original moving structure gauge and clearances of 1870 were being increased to accommodate increased traffic on open lines. Stations

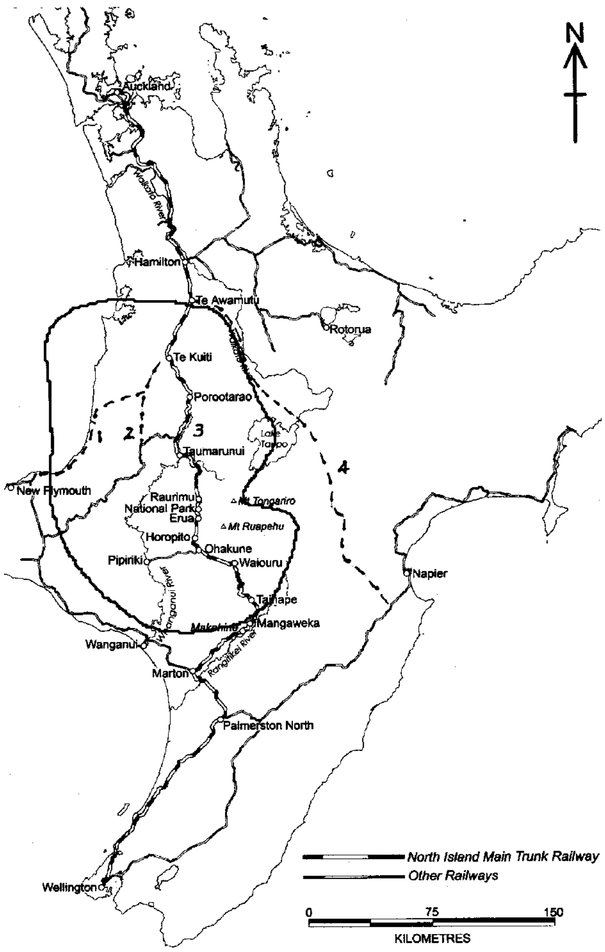

Figure 2: *Route finding surveys for the NIMT. Western routes 1 and 2 surveyed by R W Holmes & M Carkeek; route 3 by J Rochfort; and route 4 by G P Williams.*

and yard facilities were more extensive, minimum acceptable curves radii for main lines had been increased by 50% to 150 metres; standard rail weights had been increased by 40% to suit increased locomotive axle-loads; and bridges were being built of Australian hardwood instead of the weaker, but available at the lineside, native timbers. Also, labour and materials prices had increased.

The northern descent from the volcanic plateau, from National Park, has always been the critical part of the NIMT route. Finding a practicable route took from 1887 until 1898, and the final decision to adopt the route built was only taken in 1900. R A Brown and G B Beere began explorations for a workable route graded at 1 in 70 as thought possible by John Rochfort, in 1887. Three survey lines were all abandoned in very rough country as impracticable. John Blackett, Engineer-in-Chief of the Public Works Department 1884-90, opted to increase the maximum design grade to 1 in 50. (Blackett was also at the centre of the Government's March 1871 decision to adopt our standard 3'-6" (1067 mm) track gauge.)

A further survey by J B Browne and C B Turner found a very expensive route on this grade that would entail nine viaducts with an aggregate length of 1.3 kilometres. Two other trial surveys at 1 in 50 are known to have been made, and a fourth possible route appears to have been briefly considered.

The difficulties and estimated costs of the routes explored thus far were such that in 1888 two more western routes to Taranaki were investigated. The westernmost, to Waitara, would open no land considered suitable for settlement until it reached the coast. The second was similar to today's Stratford-Okahukura Line, except that it went from Ongarue to Ngaire (south of Stratford). Both would be indirect and expensive to build and operate. The final decision on what route to adopt was still 12 years away.

The combination of tectonic uplift and erosion of soft rocks forcing rivers into an uncertain drainage pattern, and the very dense forests similar in nature to that shown in Figure 3, were a railway route-finder's nightmare. The west-central North Island of the time was incredibly difficult to travel through by present-day standards. Maori used either footpaths or canoes on the rivers. Footpaths could be widened sufficiently for horses to be used, either to ride or to carry supplies as pack animals.

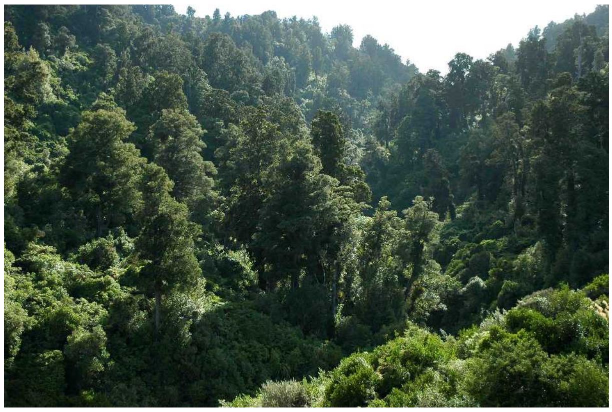

Figure 3: *Hapuawhenua valley with regenerating bush indicative of the roughness and original cover throughout the west-central North Island.*

Geological features proved helpful in locating and building the southern climb to Waiouru. Mr Field had recognised that the several terraces that persist for considerable distances up the Rangitikei and Hautapu valleys to a point beyond Taihape offered an even and easily constructed gradient for a railway. Problems arose where these terraces were interrupted by side valleys, as at Makohine or Mangaweka, or where they ran out, as between Mangaweka and Utiku. John Rochfort capitalised on these advantages, though at a cost of needing large viaducts and extensive tunnels, respectively.

Subsequently, further geological problems in this area have revealed themselves.

The Hautapu River, which is still cutting downward at a rapid rate, has generated very large block landslides that move towards the river as their toe support is eroded. Best known active slides are one across the NIMT and State highway 1 immediately south of Utiku village and another underlying the southern part of Taihape township. Considerable effort has gone into stabilising these as far as can be achieved. Many other such slides have been identified as inactive at present.

A more dramatic phenomenon comes from the release of triaxial stresses in the free face at the papa cliffs of the trenches being carved by the rivers. The rock is in a state of compression arising from its formation under the sea and subsequent burial. Release of that compression at a free face generates horizontal tension that pops slabs of rock off the face of the cliff. In conjunction with scour and weathering, this is a major reason for the clean white vertical faces to be seen in this area. Retreat of the western cliff along the Rangitikei valley had progressed sufficiently rapidly that the five tunnels parallel with it north of Mangaweka were becoming endangered. Tunnel 11, named Black with good cause for its gradient, sharp curve and confined size, was the most endangered: how long would it remain stable and safe under the weight of trains? At some time the retreat of the cliffs will expose and eventually undermine those tunnels. A major deviation to the other side of the valley bypassing this part of the line had to be built 1971-81 to forestall the risk to rail traffic becoming unacceptably high.

Figure 4: *Cliffs and terraces of the Rangitikei Valley as used for locating the NIMT for easiest construction and gradients. River bed greywacke gravels are one of the few sources of competent rock in this part of the North Island.*

4. CONSTRUCTION OF THE NIMT RAILWAY

Access for the early stages of railway construction was by road, as far as possible. In the south, a route had been formed from Marton to Tokaanu as early as 1894. This was metalled from the Rangitikei River (sole source of suitable gravels until those originating from Mt Ruapehu were reached), initially using packhorses to carry the material up the Hautapu valley and through the site of Taihape. S G Laurenson, writing in "Rangitikei: the days of striding out", a history of Rangitikei County, records how the first means of land transport in the County was packhorses and bullock-drawn sledges. Bullocks were stronger but slower than horses and had more stamina under difficult conditions. Metalling of the main road through the County, now State highway 1, to make it adequate for coaches and horses was completed in 1906, two years after the first train reached Taihape. Thirty years later, some County roads were still being given their first applications of road metal.

Bruce Dobson, in his unpublished paper "Road Access a Burning Issue for Settlers of Inland Taranaki" (2003), quotes "History of Whangamomona County", edited by J Garcia (1940), "*Keeping the clay roads at all passable for bullock teams was a difficult matter. In the winter the worst places had to be "corduroyed" with split slabs, or "fascined" with scrub, and even then bullocks got bogged, some even having their necks broken. In the dry weather these deep ruts dried up and became almost impossible to negotiate.*"

One effective but laborious and expensive option which first appears to have been used in the northern Wairarapa and subsequently elsewhere from 1894, was to set up an impromptu kiln at the roadside to burn papa to a brick-like substance that has proven remarkably durable in road pavements.

Until railways were available to transport durable river gravels into the interior, progress on improving and weather-proofing roads was painfully slow. Into the 1950s, North Island hill country roads commonly were closed to heavy motor vehicles through each winter. In this period, and when roads were passable, axle-loads for heavy vehicles were restricted to maxima as low as 3.6 tonnes (2.5 tonnes for axles spaced 1.0-2.4 metres apart) for Class IV loading. As road pavements and trucks improved after about 1950 more extensive metalling programmes gradually brought roads to a reliable condition. Even so, and as late as 1980-85 I recall long debates between National Roads Board staff and rural councils as we tried to persuade them that they could lift Class II load limits to Class I and could rely on the Board to fund any increase of maintenance needs.

Similar problems were encountered at the northern railhead. For example, the contractor for the construction of the Poro-o-tarao tunnel envisaged bringing equipment, materials, and stores in 70 kilometres from Te Awamutu by water using the Waikato and Waipa Rivers to Pirongia, thence by dray through existing bridle tracks. He was successful in bringing some machines and materials to Te Kuiti by barge, though with great difficulty. Sledges had to be used from there. The government began building a road along the route in 1885, the year the tunnel contract was let. As many as 30 bullocks, supplemented by block and tackle, were needed to drag loads up the hills. Wagons went up to their axles in mud. Stores were mainly transported up-country by packhorse. The remarkable achievement was that the tunnel was completed seven years before the railhead reached it. R J Seddon, Minister of Public Works in 1892, commented during a site inspection, what a waste of public money the transport costs for this contract had been in the absence of a usable railway.

Similar transport problems were encountered when preparations began for the construction of the major steel viaducts crossing the deeply incised streams flowing off Mt Ruapehu (between Makatote and Ohakune). The original plan was to ship steel and other materials up the Whanganui River to Pipiriki, then to transport them to site by road using steam traction engines. The road was built but weather and mud defeated the traction engines: the Minister of Public Works was taunted in Parliament over the number of weeks it took to get each load through by this means. In the end, steel for the viaducts was fabricated in factories established at Makatote and Mangaonoho (originally built for construction of Makohine Viaduct). Permanent and temporary railways were used for transport to site as much as possible, also horse teams on a very well built road from Ohakune to Oio, until the construction railhead advanced further.

The story of R W Holmes' brilliant work in devising the Raurimu Spiral has been told many times before, as in R S Fletcher's book "Single Track". Holmes' 1898 surveys found a practicable means to drop the NIMT off the volcanic plateau. Until construction reached there, all aggregates and ballast had to be hauled from the Whanganui River at Kakahi. This had considerable implications as the railhead extended southward. Much of the haulage capacity of the small and obsolete Public Works Department locomotives was being taken up hauling materials, so that in 1906 the PWD bought two locomotives to the design of the Railways Department's new 44 tonne "Wf" class to supplement them. Another consequence was that Taumarunui remained the Railways Dept's railhead for almost five years, December 1903-November 1908.

Once construction reached the volcanic plateau andesitic gravels became accessible. The problems of transporting materials to the construction work eased greatly, so that the Railways Department railhead could advance 58 kilometres southward from Taumarunui, to Erua.

Construction of the earthworks for the NIMT was almost entirely by manual labour. The first steam shovels were imported to the work in 1906.

Cuttings were mostly excavated in a single face from each end. Horse-drawn end-tip wagons were used to carry the spoil away. These were either loaded directly at the face or through a "chinaman", a wooden platform with a hatch in it directly over the rail track used by wagons.

R S Fletcher records in his book "Single Track" that the contractor for the Te Kuiti-Puketutu section, J & A Anderson Ltd., was caught by a bad winter. The walls of completed cuttings collapsed under the wet conditions, "taking the hopes of a good profit from the job with them", as Mr Fletcher put it.

Embankments were formed by end-tipping from formation level. This method of construction was not conducive to good compaction of the tipped material, so embankments could continue to consolidate over a long period and were at risk from slumping during wet weather. One hazard to the workmen was that if wet papa stuck to the bed of the tipping wagon, load, wagon and all went over the tip-head. Recovering the wagon was usually a laborious and slow task.
Drilling for shot-holes in tunnels was originally by hand, using hammer and steel. I have no evidence of the method used for the NIMT tunnels, but this is the likely method used. Later, when air powered tools became available, coal augers were used to drill shot-holes in papa. These certainly were used for the tunnels on the railway between Napier and Gisborne. There, one hazard was that when the auger bit into a concretion in the rock, suddenly it was the drill that rotated, throwing the man handling it off his feet.

Formation in swampy ground was built in one of two ways. If possible, an earth embankment was tipped to displace the peat and to reach a base on solid ground. This was easier and surer if the swamp could be drained.

In the extensive and deep Waikato swamps floating formation was built on fascines laid transversely to the formation. These provided a base upon which an embankment could be built. Manuka was preferred for the fascines, as it didn't rot when placed under water. The track had to be centrally placed on floating formation lest the whole start to capsize under any unbalanced weight of trains. (This last phenomenon is clearly visible on some rural roads between Hamilton and Morrinsville.) It also had implications when formation widening was carried out by Railways in the early 1980s to carry the masts for the NIMT electrification. As one County Engineer complained to me, he was told to expect a stated quantity of sand to be carted to worksites using his roads. "Then the [unmentionable word describing the contractors] carted twice as much!" I knew why.

5. PRACTICALITIES AND POLITICS

The NIMT took over 23 years to complete between Te Awamutu and Marton. The length of this period related primarily to the economic circumstances of the colony. The Vogel loans monies dried up following the collapse of the City Bank of Glasgow in 1878. Export demand for products such as building timber, wool and grain became uncertain and prices poorer.

New export commodities took time to build up. New processes such as refrigerated transport by sea began to contribute after the first successful shipment of frozen meat in 1882. Production of the centrifugal cream separator from 1874 in conjunction with refrigerated shipping led to a new export trade, in butter and cheese, that was going to serve New Zealand well. In the meantime, the 1880s was a hard decade, in the middle of the "long depression" – some 15 years. No wonder progress on the NIMT was so very slow: the governments of the time were very short of cash and financially conservative by nature.

Change in this began following the election of a Liberal Government in 1891. They set out to reinvigorate the economy by breaking up the large wool-producing grazing leases that blocked higher production from the land in many parts of New Zealand. More intensive settlement, the rise of arable farming to succeed the graziers, and better market prices all combined to create an economy within which the government would have the revenue to fund completion of the NIMT. Strictly speaking, these political moves affected the NIMT only to a minor extent, as it was extending through largely virgin forest. Small farmers, running dairy cows and sheep, came in slightly ahead of or following the railway. Large grazing properties running merino sheep for wool had occupied the tussock-lands east of Mt Ruapehu and north of Taihape since the 1850s. Their access and business links came from Hawkes Bay via the Gentle Annie route. They switched to transporting the wool clip by rail from Taihape when the state of the roads made this possible.

R W Holmes' finding of a practicable northbound descent from the volcanic plateau from National Park to Raurimu helped create a political atmosphere within which completion of the NIMT was seen to be desirable and feasible. The 1900 Royal Commission firmly opted for the route that was built, over alternative western routes through inland Taranaki. (The building and operation of the Stratford-Okahukura Line exemplifies the great difficulty of running a rail route through inland Taranaki. This was opened in stages 1902-33.) After 1900 New Zealand was literally booming, so construction funding, especially with completion visibly drawing closer, came easier.

6. CONCLUSION

The engineers clearly made up their minds on which route to adopt with certainty. They knew how to overcome the technical difficulties, it just remained to gain political support and hence funding to complete the unfinished part of the work.

The 1900 Royal Commission adopted completely the recommendations R W Holmes presented under PWD auspices, passing them on to the Government. The central route was 82 kilometres shorter than any alternative, had 344 metres less of rises and falls, had consistently easier gradients, and avoided the need for Main Trunk traffic to travel through the heavy gradients between Palmerston North and Hawera (the part of which east of Wanganui has since been deviated through long tunnels under the worst hills). The NIMT was the only way of tapping the timber resources of the Waimarino forests, of giving access for settlement and farming of the land all along its route to the benefit of the country as a whole, and of providing reliable, speedy transport and communication through the heart of the North Island.

An apparent oddity of the opening of the NIMT was the seeming lack of enthusiasm of the Railways Department senior management for its new trunk line. Ian Bullock writing in "The New Zealand Railway Observer" comments that it was a route for long-distance transport completed at a time when there was no demand for the long-distance carriage of freight on land. Formerly, Railways' task had focussed on linking hinterland with (usually the nearest) port, from which coastal shipping carried produce to an export port. Their first sign of a change of thinking may be seen in the strategic pricing designed to make Waikato coal railed south competitive with West Coast coal brought by sea to the lower North Island.

Figure 5: *Construction complete, trains were able to link north and south with the first reliable means of transporting freight and passengers overland.*

The opening of the NIMT really did mark a watershed in the development of New Zealand transport. It was a big step in bringing the country together as one commercial entity, in its own time as significant as the institution of roll on-roll off ferries across Cook Strait.

7. ACKNOWLEDGMENTS

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Rob. Merrifield,
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